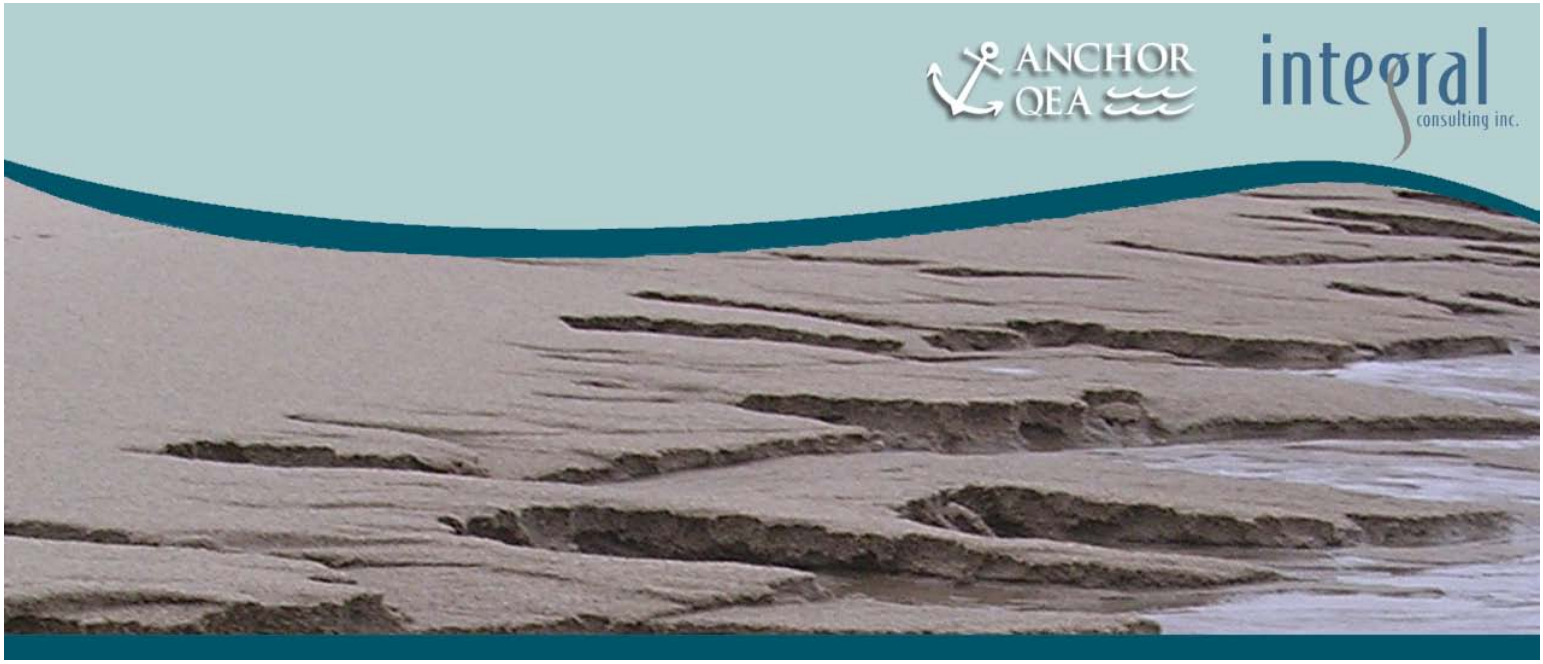


REVISED REMEDIAL INVESTIGATION/FEASIBILITY STUDY WORK PLAN SAN JACINTO RIVER WASTE PITS SUPERFUND SITE

Prepared for

McGinnes Industrial Maintenance Corporation

International Paper Company

U.S. Environmental Protection Agency, Region 6

Prepared by

Anchor QEA, LLC
614 Magnolia Avenue
Ocean Springs, Mississippi 39564

Integral Consulting Inc.
411 First Avenue South, Suite 550
Seattle, Washington 98104

July 2010

9182381

REVISED REMEDIAL INVESTIGATION/FEASIBILITY STUDY WORK PLAN

SAN JACINTO RIVER WASTE PITS SUPERFUND SITE

Prepared for

McGinnes Industrial Maintenance Corporation

International Paper Company

U.S. Environmental Protection Agency, Region 6

Prepared by

Anchor QEA, LLC
614 Magnolia Avenue
Ocean Springs, Mississippi 39564

Integral Consulting Inc.
411 First Avenue South, Suite 550
Seattle, Washington 98104

July 2010

TABLE OF CONTENTS

1 INTRODUCTION 1
1.1 Purpose 1
1.2 RI/FS Approach and Scope 2
1.2.1 Site Management Strategy 2
1.2.2 Project Management Plan 3
1.3 Work Plan Organization 7
2 PROBLEM DEFINITION 9
2.1 Site History 9
2.2 Physical Setting 11
2.2.1 Overview 11
2.2.2 Watershed Characteristics and Galveston Bay Ecosystem 11
2.2.3 Land Use 12
2.2.4 Climate 14
2.2.5 Regional Geology 15
2.2.6 Local Geology 16
2.2.7 Regional Hydrogeology 17
2.2.8 Local Hydrogeology 18
2.2.9 Surface Water Use 20
2.2.10 Hydrography 22
2.2.11 Sediment Physical Characteristics 23
2.2.12 Sediment Transport 23
2.3 Chemical Setting 24
2.3.1 Soil 24
2.3.2 Sediment 24
2.3.3 Groundwater 27
2.3.4 Surface Water 27
2.3.5 Air 28
2.3.6 Biological Tissue 30
2.3.7 Other Studies 31
2.3.7.1 Louchouarn and Brinkmeyer (2009) 31
2.3.7.2 Houston Ship Channel Toxicity Study (ENSR and EHA 1995) 32

2.3.7.3 Frank et al. (2001) ... 35
2.3.7.4 Dean et al. (2009) ... 37
2.3.7.5 Fish Consumption Advisories ... 38
2.3.7.6 Summary ... 39
2.4 Demographics and Human Site Use Information ... 40
2.4.1 Demographics ... 41
2.4.2 Harvesting Shellfish and Fish ... 42
2.4.3 Other Recreational Activities ... 42
2.4.4 Potable Use of Surface Water from the Site ... 43
2.5 Ecological Resources ... 43
2.5.1 Habitats ... 43
2.5.2 Benthic Macroinvertebrates ... 44
2.5.3 Fish ... 44
2.5.4 Reptiles and Amphibians ... 45
2.5.5 Birds ... 45
2.5.6 Mammals ... 45
2.6 Cultural Resources ... 46
2.6.1 Historical Context ... 46
2.6.2 Previous Research ... 48
2.6.3 Recommendations ... 49

3 ASSESSMENT OF DATA QUALITY AND USABILITY ... 50
3.1 Chemical Data Review Criteria ... 50
3.2 Data Quality Assessment Results ... 51
3.2.1 Soil ... 51
3.2.2 Sediment ... 51
3.2.3 Groundwater ... 52
3.2.4 Surface Water ... 52
3.2.5 Air ... 52
3.2.6 Biological Tissue ... 52
3.3 Database Entry Quality Assurance ... 52

4 CONCEPTUAL SITE MODEL ... 53

4.1 Dioxin and Furan Chemistry, Sources, Release Mechanisms, and Transport Pathways 54
4.1.1 Dioxin and Furan Chemical Properties and Behavior in the Environment 54
4.1.2 Dioxin and Furan Toxicity 56
4.1.3 Site-Related Dioxin and Furan Sources 57
4.1.4 Global and Regional Dioxin and Furan Sources, Release Mechanisms, and Transport Pathways 59
4.2 Human Health Site Conceptual Model 60
4.2.1 Human Health Receptors 61
4.2.2 Human Health Exposure Pathways 61
4.3 Ecological Site Conceptual Model 62
4.3.1 Ecological Receptors 63
4.3.2 Ecological Exposure Pathways 64

5 STUDY ELEMENTS AND DATA NEEDS 65
5.1 Study Element 1: Nature and Extent of Contamination 65
5.1.1 Soil Data Gaps 66
5.1.2 Sediment Data Gaps 66
5.1.3 Groundwater Data Gaps 67
5.2 Study Element 2: Exposure Assessment 68
5.2.1 Soil Data Gaps 69
5.2.2 Sediment Data Gaps 69
5.2.3 Water Data Gaps 70
5.2.4 Tissue Data Gaps 71
5.3 Study Element 3: Physical CSM and Fate and Transport Evaluation 72
5.4 Study Element 4: Engineering Design Evaluation 73

6 REMEDIAL INVESTIGATION APPROACH 75
6.1 Site Characterization 77
6.1.1 Sediment 77
6.1.2 Surface Water Investigation 80
6.1.3 Biota Investigation 81
6.1.4 Tissue Sampling and Analysis 81
6.1.5 Groundwater Investigation 83

6.1.6 Chemical Fate and Transport Analysis....83
6.1.6.1 Phase 1: Data Analysis and Hydrodynamic Modeling 84
6.1.6.2 Phase 2: Sediment Transport Modeling and Analysis 84
6.1.6.3 Phase 3: Chemical Fate and Transport Modeling and Analysis.... 85
6.1.6.4 Bioaccumulation and Food Web Analysis 86
6.1.7 Source Evaluation....86
6.2 Background/Reference Area Characterization....87
6.3 Baseline Human Health Risk Assessment....90
6.3.1 Data Usability 91
6.3.2 Screening and Selection of COPCs....92
6.3.3 Exposure Assessment....92
6.3.3.1 Conceptual Site Model 93
6.3.3.2 Exposure Point Concentrations 93
6.3.3.3 Intake Estimates.... 94
6.3.4 Toxicity Assessment 96
6.3.4.1 Toxicity Criteria 97
6.3.4.2 Toxicity of Dioxins and Furans.... 99
6.3.5 Risk Characterization....99
6.3.5.1 Calculation of Cancer Risks 100
6.3.5.2 Calculation of Non-Cancer Risks.... 100
6.3.5.3 Background Risk Comparisons 101
6.3.6 Uncertainty Analysis....102
6.4 Baseline Ecological Risk Assessment....103
6.4.1 Assessment Endpoints and Risk Questions....104
6.4.2 Ecological Conceptual Site Model 105
6.4.3 Measures of Exposure....106
6.4.3.1 Aquatic Life.... 107
6.4.3.2 Aquatic-dependent Wildlife 108
6.4.3.3 Exposure Statistics 109
6.4.4 Measures of Effects....109
6.4.4.1 Toxicity Reference Values 110
6.4.4.2 Species Sensitivity Distributions.... 111
6.4.5 Characterization of Risk and Uncertainty 112

6.4.5.1 Calculation of Hazard Quotients 113
6.4.5.2 Probabilistic Risk and Uncertainty 113
6.4.5.3 Addressing Population Level Assessment Endpoints 114
6.4.5.4 Characterization of Background Risks 114

7 FEASIBILITY STUDY APPROACH 116
7.1 Feasibility Study Process 116
7.2 RAOs 116
7.3 Preliminary Identification of ARARs 116
7.4 PRG Development 117
7.5 Identify and Characterize Management Areas 119
7.6 Identify and Screen Remedial Technologies 119
7.6.1 Monitored Natural Recovery 120
7.6.2 Capping Technologies 120
7.6.3 Dredging Technologies 121
7.6.3.1 Water Quality Controls 122
7.6.3.2 Dredge Material Handling (Transportation and Treatment) Technologies 123
7.6.4 Disposal Technologies 125
7.7 Develop and Screen Alternatives 125
7.8 Comparative Evaluation of Alternatives 126
7.8.1 Threshold Criteria 127
7.8.1.1 Overall Protection of Human Health and the Environment 128
7.8.1.2 Compliance with ARARs 128
7.8.2 Primary Criteria 128
7.8.2.1 Long-term Effectiveness and Permanence 128
7.8.2.2 Reduction of Toxicity, Mobility, and Volume through Treatment 128
7.8.2.3 Short-term Effectiveness 129
7.8.2.4 Implementability 129
7.8.2.5 Cost 130
7.9 Select Preferred Alternative 130

8 RI/FS SCHEDULE 131

9 REFERENCES 132

LIST OF TABLES

Table 2-1 NPDES-Permitted Facilities Upstream of the Site
Table 2-2 Registered TWDB Groundwater Wells Near the Site
Table 2-3 San Jacinto River/Houston Ship Channel Water Quality Segments
Table 2-4 Data Sets with Information on the Chemical Setting Evaluated for the San Jacinto River Waste Pits Site
Table 2-5 Number of Surface Sediment and Core Sampling Locations by Study
Table 2-6 Detection Frequencies and Summary Statistics for Analytes in Sediment Samples from the Site
Table 2-7 Detection Frequencies and Summary Statistics for Analytes in Sediment Samples Within the Nearby Area but Outside the Site Perimeter
Table 2-8 Detection Frequencies and Summary Statistics for Dioxins and Furans Surface Water Samples from the Site
Table 2-9 TCDD and TCDF Concentrations in Surface Water Samples from the Site
Table 2-10 Dissolved TCDD and TCDF Concentrations in Upstream Surface Water Samples
Table 2-11 Ambient Air Sampling Event
Table 2-12 Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004
Table 2-13 Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected Upstream of the Site in 2002-2004
Table 2-14 Chronological Summary of TDSHS Fish Consumption Advisories Relevant to Site
Table 2-15 Recorded Archaeological Sites
Table 2-16 Archaeological Surveys
Table 3-1 Summary of Data Quality and Usability Assessment Checks
Table 3-2 Data Quality Assessment Summary - Historical Data
Table 4-1 Toxicity Equivalency Factors for Dioxins and Furans
Table 6-1 Summary of Ecological Receptor Surrogates
Table 6-2 Summary of Receptor Surrogates, Assessment Endpoints, and Risk Questions for the BERA

List of Figures

Figure 1-1 Project Organization Chart
Figure 2-1 Overview of Current Site
Figure 2-2 Land Use in the Vicinity of the Site
Figure 2-3 San Jacinto River Watersheds and Sub-basins
Figure 2-4 Permitted Dischargers and TMDL Sampling Locations
Figure 2-5 10-Year Average Monthly Rainfall for Houston Area
Figure 2-6 Surficial Geology and Nearby Groundwater Wells
Figure 2-7 Fence Diagram A-A
Figure 2-8 Generalized Cross Section Showing Hydrogeologic Units of Interest in Houston, Texas area
Figure 2-9 Map of Recharge Areas in Chicot and Evangeline Aquifers North of Houston, Texas, Area
Figure 2-10 Stiff Diagrams of Private Wells and San Jacinto River
Figure 2-11 Piper Diagram of Private Wells and San Jacinto River
Figure 2-12 Dioxin Sampling Locations at the Site
Figure 2-13 Metals Sampling Locations at the Site
Figure 2-14 Surface Water Locations at the Site
Figure 2-15 Upstream Surface Water Sampling Locations Used by the TMDL Study
Figure 2-16 Locations of Tissue Samples Collected Between 2002 and 2004 in the Nearby Areas
Figure 2-17 Habitats in the Vicinity of the Site
Figure 2-18 1917 Map, Guillaume Delisle (David Rumsey Map Collection)
Figure 2-19 1944 Aerial Photograph
Figure 2-20 1957 Aerial Photograph
Figure 2-21 1967 Topographic Map
Figure 4-1 CSM Pathway Diagram
Figure 4-2 Physical/Chemical Fate and Transport Processes
Figure 4-3 Change in Toxicity Equivalent Concentration with Distance from the San Jacinto Impoundment
Figure 4-4 Conceptual Site Model for Human Health
Figure 4-5 Conceptual Site Model for Ecological Exposures

Figure 4-6 Conceptual Site Model for Ecological Exposures: Exposure Details for Receptor Feeding Guilds and Habitat Associations
Figure 8-1a Schedule of Deliverables – Pre Preliminary Site Characterization Report
Figure 8-1b Schedule of Deliverables – Post Preliminary Site Characterization Report

List of Appendices

Appendix A – Data Management Plan
Appendix B – Screening Level Ecological Risk Assessment
Attachment B1–Species That May Be Expected in the Vicinity of the San Jacinto River Waste Pits Site
Attachment B2-Toxicity of Dioxin-Like Compounds to Invertebrates, Fish, Reptiles, Birds, and Mammals
Appendix C – Chemicals of Interest and Selection of Chemicals of Potential Concern
Appendix D – Data Quality and Usability Assessment Checklists
Appendix E – Geochemical Characteristics of Primary COPCs
Appendix F – Select Boring Logs From Within the Preliminary Site Perimeter
Appendix G – Response to Agency Comments on the Draft RI/FS Work Plan

LIST OF ACRONYMS AND ABBREVIATIONS

Abbreviation	Definition
95UCL	95 percent upper confidence limit
AhR	aryl hydrocarbon receptor
Anchor QEA	Anchor QEA, LLC
ARAR	applicable or relevant and appropriate requirement
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
B.P.	before present
BAF	bioaccumulation factor
BERA	baseline ecological risk assessment
BHHRA	baseline human health risk assessment
BMP	best management practice
BSAF	biota-sediment accumulation factor
CDD	chlorinated dibenzo-p-dioxins
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
cfs	cubic feet per second
CHPDD	City of Houston Planning and Development Department
COI	chemical of interest
COPC	chemical of potential concern
CSF	cancer slope factor
CSM	conceptual site model
CT	central tendency
CTR	critical tissue residue
CU triax	consolidated-undrained triaxial
DDE	dichlorodiphenyldichloroethylene
DMP	Data Management Plan
DQO	Data Quality Objective
EMS	Environmental Management System
EPC	exposure point concentration
EqP	equilibrium partitioning

ERA	ecological risk assessment
FS	Feasibility Study
FSP	Field Sampling Plan
HASP	Health and Safety Plan
HCB	hexachlorobenzene
HQ	hazard quotient
HRGC/HRMS	high-resolution gas chromatography with high-resolution mass spectrometry
I-10	Interstate Highway 10
Integral	Integral Consulting Inc.
IPC	International Paper Company
IRIS	Integrated Risk Information System
Koc	partition coefficient of a chemical in the organic matter of soil/sediment
Kow	octanol-water partition coefficient
LOAEL	lowest observed adverse effect level
MIMC	McGinnes Industrial Maintenance Corporation
MNR	Monitored Natural Recovery
MRL	method reporting limit
MSL	mean sea level
NCP	National Contingency Plan
NPL	National Priorities List
NRHP	National Register of Historic Places
NTCRA	Non-Time Critical Removal Action
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCL	protective concentration level
PPRTV	provisional peer reviewed toxicity values
PRG	Preliminary Remediation Goal
PVC	polyvinyl chloride
QA	quality assurance
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance/quality control

QC	quality control
RAO	remedial action objective
RfD	reference dose
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RME	reasonable maximum exposure
ROD	record of decision
SAP	Sampling and Analysis Plan
SEM	structural equation modeling
Site	San Jacinto River Waste Pits Superfund Site
SJRWP	San Jacinto River Waste Pits
SLERA	screening level ecological risk assessment
SOW	scope of work
SPT	standard penetration test
SSD	species sensitivity distribution
SVOC	semivolatile organic compound
TBC	to be considered
TCDD	Tetrachlorodibenzo-*p*-dioxin
TCDF	Tetrachlorodibenzofuran
TCEQ	Texas Commission on Environmental Quality
TCRA	time critical removal action
TDES	Texas Pollution Discharge Elimination System
TDSHS	Texas Department of State Health Services
TEF	toxicity equivalency factor
TEQ	toxicity equivalent
TMDL	total maximum daily load
TOC	total organic carbon
TRV	toxicity reference value
TXDOT	Texas Department of Transportation
UAO	Unilateral Administrative Order
UCL	upper confidence limit
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency

VOC	volatile organic compound
WTP	water treatment plant

1 INTRODUCTION

This Work Plan for a Remedial Investigation/Feasibility Study (RI/FS Work Plan) was prepared on behalf of International Paper Company (IPC) and McGinnes Industrial Maintenance Corporation (MIMC) (collectively referred to as the Respondents), pursuant to the requirements of Unilateral Administrative Order (UAO), Docket No. 06-03-10, which was issued by the U.S. Environmental Protection Agency (USEPA) to IPC and MIMC on November 20, 2009, (USEPA 2009b). The 2009 UAO directs IPC and MIMC to prepare an RI/FS Work Plan for the San Jacinto River Waste Pits (SJRWP) Site in Harris County, Texas (the Site), which consists of a series of manmade impoundments used for disposal of pulp mill wastes during 1965 and 1966, and surrounding areas. The 2009 UAO also directs IPC and MIMC to submit a Screening Level Ecological Risk Assessment (SLERA), a Sampling and Analysis Plan (SAP) and a Health and Safety Plan (HASP) in conjunction with submittal of the RI/FS Work Plan. This document is the required RI/FS Work Plan, and includes the SLERA as Appendix B. The project HASP (Anchor QEA and Integral 2009) was submitted to USEPA on December 15, 2009. The draft Sediment SAP (Integral and Anchor QEA 2010) was submitted to USEPA on February 17, 2010; with revisions according to agency comments submitted on April 9, 2010; additional SAPs setting forth the quality assurance project plans (QAPPs) and field sampling plans (FSPs) will be submitted according to the RI/FS schedule provided in Section 8 of this document.

1.1 Purpose

On March 19, 2008, USEPA added the Site to the National Priorities List (NPL), and the 2009 UAO requires that an RI/FS be conducted at the Site. The RI/FS will be undertaken to address the following objectives:

- Characterize the nature and extent of Site-related contamination
- Perform a baseline human health risk assessment (BHHRA) and a baseline ecological risk assessment (BERA)
- Evaluate the physical characteristics of the Site and physical processes governing fate and transport of Site-related contaminants
- Develop and evaluate potential remedial alternatives for the Site

The purpose of this document is to provide a comprehensive description of the work to be performed, the methods to be used, and the schedule of activities that will address these objectives. Once the RI/FS is complete, USEPA will select a Site remedy and will publish a proposed plan, which will be released for public comment. USEPA will subsequently document final selection of the remedy in a record of decision (ROD). A detailed schedule of activities leading up to submittal of the final FS Report is provided in Section 8.

1.2 RI/FS Approach and Scope

This RI/FS Work Plan was scoped following an evaluation of existing data, identification of data gaps, and a review of USEPA requirements as defined by the 2009 UAO. In addition, representatives of IPC and MIMC attended an RI/FS scoping meeting held by USEPA and attended by several other agencies on December 7, 2009; conducted a Site visit with USEPA and others on December 10, 2009; and met with USEPA and others on January 20, 2010, to discuss the approach to the RI/FS and the sediment study design that is described in the Sediment SAP (Integral and Anchor QEA 2010). USEPA and Respondents have also been actively discussing the overall Site management strategy and the project management plan. As a result of these activities, a Site management strategy, project management plan, and approach to the RI/FS have been developed, and are summarized below.

1.2.1 Site Management Strategy

The scoping process for the RI/FS has resulted in a general understanding of the types of actions that may be required to address the problems at the Site, has defined specific interim actions, and has clarified the appropriate sequence for Site actions and required investigations.

An important consideration in the development of the RI/FS Work Plan is that the original waste impoundments for the Site are considered a potential ongoing source of dioxin and furan contamination to the surrounding area in the San Jacinto River, because the original containment berms on the northwestern, northern, and eastern portions of the original impoundments are largely removed or submerged, and dioxin-bearing pulp waste is exposed to erosional forces associated with currents and tides in the river (Section 4).

According to USEPA guidance, risk management strategies for contaminated sediment sites should include early source control as part of the Site remediation (USEPA 2005a). The Respondents and USEPA are working together to implement source control actions as defined in USEPA's Time Critical Action Memorandum, dated April 2, 2010, that will be conducted concurrently with the RI/FS to minimize the continuing release of wastes from the impoundments. The Time Critical Removal Action (TCRA) would involve short-term stabilization activities on those areas of the Site that present an imminent or substantial endangerment to people or the environment. Additional actions are being taken to restrict public access. The Respondents and USEPA also plan to explore conducting a non-time critical removal action (NTCRA) to aid in the long term remedy of the Site.

The RI/FS will be used to plan the longer term stabilization, containment and removal of contaminated sediment. The overall Site management strategy is to perform immediate steps to implement source control remedies, reduce exposure and risks at the Site, to develop the information necessary to evaluate long-term remedial alternatives quickly and efficiently, and to accelerate the implementation of a final remedy for the entire area.

1.2.2 Project Management Plan

The RI/FS will be based on reliable and detailed information on the nature and extent of contamination under current (baseline) conditions, and evaluation of associated risks, processes controlling contaminant fate and transport and physical properties and conditions to allow the selection and implementation of a final remedy.

IPC and MIMC have retained Anchor QEA, LLC (Anchor QEA) and Integral Consulting Inc. (Integral) to perform the RI/FS. Figure 1-1 illustrates the organization of personnel on the project. The primary contacts for USEPA, IPC, and MIMC are provided in the next table. A description of the project organization and contacts pertaining to the RI/FS are provided after the table.

USEPA and Respondent Project Managers

Title	Name	Contact Information
USEPA Remedial Project Manager	Stephen Tzhone	U.S. Environmental Protection Agency, Region 6 1445 Ross Avenue Dallas, TX 75202-2773 (214) 665-8409 tzhone.stephen@epa.gov
International Paper Company Project Manager	Philip Slowiak	6400 Poplar Avenue Memphis, TN 38197-0001 (901) 419-3845 philip.slowiak@ipaper.com
McGinnes Industrial Maintenance Corporation Project Manager	Andrew Shafer	9590 Clay Road Houston, TX 77080 (713) 772-9100 Ext. 109 dshafer@wm.com

The following table shows the names, quality assurance (QA) responsibilities, and contact information of key project personnel for Anchor QEA and Integral in performance of the RI/FS. Additional roles and related personnel required for execution of specific investigation are specified in SAPs.

Project Personnel Quality Assurance Responsibilities

Title	Responsibility	Name	Contact Information
Project Coordinator	Coordination of project information and related communications on behalf of IPC and MIMC with USEPA; liaison between USEPA project managers and respondent project managers.	David Keith	Anchor QEA, LLC 614 Magnolia Avenue Ocean Springs, MS 39564 (228) 818-9626 dkeith@anchorqea.com
Anchor QEA Project Manager	Project planning and implementation; liaison between respective internal and external team members.	David Keith	Anchor QEA, LLC 614 Magnolia Avenue Ocean Springs, MS 39564 (228) 818-9626 dkeith@anchorqea.com

Title	Responsibility	Name	Contact Information
Integral Project Manager	Project planning and implementation; liaison between respective internal and external team members.	Jennifer Sampson	Integral Consulting Inc. 411 1st Avenue South Suite 550 Seattle, WA 98104 (206) 957-0351 jsampson@integral-corp.com
Anchor QEA and Integral Corporate Health and Safety Managers	Oversight of health and safety program for field tasks associated with RI/FS.	David Templeton	Anchor QEA, LLC 1423 Third Avenue, Suite 300 Seattle, WA 98101 (206) 287-9130 dtempleton@anchorqea.com
		Eron Dodak	Integral Consulting Inc. 319 SW Washington Street Suite 1150 Portland, OR 97204 (503) 284-5545 edodak@integral-corp.com
Project Database Administrator Integral	Database development and data management.	Dreas Nielsen	Integral Consulting Inc. 411 1st Avenue South Suite 550 Seattle, WA 98104 (206) 957-0311 dnielsen@integral-corp.com
Laboratory QA Coordinator for Study Elements 1 and 2 Integral	Completeness of QA documentation and procedures; liaison between project personnel, laboratories, and data validators and for related QA communications with USEPA.	Craig Hutchings	Integral Consulting Inc. 1205 West Bay Dr. NW Olympia, WA 98502 (360) 705-3534 chutchings@integral-corp.com
Laboratory QA Coordinator for Study Elements 3 and 4 Anchor QEA		John Laplante	Anchor QEA, LLC 1423 Third Avenue, Suite 300 Seattle, WA 98101 (206) 287-9130 jlaplante@anchorqea.com

Anchor QEA and Integral plan to undertake an adaptive and iterative management approach to the RI/FS process. In this approach high-value work is identified in conjunction with USEPA, IPC, and MIMC and prioritized to be completed early in the RI/FS process. As each work element is completed, the results are evaluated; the understanding of the Site updated,

and plans for future work are revised as appropriate. The order of future work will be prioritized based on the Site's needs. Existing and new data will be used for building a better conceptual understanding of the Site and a remedial solution for the Site.

The RI/FS team will evaluate existing and newly collected data at each step in the RI/FS process to determine if there are opportunities for early removal actions and/or controls that would significantly reduce risk posed by the Site.

This document and the sediment SAP (Integral and Anchor QEA 2010), Data Management Plan (DMP) (Appendix A), and HASP (Anchor QEA and Integral 2009) provide administrative and programmatic direction for the project and are the foundation of subsequent work packages (either Work Plans or SAPs) for the RI/FS. If needed, addenda to the HASP and other global plans will be prepared for each SAP to cover activities outside of the scope of the global documents.

Work packages, consisting of SAPs and/or technical memoranda, will be prepared detailing each specific investigation or other work that will occur according to the schedule provided in Section 8. This process will continue until the RI is completed. Based on a review of the considerable amount of historical data that is available for the Site, and other information, the major elements anticipated for the San Jacinto RI/FS include the following:

- Nature and Extent Data Collection and Analysis
- Ecological and Human Health Risk Assessment Data Collection and Evaluation, including bioaccumulation data collection and modeling
- Chemical Fate and Transport Data Collection and Evaluations, including hydrodynamic and sediment stability data collection and modeling and surface water modeling
- Feasibility Study Engineering Data Collection and Evaluations

The focus of each of these work elements is discussed in more detail in this RI/FS Work Plan. During preparation of each work package, and after the evaluations of data associated with each work package are completed, the Respondents' technical team will provide interim reports (according to the 2009 UAO) to the respondents and agencies to keep team members apprised of the progress of the project. Work package deliverables subsequent to this Work

Plan that will describe the specific methods and approaches for addressing data gaps include the following:

- Technical Memorandum on Fate and Transport Modeling, and Addendum to the Sediment SAP
- Technical Memorandum on Bioaccumulation, and Tissue SAP
- Soil SAP
- Groundwater SAP
- Exposure Assessment Memorandum
- Toxicological and Epidemiological Studies Memorandum

The first two technical memoranda will provide the information required in the "Technical Memorandum on Modeling of Site Characteristics" identified by the 2009 UAO. These memoranda will evaluate relevant information and identify data necessary for modeling (i.e., the data gaps), and the SAPs that accompany these memoranda will address those data gaps. The Soil SAP will address data gaps for soil identified later in this document. The last two memoranda are stipulated by the 2009 UAO, and address methodological issues related to the human health risk assessment. A work plan for performance of the BERA is not planned for this project, but Section 6.4 of this document provides the approach to the BERA, and details presented in the DQOs of each SAP articulate the anticipated role of each new data set in the BERA. The schedule for these, and for the other deliverables required by the 2009 UAO, is provided in Section 8. It is likely that the COPC selection criteria outlined in this document will fulfill the requirements of the preliminary contaminant of concern (PCOC) memorandum required in the UAO. Any need for additional analyses, memoranda, and SAPs will be determined in consultation with USEPA.

1.3 Work Plan Organization

The following sections of this Work Plan provide a history of the Site and describe the physical and chemical setting (Section 2), an assessment of data quality and usability (Section 3), a description of the current Conceptual Site Model (CSM) (Section 4), a review of study elements and data needs (Section 5), a description of the RI and FS approaches (Sections 6 and 7, respectively), and the proposed RI/FS schedule (Section 8). Supporting information is provided in the following Appendices:

Appendix A – Data Management Plan

Appendix B – Screening Level Ecological Risk Assessment

Attachment B1 – Ecological Receptors Potentially Present at the Site

Attachment B2 – Overview of Toxicity of Dioxins and Furans to Ecological Receptors

Appendix C – Chemicals of Interest and Selection of Chemicals of Potential Concern

Appendix D – Data Quality and Usability Assessment Checklists

Appendix E – Geochemical Characteristics of Primary COPCs

Appendix F – Select Boring Logs From Within the Preliminary Site Perimeter

Appendix G – Response to Agency Comments on the Draft RI/FS Work Plan

2 PROBLEM DEFINITION

2.1 Site History

The Site consists of a set of impoundments approximately 14 acres in size, built in the mid-1960s for disposal of paper mill wastes, and the surrounding areas containing sediments and soils potentially contaminated with the waste materials that had been disposed of in the impoundments. The set of impoundments is located on a 20-acre parcel on the western bank of the San Jacinto River, in Harris County, Texas, immediately north of the Interstate Highway 10 (I-10) Bridge over the San Jacinto River (Figure 2-1).

USEPA has identified the possibility of an additional impoundment that is located south of I-10. USEPA contends that the additional impoundment contains material similar to that disposed of in the two impoundments described above, based on information contained in a Texas Department of Health report dated May 1966. USEPA has not identified any evidence of releases or threatened releases from the additional impoundment. Six sediment samples were taken in the Old River area south of I-10, adjacent to the potential impoundment. The six sediment samples were collected as part of the April 2010 approved "Sampling and Analysis Plan: Sediment Study San Jacinto River Waste Pits Superfund Site," and results from the sampling will be reported as part of the RI/FS process.

In 1965, the impoundments north of I-10 were constructed by forming berms within the estuarine marsh, to the west of the main river channel. These impoundments at the Site were divided by a central berm running lengthwise (north to south) through the middle, and were connected with a drain line to allow flow of excess water (including rain water) from the impoundment located to the west of the central berm, into the impoundment located to the east of the central berm (Figure 2-1). The excess water collected in the impoundment located to the east of the central berm was pumped back into barges and taken off-Site.

In 1965 and 1966, pulp and paper mill wastes (both solid and liquid) were reportedly transported by barge from the Champion Paper Inc. paper mill in Pasadena, Texas and unloaded at the Site into the impoundments north of I-10 where the waste was stabilized and disposed. The excess water from these impoundments was pumped back into barges and taken off-Site. The Champion Paper mill used chlorine as a bleaching agent, and the wastes

that were deposited in the impoundments have recently been found to be contaminated with polychlorinated dibenzo-*p*-dioxins, polychlorinated furans (dioxins and furans), and some metals (TCEQ and USEPA 2006); additional discussion of the chemical constituents typical of materials like those deposited in the impoundments is provided in Section 1.5 of the Sediment SAP (Integral and Anchor QEA 2010). The impoundments north of I-10 were used for waste disposal from September 1965 through May 1966, until both impoundments were filled to capacity. Since the eastern impoundment was used to dewater the western impoundment (as noted above), the capacity of the eastern impoundment for waste disposal is thought to have been less than that of the western impoundment.

Physical changes at the Site in the 1970s and 1980s, including regional subsidence of land in the area due to large scale groundwater extraction and sand mining within the river and marsh to the west of the impoundments, have resulted in partial submergence of the impoundments north of I-10 and exposure of the contents of the impoundments to surface waters. Based upon review of U.S. Army Corps of Engineers (USACE)-approved dredging permits, dredging by third parties has occurred in the vicinity of the perimeter berm at the northwest corner of these impoundments. Recent samples of sediment in nearby waters north and west of these impoundments (University of Houston and Parsons 2006) indicate that dioxins and furans are present in nearby sediments at levels higher than levels in background areas nationally (USEPA 2000).

Freshwater, estuarine, and marine habitats in the vicinity of the Site are shown in Figure 3. Residential, commercial, industrial, and other land use activities occur within the preliminary Site perimeter and in the surrounding area. Residential development on the eastern bank of the river is present within 0.5 mile of the Site. The impoundments north of I-10 are currently occupied by estuarine riparian vegetation to the west of the central berm, and are consistently submerged even at low tide to the east of the central berm. Estuarine riparian vegetation lines the upland area that runs parallel to I-10 and the uplands west of the impoundments. A sandy intertidal zone is present along the shoreline throughout much of the Site (Figure 2-1).

2.2 Physical Setting

The physical setting of the Site is described in this section. Consistent with USEPA guidance (USEPA 1988a), this discussion emphasizes factors that are important in developing the CSM for the Site.

2.2.1 Overview

The Site is within the estuarine portion of the lower San Jacinto River. Movement of contaminants into and out of the Site is expected to occur primarily through the movement of sediments, but other modes of transport are also possible. Upstream conditions may have influenced sediment conditions on the Site, and will continue to do so in the future.

2.2.2 Watershed Characteristics and Galveston Bay Ecosystem

The San Jacinto River drains an area of 3,900 square miles and supplies approximately 28 percent of the fresh water entering Galveston Bay (Gardiner et al. 2008). The mainstem of the San Jacinto River, downstream from the Lake Houston dam in northeastern Harris County, flows southeast for 28 miles to its mouth on Galveston Bay east of Houston. The 9-mile-long Lake Houston and the river below it are formed by the confluence of the 69-mile-long East Fork and the 90-mile-long West Fork of the San Jacinto rivers. The dam that forms Lake Houston is an earthfill dam that is 62 feet high with a concrete spillway. The reservoir that is created by the dam is used for recreation, as well as an industrial, municipal, and agricultural water supply.

The Houston Ship Channel which was created in 1914, was dredged and widened the lower San Jacinto River (dredging did not extend as far upstream as the Site) to link the Port of Houston with Galveston Bay and the Gulf of Mexico. It is likely that construction of the Houston Ship Channel directly altered surface water circulation by providing a larger cross-section for north to south water movement on the main axis of the bay and by breaching Redfish Bar, which had previously limited water exchange between the upper and lower bay (Lester and Gonzalez 2005).

The Site is located in a hydrologically dynamic tidal section of the San Jacinto River. Wildlife habitats on the northern portion of the Site include shallow and deep estuarine

waters and shoreline areas occupied by estuarine riparian vegetation. Minimal habitat is present in the upland terrestrial area west of the impoundments, as sand sorting activities created a denuded upland area with a covering of crushed cement and sand. The sandy shoreline of this area is littered with riprap, other metal debris, and piles of cement fragments. Estuarine riparian vegetation lines the upland area that runs parallel to I-10. To the west of the central berm within the impounded area, the area is currently occupied by late successional stage vegetation, and to the east the historically impounded area is consistently submerged even at low tide.

2.2.3 Land Use

The San Jacinto River watershed is one of several larger watersheds in the greater Houston area and encompasses nearly 4,000 square miles (Figure 2-3). Within this large area, which extends more than 80 miles north of the Site the land type varies from farmland, parks, and undeveloped lands to urban and industrial areas. The land type typical of the area surrounding the Site is shown in Figure 2-2 and is better described within the appropriate sub-basin that is mapped within the San Jacinto watershed. There are three sub-basins within the larger San Jacinto watershed that are in the vicinity of the Site. These include The San Jacinto River Tidal, Houston Ship Channel, Houston Ship Channel/San Jacinto River, which are highlighted in Figure 2-4. Within these areas, the land parcels closest to the Site are predominantly commercial/industrial, followed by residential areas. As you move further from the Site, the amount of residential land use increases, along with other land use categories not found in the immediate vicinity of the Site, such as undeveloped land, farms, parks, and lands listed as other (e.g., schools and hospitals). Generally development is more intense near the San Jacinto River and Houston Ship Channel to the south.

Land uses upstream include industrial and municipal activities that may result in releases of dioxins and furans or other COPCs in to the San Jacinto River upstream of the Site. Several facilities with discharge permits are located on lands upstream and downstream of the Site. All of the permitted facilities discharging to water quality segment 1001 shown in Figure 2-4 and listed in Table 2-1 (discussed further below) are part of the National Pollution Discharge Elimination System (NPDES) which assigns effluent limitations for a variety of chemical constituents but does not address dioxins and furans. The TCEQ's Houston Ship Channel

TMDL project for dioxin, which began in May of 2000, was implemented as a result of the Texas Department of Health seafood consumption advisory for catfish and blue crab issued in 1990. The goal of the TMDL project is "to determine the measures necessary to restore water quality to water bodies affected by the consumption advisory" (TCEQ 2010). The TMDL project included an effort to sample sludges and effluents at facilities throughout the HSC area, including areas upstream of the Site. Facilities volunteered to have effluents or sludges sampled; the absence of a sample is not an indication that the facility is not a potential contributor of dioxins and furans to the San Jacinto River. Both the discharge permits and the TMDL sludge and effluent information are relevant to planning the RI/FS investigation because the upstream condition affects risk management decisions for the Site (USEPA 2002d), and potential upstream sources should therefore be considered. This section lists those facilities permitted to discharge to water quality segment 1001 (which extends upstream from the Site to a point just south of Lake Houston). Whether sludge or effluent sampling was performed by the TMDL project at the facility, confirming the presence of dioxins and furans in sludges or effluents is noted in Table 2-1. Figure 2-4 shows the locations of facilities with discharge permits and the of sludge or effluent samples that are listed in Table 2-1.

There are six registered discharge permits upstream of the Site on the San Jacinto River (Figure 2-3: Table 2-1). The facilities listed in Table 2-1 range from one to eight miles upstream of the Site. The City of Baytown – West District Water Treatment Plant (WTP) (NPDES ID TX0072834) is the closest facility, located just over 1 mile to the east of the impoundments. Further upstream are two chemical manufacturing facilities, an industrial facility, and two more WTPs. According to permit records, all of these facilities discharge to river segment 1001 of the San Jacinto River. The Texas Pollution Discharge Elimination System (TPDES) permits for the WTP facilities list carbonaceous biochemical oxygen demand, total suspended solids, ammonia nitrogen, and total Kjeldahl nitrogen as the regulated effluent characteristics for operating the facilities. The TPDES permits for the Donohue Industrial Facility upstream of the Site lists biological oxygen demand (BOD), chemical oxygen demand (COD) and total suspended solids as the regulated effluent characteristics for this facility. The two chemical manufacturing facilities Lyondell Chemical and Channelview Complex (Equistar), also both upstream of the Site, have the largest lists of

regulated effluent characteristics, both of which include extensive lists of volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs).

Table 2-1
NPDES-Permitted Facilities Upstream of The Site

Facility Name	NPDES Permit ID	Notes	A Sludge or Effluent Sample was Collected and Dioxins and Furans Were Found
NEWPORT MUD WWTP	TX0023230	Permitted Discharger	X
DONOHUE INDUSTRIES INCORPORATED	TX0053023	Permitted Discharger	
EQUISTAR CHANNELVIEW COMPLEX	TX0003531	Permitted Discharger	X
LYONDELL CHEMICAL CHANNELVIEW	TX0069493	Permitted Discharger	X
HARRIS COUNTY WCID NO. 1 WWTP	TX0023311	Permitted Discharger	X
BAYTOWN WEST 1	TX0072834	Permitted Discharger	X

2.2.4 Climate

The climate along the Gulf Coast of Texas and the area surrounding Houston is humid subtropical. The average annual precipitation is 54 inches, the warmest month is July, with an average temperature of 85°F, and the coldest month is January, with an average temperature of 54°F. Prevailing wind directions for the region are primarily from the south or southeast. During the spring season large thunderstorms are common and are capable of producing tornados. This transition to the summer months with mild temperatures noted above, but relative humidity that can reach upwards of 90 percent and results in a heat index much higher.

Monthly rainfall data over a 10 year period was tabulated and the average monthly precipitation is shown in Figure 2-5. The monthly average precipitation varies from approximately 2.5 inches in February to over 7 inches in June. The figure shows that from a high in June, average monthly rainfall drops until October, where there is another abrupt

increase followed by another decline. This decline leads into the winter months before reversing in late winter into early spring, where monthly average values once again increase, until reaching their peak in June.

It is not uncommon to have precipitation events that exceed 2 inches per day, and on a 10-year basis, events that exceed 10 inches per day should be expected. These types of precipitation events produce wide variations in the volume of discharge into and out of the San Jacinto River and have significant implications concerning variations in flow velocities, sediment stability, and suspended sediment loads.

Tropical weather systems can have tremendous impacts on regional precipitation and hydrology along the Gulf Coast. Hurricane season runs from June 1 to November 30. Between 1851 and 2004, 25 hurricanes have made landfall along the north Texas Gulf Coast, seven of which were major (Category 3 to 5) storms (NOAA 2005). Tropical Storm Allison, which hit the Texas Gulf Coast on June 5 through 9, 2001, resulted in 5-day and 24-hour rainfall totals of 20 and 13 inches, respectively, in the Houston area, resulting in significant flooding. More recently, Hurricane Rita made landfall on September 23, 2005, between Sabine Pass, Texas, and Johnsons Bayou, Louisiana, as a Category 3 on the Saffir-Simpson Hurricane Scale, with winds at 115 mph and it continued on through parts of southeast Texas. The storm surge caused extensive damage along the Louisiana and extreme southeastern Texas coasts. On September 13, 2008, the eye of Hurricane Ike made landfall at the east end of Galveston Island and travelled north up Galveston Bay, along the east side of Houston. Ike made its landfall as a strong Category 2 hurricane, with Category 5 equivalent storm surge, and hurricane-force winds that extended 120 miles from the storm's center.

2.2.5 Regional Geology

Sediments of the Texas Gulf Coast are generally Cenozoic fluvial-deltaic to shallow-marine deposits of a coastal plain environment (USGS 2002). Sea-level transgression-regression cycles and natural basin subsidence have produced beds of clay, silt, sand and gravel that gently dip southeast towards the Gulf of Mexico. This complex depositional process created both a continental assemblage of sediments that now makes up the aquifers within the area and a marine sequence of sediments that contain clay layers and confining units. This

process resulted in a regional aquifer system with a high degree of heterogeneity in both lateral and vertical extent (USGS 2002) commonly referred to as the Gulf Coast Aquifer System (GCAS; TNRCC 1999). The unconsolidated deposits mapped within the area of the Site are shown in Figure 2-6.

2.2.6 Local Geology

In the Site area, the surface and underlying local soils include Holocene alluvial deposits and the Beaumont formation, which is the youngest and uppermost of the series of coast-parallel Pleistocene deposits that make up the GCAS. The soils of the Beaumont formation are dominated by clays and silts that thicken seaward that were deposited in a fluvial-deltaic environment (Van Siclen 1991). The Beaumont formation and overlying recent alluvial soils make up the uppermost units of the Chicot Aquifer (USGS 2002) which is discussed along with the Evangeline Aquifer in section 2.2.7 below.

Figure 2-7 shows a fence diagram of former containment berm soils and river sediments in the Site vicinity, based on recent geotechnical borings completed at the Site[1] and four borings completed by the Texas Department of Transportation (TXDOT). The locations of the recent geotechnical and TXDOT borings shown in the fence diagram, along with the boring logs are included in Appendix F as Figures F-1 through F-10. The map location of the diagram on Figure 2-7 is shown on Figure F-10. Grain size data from the TXDOT borings have been incorporated into the analysis of soil and sediment stratigraphy shown on Figure 2-7. The soil borings confirm the presence of berms soils and recent alluvial sediments (interbedded clays, silts and sands), underlain by approximately 10 to 20 feet of the Beaumont formation. The boring logs included in Appendix F show histograms of the grain size distribution where data was collected and analyzed. The boring logs and grain size information presented in Appendix F clearly show the presence of the Beaumont Formation underlying the alluvium at the Site. The thickness and extent of the Beaumont Formation are shown on Figure 2-7. Additional discussion of the regional and local hydrogeology follows.

[1] The recent geotechnical borings noted here were collected as part of the sediment sampling for the RI/FS required by the 2009 UAO. Methods for their collection are as described in the Sediment SAP (Integral and Anchor QEA, 2010).

2.2.7 Regional Hydrogeology

The GCAS is located along the coast of the Gulf of Mexico and has been divided into four units; the Chicot and Evangeline Aquifers, Burkeville confining unit, and Jasper Aquifer. Each of these hydrogeologic units has particular hydrogeologic properties. The Site, located in Harris County, is above the Evangeline and Chicot Aquifers as shown in Figure 2-8. The Evangeline Aquifer is the deeper aquifer and it consists of the Goliad Sand Formation, which overlies the Burkeville confining unit of the Fleming formation (not shown). The Burkeville unit is considered the basal unit within the Houston area and is a "no-flow" unit that separates the two above-mentioned aquifers from the more dense saline waters below. The base of the Evangeline Aquifer ranges from 5,000 feet below mean sea level (MSL) south of the coastline to slightly more than 200 feet above MSL at its northern, up-dip extent. The aquifer extends as far north as Washington County, Walker County, and surrounding counties and is thinnest in the up-dip direction. The Evangeline Aquifer has shallow water table conditions in these locations and becomes confined when moving southward through the Houston area toward the coast (USGS 2002).

The local stratigraphy at the Site, as described above, makes up the uppermost units of the Chicot Aquifer. In stratigraphic order from youngest to oldest, the Chicot Aquifer consists of the Holocene surficial river alluvium underlain by and the Beaumont, Montgomery and Bentley Formations, and Willis Sand Formations [USGS 2002]). The formations within in Chicot Aquifer are shown on the inset table on Figure 2-6. Similar to the Evangeline Aquifer, the Chicot Aquifer extends from the coastline to the north of Houston into Austin, Waller, Polk, and surrounding counties, but not as far north as the Evangeline aquifer (Figure 2-8). The base of the Chicot Aquifer is located more than 1,500 feet below MSL near the coast, to more than 100 feet above MSL near the upland limit of the aquifer. Like the Evangeline, the Chicot Aquifer has shallow water table conditions in upland locations and becomes confined by the Beaumont Formation clays and silts moving south through the Houston area toward the coast.

Groundwater elevation maps for the Evangeline and Chicot Aquifers show that regional groundwater flow is directed down dip (i.e., approximately southeast) towards the Gulf of Mexico (USGS 2002). On a net flow basis, shallow groundwater discharges to the river and provides some of the river baseflow. Under high tide and river flow conditions, it is expected

that a temporary gradient reversal will exist which causes rivers water to temporarily recharge the shallow alluvium adjacent to the river. Recharge to the Chicot Aquifer primarily occurs in the northern up-dip outcrop areas shown in Figure 2.9 where the Beaumont Formation is thinner or nonexistent. This area of recharge for the Chicot Aquifer is well up-gradient from the Site. As described later in this report, the fine-gradient Beaumont Formation separates the shallow alluvium from the underlying formations of the Chicot Aquifer and greatly restricts any recharge that might occur from alluvium to the Chicot formations underlying the Beaumont (USGS 1997).

The Chicot Aquifer is used as a drinking water source within the greater Houston area, but water used for this source is pumped from wells screened much lower in the aquifer (i.e., below the Beaumont formation). Although there are some upper Chicot Aquifer wells, privately owned, near the Site (see below), infiltrating surface waters or shallow groundwater would likely be prevented by the thick sequence of the clay and silt deposits of the Beaumont formation, effectively isolating confining the lower portion of the Chicot Aquifer from shallower groundwater and surface water in the Site vicinity (USGS 2002).

2.2.8 Local Hydrogeology

The local water table (i.e., shallow groundwater) is found near land surface in the shallow alluvium sediments, generally at the approximate elevation of the San Jacinto River water surface. Groundwater movement in the shallow alluvium in the Site area is dominated by surface water/groundwater interactions with the river, which surrounds the former impoundments. In regions such as the Site area (i.e., shallow water table, relatively flat topography), groundwater discharges to surface water bodies (Fetter 1994; Freeze and Cherry 1979). This reach of the San Jacinto River watershed is characterized by extremely flat groundwater gradients indicating that the area surrounding the Site is an area of minimal recharge to the aquifers (see Figure 2-9). The Beaumont Formation under the Site is a confining unit that isolates shallow groundwater in the Holocene alluvium and in the San Jacinto River sediments from the underlying formations of the Chicot Aquifer. This presence of the Beaumont Formation underlying the alluvium is shown on the fence diagram in Figure 2-7, and in Appendix F.

There are three groundwater wells near the east bank of the San Jacinto River that are within approximately 3,000 feet of the impoundments (Figure 2-6, Table 2-2). The Harris County WCID 1 (#6516506) well penetrates the Lower Chicot Aquifer at a depth of 537 feet (elevation -497 feet MSL) and is approximately 1,000 feet due east of the former impoundments. A well owned by C. Fitzgerald (#6516812) penetrates the Upper Chicot Aquifer at a depth of 125 feet (elevation -95 MSL) and is approximately 1,900 feet southeast of the former impoundments. A well owned by Vahlco Corp (#6516811) penetrates the Lower Chicot Aquifer at a depth of 530 feet (elevation -94 MSL) and is approximately 3,500 feet south of the former impoundments.

Table 2-2
Registered TWDB Groundwater Wells Near The Site

TWDB Well Number	Owner	Top of Well Elevation (feet)	Well Depth (feet)	Aquifer
6516506	Harris County WCID 1	40	537	Lower Chicot
6516811	Vahlco Corp	32	350	Lower Chicot
6516812	C. Fitzgerald	30	125	Upper Chicot

Given that these potable water wells are screened within or below the Beaumont formation, it is expected that their water quality would be different than the relatively brackish, non-potable shallow groundwater adjacent to the river and potentially influenced by the San Jacinto River. Since the San Jacinto River is in a tidal estuary, the river water has a very high natural salt content and total dissolved solids, which should be reflected in shallow groundwater near the former impoundments. Figures 2-10 and 2-11 depict water quality data from wells 6516811 and 6516812, collected in 1972 (TWDB 2010), screened in the Lower Chicot, and water quality data from the San Jacinto River. Note, that these well completion data from 1972 are the only publicly available data for these wells. The data shown for the San Jacinto River is an average of all data collected in 2009 from station 11193 (HGAC 2010) as river data does not exist from 1972 when the wells were sampled. The data are presented on a Stiff diagram (Figure 2-10) and Piper diagram (Figure 2-11). These are

commonly used graphical presentations for water quality data used to determine water source similarities and differences by comparing concentrations of common cations and anions. The signature of the San Jacinto River water is markedly different than the two monitoring wells on both the Stiff diagram and Piper diagram, indicating two distinct water sources and that the Beaumont Formation effectively isolates the Chicot Aquifer from recharge from shallow groundwater in the Site vicinity. Because the depth of the channel of the San Jacinto River is deeper than the depth of the base of the impoundments, it can be assumed that the Beaumont Formation not only acts as an aquitard that keeps saline surface water from infiltrating into potable water supplies in the Chicot, but that the Beaumont also is an effective aquitard to saline shallow groundwater surrounding the Site.

Given the above described local hydrogeology, water quality analysis and regional recharge considerations, it is unlikely that shallow groundwater in general, or any Site related contaminants of concern specifically would affect local wells. In order for shallow groundwater near the Site to affect local wells in the Chicot Aquifer, groundwater from the Site alluvial sediments would have to overcome significant surface water/groundwater interactive forces, penetrate up to approximately 20 feet of Beaumont Formation clay and silt, which has been shown to confine the Chicot aquifer in the region by the USGS (2002), and flow under the San Jacinto River to reach these wells—a very unlikely scenario. No data are available to demonstrate that either these three wells or any other public water supply wells have been impacted or are threatened by Site related contaminants. Finally, the main Site COPCs, dioxins/furans, strongly adsorb to soil particles and are believed to be virtually immobile in the subsurface (Fan et. al. 2006; USAF 2006; ATSDR 1998), further decreasing the likelihood of contaminant transport by groundwater from the Site to these distant wells. ATSDR (1998) indicates that chlorinated dibenzo-p-dioxins (CDDs) "…bind strongly to the soil, and therefore are not likely to contaminate groundwater…" and "CDDs are unlikely to leach to underlying groundwater…"

2.2.9 Surface Water Use

South of the dam at Lake Houston, the San Jacinto River, including the area surrounding the Site, is tidally influenced. The area south of the Site is dominated by the Houston Ship Channel and the industrial sites that are served by the barges and ocean going vessels that

use the channel. From the preliminary Site perimeter north to Lake Houston there is much less industrialization along the river because the Houston Ship Channel turns west south of the Site. The water quality segments upstream and downstream of the Site include the following uses (listed in Table 2-3): aquatic life, general, recreation and restricted fish consumption. The river segments of interest are segments 1001 and 1005. River segment 1001, which includes the study area, begins at a point 100 meters downstream from the I-10 Bridge and continues north until reaching Lake Houston. Segment 1005 begins at the same point below the I-10 Bridge and continues downstream to the confluence with Galveston bay at Morgan's Point. Fish consumption in the San Jacinto River, both up and downstream of the Site is restricted, due to the elevated concentrations of polychlorinated biphenyls (PCBs) and dioxins and furans found in fish and crab tissue (TCEQ 2010). Detailed descriptions of all restrictions in segment 1001 of the San Jacinto River are provided in detail online (http://www.tceq.state.tx.us/compliance/monitoring/water/quality/data/wqm/305_303.html#fy2010) and are posted on signs at locations along the river. In all but one of the segments, the river is considered suitable for aquatic life and recreation. This unsuitable area is located in the Houston Ship Channel after it turns west from the San Jacinto River and is likely the result of the heavy industrialization and vessel traffic along this portion. The remaining water quality segments are deemed suitable for these activities.

Lynchburg Reservoir, located on the east bank of the San Jacinto River just south of the I-10 Bridge, uses off-channel water from the San Jacinto River in Harris County, Texas. It is owned by the City of Houston, and construction was completed in 1976. At normal levels the lake has a surface area of 200 acres. The lake dam is earthen construction, with a height of 35 feet and a length of 15,315 feet. The lake capacity is 5,188 acre feet; however, normal storage is 4,700 acre feet. The lake drains an area of 0.32 square miles. Lost Lake (located south of I-10 between the primary channel of the San Jacinto River and the Old Channel to the west) is not a surface water reservoir; rather, it is a confined disposal facility for sediments from the Houston Ship Channel maintenance dredging program. It is managed by the Port of Houston Authority and USACE, Galveston District.

Table 2-3
San Jacinto River/Houston Ship Channel Water Quality Segments

Stream Segment	Segment Name	Location	Aquatic Life	Recreation	Fish Consumption	General
1001	San Jacinto River Tidal	Upstream	A	A	R	A
1005	Houston Ship Channel/San Jacinto River Tidal	Downstream	A	A	R	R

A = Approved R = Restricted

2.2.10 Hydrography

Flow rates in the San Jacinto River in the vicinity of the Site are partially controlled by the Lake Houston dam, which is located about 28 miles upstream of the waste impoundments. The average flow in the river is 2,200 cubic feet per second (cfs). Floods in the river primarily occur during tropical storms (e.g., hurricanes) or intense thunderstorms. Extreme flood events have flow rates of 200,000 cfs or greater. The October 1994 flood had a peak discharge of 360,000 cfs, which has a return period of greater than 100 years. River stage height during the October 1994 had a maximum value of 27 feet above MSL.

The river in the vicinity of the waste impoundments is affected by diurnal tides, with a typical tidal range of 1 to 2 feet. Tidal range varies over a 14-day cycle, with neap and spring tide conditions corresponding to minimum and maximum tidal ranges, respectively. Tropical storms and wind storms from the north can have significant effects on water levels at the Site. Tropical storms can cause storm surges with water levels that are significantly higher than typical tidal elevations. Storms with strong winds from the north can cause water to be transported out of the Galveston Bay system which can result in water levels that are much lower than low tide elevations.

Salinity in the vicinity of the waste impoundments generally ranges between 10 and 20 parts per thousand during low to moderate flow conditions in the river. During floods, salinity values will approach freshwater conditions.

2.2.11 Sediment Physical Characteristics

Four distinct types of sediment particles are found in the sediment bed: 1) clay (particle diameter less than 2 microns); 2) silt (particle diameter 2 to 62 microns); 3) sand (particle diameter 62 to 2,000 microns); and 4) gravel (particle diameter greater than 2,000 microns). The sediment bed is composed of varying amounts of clay, silt, sand, and gravel. Within the unconsolidated sediments in the Site area (Section 2.2.5), the sediment bed may be separated into two distinct categories (or bed types): 1) non-cohesive; and 2) cohesive. A non-cohesive bed is primarily composed of sand and gravel, with relatively small amounts of clay and silt. Non-cohesive (sandy) bed areas are usually found in locations with relatively high hydrodynamic energy, such as the main channel of the river. A cohesive bed is primarily composed of clay, silt, and fine sand (62 to 250 microns), with relatively small amounts of coarse sand and gravel. Cohesive (muddy) bed areas generally occur in locations with relatively low hydrodynamic energy, such as shallower areas that are adjacent to the main channel.

2.2.12 Sediment Transport

Sediment is transported in the San Jacinto River, and within the vicinity of the waste impoundments, by two modes: 1) bed load; and 2) suspended load. Typically, bed load transport is relatively small when compared to suspended load transport. In addition, bed load transport will generally be limited to non-cohesive bed areas within the main channel.

A portion of the sediment transported down the San Jacinto River will be deposited within the area of the Site, due to a widening of the channel and dispersal of sediment into the shallower areas adjacent to the channel. Due to relatively high flow rates in the river during floods, a large majority of the annual sediment load is transported during a small number of floods each year. This process will result in episodic deposition during floods (i.e., a layer of sandy or muddy sediment being deposited) at various locations within the area of the Site. Due to increased current velocities during floods, bed scour may also occur at some locations in the Site area during these events.

2.3 Chemical Setting

There are currently several data sets available to describe chemical contamination in the environment at the Site and in the nearby area; the available data that will be used to define the baseline condition are summarized in Table 2-4. Determination of whether any of these data sets can be used to describe the baseline condition at the Site will be made using results of sediment sampling, as described in the Sediment Sap. This section describes the existing chemical conditions in the vicinity of the Site using the available data for the following media:

- Surface water
- Sediment
- Biological tissue

In addition, several studies have been conducted in the local area, which provide important context and insights on contaminants in the environment in the vicinity of the Site:

- Louchouarn and Brinkmeyer (2009)
- Houston Ship Channel toxicity study (ENSR and EHA 1995)
- Frank et al. (2001)
- Texas Department of State Health Services (TDSHS) fish consumption advisories

Data for these studies were either not available for the RI/FS scoping process, or were collected prior to 2000. The sections below summarize the available information, including some data analyses.

2.3.1 Soil

There are currently no chemistry data for soils collected from the Site.

2.3.2 Sediment

The preliminary Site perimeter identified in the 2009 UAO is within the estuarine portion of the lower San Jacinto River, in an area from which sediments have previously been sampled for several studies (Table 2-4 and Figure 2-12). The studies or programs providing sediment

chemistry data that addresses the objectives of one or more study elements for the RI/FS include the following:

- The Screening Site Inspection Report (TCEQ and USEPA 2006)
- Sampling for the I-10 dolphin project (Weston 2006)
- The Houston Ship Channel dioxin Total Maximum Daily Load (TMDL) study (University of Houston and Parsons 2006)
- Samples collected for Texas Commission on Environmental Quality (TCEQ) in August 2009 (URS 2010)
- Data generated by the November 1, 2009, Permit Evaluation Process initiated by USEPA, USACE, and TCEQ, and managed by TCEQ (USEPA et al. 2009); this currently includes a data set for one permit application (Orion 2009)
- The Houston Ship Channel Toxicity Study (ENSR and EHA 1995)
- The Houston Ship Channel PCBs TMDL study (University of Houston and Parsons 2009; Koenig 2010, pers. comm.)

Within the preliminary Site perimeter, surface sediment samples have been collected from 50 locations, and sediment cores have been collected from five locations for the studies listed above (Table 2-5 and Figure 2-12). In some cases, a location was sampled more than once, so more than 50 individual surface sediment samples are represented in the database. Nine of the surface sediment sample locations are within the impoundments, and an additional five are in their immediate vicinity. The highest spatial density of samples within the preliminary Site perimeter is in and adjacent to the impoundments and adjacent to the I-10 Bridge (Figures 2-12 and 2-13). Sediment samples collected within the Site upstream of the impoundments are approximately 1,000 feet (305 m) apart. Under or downstream of the I-10 Bridge, 25 samples were collected, but 16 of these are not within the preliminary Site perimeter and 15 are closely spaced around the Sneed Shipbuilding facility. Louchouarn and Brinkmeyer (2009) also collected samples for analysis of dioxins and furans and organic carbons (OC) in one surface grab sediment sample, and in one 1-m (3-foot) core from within the impoundments and sectioned at 2-cm (0.8-inch) intervals, but these data could not be accessed in time for this evaluation.

Surface sediment chemistry samples from 45 of the Site locations and all of the cores were collected in 2000 or later (Table 2-4). All of these samples were analyzed for dioxins and

furans; metals and other chemicals were also analyzed in sediment from 17 surface and four subsurface locations within the Site, and in surface sediments at five locations nearby but outside the Site (Table 2-5). Data for pesticides, PCBs, and many SVOCs in surface sediments were generated by TCEQ and USEPA (2006), University of Houston and Parsons (2009), Koenig (2010, pers. comm.), and by Weston (2006) (Table 2-5). In most of these samples, none of these chemicals (other than dioxins, furans, and metals) were detected, with very few exceptions. PCBs were measured as Aroclors by Weston (2006) and as congeners by the TMDL program (University of Houston and Parsons 2009, and Koenig 2010 (pers. comm.). PCBs were not detected in any of the samples collected by Weston (2006), which were from the vicinity of the I-10 Bridge downstream of the impoundments. Individual congeners were detected in the sediment samples collected in 2002, 2003, 2008, and 2009 by the TMDL program at a location (station 11193) downstream of the impoundments and of the I-10 Bridge.

Upstream sediments in the San Jacinto River have likely influenced sediment conditions within the Site and can be expected to continue to influence them in the future[2]. Available sediment data for the area upstream of the Site indicates that there are dioxins and furans present in sediments upstream (University of Houston and Parsons 2006). TCEQ's TMDL data also indicated that the TEQ concentrations in the tidally influenced embayment upstream of the Site are higher than those further upstream in the freshwater portion of the river.

TCEQ has investigated several possible sources of dioxins in this upstream area (University of Houston and Parsons 2006), including a both city and county wastewater treatment facilities, and found dioxins in both sludges and wastewaters. In addition, in October 1994, two petroleum pipelines ruptured during a flood of the San Jacinto River, igniting a fire that impacted over 186 acres of riparian habitat and shoreline areas (http://www.fws.gov/southwest/es/contaminants/NRDAR/SiteInformation/Texas/SanJac.pdf). Therefore, upstream background areas near the Site do not reflect a pristine or natural condition. Nevertheless, measurements of regional background conditions in sediments from

[2] Methods for evaluation and modeling of sediment transport between the Site and areas upstream and downstream will be addressed in a Technical Memorandum on Fate and Transport Modeling, as discussed in Section 6.1.5. The memorandum will be submitted according to the schedule in Section 8.

the San Jacinto River estuary are relevant to interpreting data from the Site and selecting appropriate remedial actions, if required.

Sediment samples were also collected from 26 locations near the Site (two locations are not shown on Figures 2-12 and 2-13 because they are farther upstream than the extent of this map. All but two of these locations were sampled in 2000 or later (Table 2-4). All of these samples were analyzed for dioxins and furans. Metals and other chemicals were measured in five of them (Table 2-5). Finally, one data set was generated for USEPA et al. (2009), but it does not provide concentrations of individual dioxin and furan congeners. This data is not included in this discussion because toxicity equivalent (TEQ) concentrations were calculated using a 1989 toxicity equivalency factor (TEF) scheme, and the dioxin and furan congener data were not available in time for this evaluation. These samples were collected at a facility directly east of the Sneed Shipbuilding site (Orion 2009).

2.3.3 Groundwater

There are currently no chemistry data for groundwater collected from the Site.

2.3.4 Surface Water

Two studies have generated surface water chemistry data for the Site:

- Houston Ship Channel dioxin TMDL study (University of Houston and Parsons 2006)
- Samples collected by TCEQ in August 2009 (TCEQ 2009)

The TMDL study collected nine surface water samples from one location within the preliminary Site perimeter on six different dates from 2002 through 2004. Dissolved dioxins and furans were measured in these samples. TCEQ collected three surface water samples from two locations within the preliminary Site perimeter in 2009 (Figure 2-14). Total (unfiltered) dioxins and furans were measured in these samples.

Within the most recent data set (TCEQ 2009) only one of the seven dioxin congeners (2,3,7,8-TCDD) was detected in any water sample, and it was detected in all three of them. Seven of the 10 furan congeners in this data set were detected (Table 2-8). Concentrations of both 2,3,7,8-TCDD and TCDF (the furan congener present at highest concentration) were

higher in water samples at location TCEQ2009_01 than in the sample in the eastern portion of the impoundment (Table 2-9). Based on the coordinates and the description in the field notes, location TCEQ2009_01 is on the vegetated portion of the impounded area rather than in the San Jacinto River.

Within the earlier data set (dissolved data during 2002 to 2004), octachlorodibenzo-*p*-dioxin was consistently detected and present at concentrations higher than all other dioxin and furan congeners. Tetra- and octachlorodibenzofuran were the only other congeners that were consistently detected.

Upstream water samples were collected from three locations during 2002 to 2004 by the TMDL study (Table 2-10, Figure 2-15). Upstream concentrations of dissolved 2,3,7,8-TCDD and TCDF during the 2002 to 2004 period were lower than those measured within the Site during the same time period, but equivalent in magnitude to the concentrations of total 2,3,7,8 -TCDD and TCDF measured in the impoundment in 2009 (Tables 2-9 and 2-10).

2.3.5 Air

There are currently no chemistry data for air samples collected from the Site; however, dioxin and furan data were collected in the Houston Ship Channel TMDL study (University of Houston and Parsons 2006).

As part of the TMDL study, an air monitoring program was implemented to assess dioxin and furan loading via ambient air the Houston area. A total of five air monitoring stations were used, representing differing ambient air conditions in the city (i.e., rural, semi-rural, urban, commercial, industrial). The program was conducted between September 2002 and May 2006, and consisted of monthly, bi-monthly and 11-month sampling events. The length of the study was required due to the ultra trace levels of dioxins and furans in ambient air. During the sampling period, data were collected using high volume samplers (ambient air), precipitation collectors fitted with resin columns (wet/dry and bulk deposition) and total suspended particulate samplers (particle size distribution). All samples were collected by University of Houston personnel. Table 2-11 summarizes the sampling events.

The ambient air, particle size distribution, and dry deposition samples were analyzed by USEPA Method TO-9A (1999) using high-resolution gas chromatography/high-resolution mass spectrometry (HRGC/HRMS) equipment. Resin columns were analyzed using USEPA Method 1613B (1994).

The TMDL study was conducted in accordance with the QAPP approved for that project. The air sampling data were subjected to quality control/quality assurance (QC/QA) assessment for accuracy, precision, reproducibility and completeness. Section 3.2.5 discusses the TMDL study air data quality and usability.

Air monitoring data from ambient, particle size distribution and atmospheric deposition are provided in Tables 2-5 to 2-10 in the TMDL report (University of Houston and Parsons 2006) and are summarized as:

- Ambient air
  - All dioxin and furan congeners were detected in ambient air samples, ranging from non detected to 1,718 femtograms (fg)/m^3
  - 2,3,7,8-TCDD was detected at concentrations up to 2 fg/m^3
  - The most elevated samples from the sampling location is in an industrial area
  - On an annual basis (September 2002 to August 2003), the annual mean concentration was found to be 12 +/- 8 fg Texas-TEQ/m^3
- Particle size distribution
  - Increased toxicity values were correlated with the smallest particle sizes
  - About 86 percent of the Texas-TEQ concentration was associated with particles less than 0.95 microns
- Atmospheric deposition
  - Dry deposition flux was measured between 1 and 4 picograms (pg) Texas-TEQ/m^2day
  - 2,3,7,8-TCDD was not detected in dry deposition samples
  - Wet deposition flux varied between 10 and 23 Texas-TEQ/m^2day
  - 2,3,7,8-TCDD contributed approximately 2 percent flux

  - Comparisons between wet and dry deposition data indicated precipitation removed "a relatively significant amount of atmospheric dioxins"

- Major findings of data analysis
  - Peak dioxin and furan concentrations in ambient air were observed in cold months (i.e., December to March)
  - Comparison of data from industrial settings and commercial/residential settings near major highways yielded no significant difference. Section 6.4.2 of University of Houston and Parsons (2006, p. 188) compares air quality between residential and industrial areas, and their finding suggest that "traffic is a potential significant source of dioxins in the Houston area."
  - Dioxin and furan concentrations were found to negatively correlate with ozone and relative humidity, and positively with NO_x

2.3.6 Biological Tissue

The studies or programs that have collected tissue chemistry data within the area of the Site include:

- Houston Ship Channel toxicity study (ENSR and EHA 1995)
- Houston Ship Channel dioxin TMDL study (University of Houston and Parsons 2006)
- Samples collected by TDSHS for the fish consumption advisory program (TDSHS 2007)

Some of these data were collected prior to 2000: (ENSR and EHA 1995). The data collected in 2002, 2003, and 2004 by the University of Houston and Parsons (2006) and in 2004 by TDSHS (2007) represent recent conditions. This subset of data includes two sampling locations within the Site boundary and three sampling locations within the nearby area upstream of the Site (Figure 2-15). All samples were analyzed as edible tissue. No analyses have been conducted on whole organisms. There are currently no tissue data within the nearby areas downstream of the Site.

Within the preliminary Site perimeter, TDSHS collected fillets from blue catfish, hybrid striped bass, red drum, spotted seatrout, and edible tissue from blue crab, from one location. These samples were analyzed for metals, dioxins and furans, VOCs, SVOCs, PCBs, and

pesticides. Detection frequencies for these samples and summary statistics for analytes are shown in Table 2-12. In general, only inorganic analytes, dioxins and furans, and a few pesticides were detected in these samples. PCBs (as Aroclor 1260) were detected in only one sample (blue catfish fillet) from the Site.

From the three upstream sampling locations, the TMDL program collected edible tissue from blue catfish, hardhead catfish, shad, and blue crab between 2002 and 2004. Blue catfish and blue crab were collected throughout this period, shad were collected only in 2002, and hardhead catfish were collected only in 2004. These samples were analyzed for dioxins and furans, PCBs, and pesticides (PCBs and pesticides were measured only in 2002). Detection frequencies for these samples and analytes are shown in Table 2-13.

2.3.7 Other Studies

Studies summarized below provide Site-specific or regional information of potential use or importance in scoping the RI/FS.

2.3.7.1 Louchouarn and Brinkmeyer (2009)

The results from the first of a four phase study on dioxins in the Houston Ship Channel and Galveston Bay system are provided by Louchouarn and Brinkmeyer (2009). The objectives of Phase 1 included evaluating possible remobilization of contaminated particles from the Site impoundments to the Houston Ship Channel and calculating porewater concentrations (through the use of different partitioning models) to estimate the sorption capacity of sediments in the impoundment. To meet these objectives, a sediment core was collected in 2006 from the submerged section of the waste impoundments (i.e., eastern side of the impoundments). The sediments from the core and archived sediment samples (from previous sampling events) were analyzed for dioxins and furans, organic and black carbon, polycyclic aromatic hydrocarbons (PAHs), and lignin-derived oxidation by-products.

By comparing the dioxin and furan fingerprints in the core to the archived sediments collected elsewhere in the Houston Ship Channel and to reference area sediments, Louchouarn and Brinkmeyer (2009) concluded that remobilization of contaminated sediment was limited to areas within close proximity to the impoundments and that contaminated

sediments from the Site have not been mobilized and distributed throughout the system. On the basis of estimated porewater concentrations, Louchouarn and Brinkmeyer (2009) also concluded that dioxins could bioaccumulate, and that affected biota could transport dioxins away from the Site. However, the report states that "all though this work is based on empirical sorption coefficients that are relevant to the environment of study, accurate porewater concentrations (and thus bioaccumulation potential) need to be measured directly before any meaningful risk assessment and remediation strategy are to be devised."

Louchouarn and Brinkmeyer (2009) stated that although there are relatively high total organic carbon (TOC) and black carbon contents in the waste impoundment sediments, the mass of dioxin and furan compounds seems to exceed the sorption capacity of the sediment TOC, according to the partitioning model used. Their partitioning models do not account for partitioning to other sediment components such as clays. In other parts of the Houston Ship Channel system, they estimate that TOC and black carbon contents in the sediment are sufficient to sorb the dioxins present.

Louchouarn and Brinkmeyer (2009) also address sediment remediation options and note that there has been no statistically significant reduction in sediment dioxin concentrations in areas that have been dredged. They conclude that in situ microbial remediation of dioxins in the Houston Ship Channel and Galveston Bay system would be preferable to other remedial alternatives (e.g., dredging), which would result in dispersal of dioxin-contaminated sediments throughout the system, stating: "[f]rom both fiscal and environmental perspectives, in situ microbial remediation of dioxins in the [Houston Ship Channel] and [Galveston Bay] is preferable to alternatives, including the removal of contaminated sediments to landfills…Moreover, dredging of highly contaminated areas, such as the San Jacinto Waste Pits, may result in rapid dispersal of dioxins throughout Galveston Bay." (pp. 5-6).

2.3.7.2 Houston Ship Channel Toxicity Study (ENSR and EHA 1995)

A study of contamination and toxicity in the Houston Ship Channel, with particular focus on side bays and tidal tributaries, was undertaken in the mid-1990s. The study was designed to address recommendations generated during an earlier USEPA study that focused largely on

the main Houston Ship Channel. A detailed water, sediment, and fish and crab sampling strategy was employed to characterize chemical concentrations and toxicity in the Houston Ship Channel and its bays and tributaries, and the temporal variability in these parameters across summer low-flow, winter low-flow, and wet weather conditions. Samples were collected from stations located in the upper, middle, and lower portion of bays and tributaries, and from stations along the main Houston Ship Channel. Water samples were collected at a uniform depth of 1 m. Sediment grab samples were collected from the center of each channel and from two locations equidistant between each bank and the center of the channel. Duplicate water and sediment samples were collected to assess sampling variability.

Water and sediment samples were collected from 35 stations during summer low-flow conditions. Samples from a five-station subset were collected at two-month intervals to assess temporal variability in contaminant levels and toxicity. Following evaluation of temporal variability using the summer low flow data, water and sediment samples from a subset of 11 selected stations were collected during winter low flow conditions; fish and crabs were also collected from a six-station subset. To evaluate the effect of wet weather on chemical concentrations and toxicity, water and sediment samples from ten stations were collected following heavy rainfall. Each subset included stations in the Houston Ship Channel and stations in representative bays and tributaries. Additional water and sediment samples were collected from seven stations for focused evaluation of dioxins and furans. Fish, crab, water, and sediment samples were collected from one station within the preliminary Site perimeter, one station upstream of the Site, and one downstream of the Site.

Water (dissolved and particulate fractions), sediment, and edible tissues from fish and crabs were evaluated for levels of numerous contaminants, including metals, SVOCs and VOCs, pesticides, PCBs, and dioxins and furans. Observed contaminant levels were compared with standards, screening values, or other criteria to identify chemicals present at high concentrations. In addition, toxicity of water and sediment samples to invertebrate species was evaluated. Chemical analyses and toxicity tests were conducted according to standard methods using appropriate positive, negative, and/or reference controls.

In water, concentrations of most chemicals evaluated were not unacceptably high, and toxicity to invertebrates was observed in a small proportion of sediment and water samples.

One exception to this generalization was the relatively high total mercury in particulate matter from water samples collected during wet weather conditions. Phthalates, chloroform, trichloroethane, and copper were also detected at relatively elevated levels. Several pesticides, including DDD, DDT, and lindane, were elevated in summer low-flow samples from a small proportion of stations. Water samples from two stations were toxic to mysid shrimp (*Mysidopsis bahia*) over a 7-day exposure period, as evidenced by decreased survival; these stations were not among those on or near the Site. Decreased survival was not observed for inland silversides (*Menidia beryllina*), although growth was reduced in water samples from two different stations. The study did not explore the causes of the observed effects.

Similarly, contaminants evaluated in sediment samples were generally not elevated, with some exceptions, notably tributyltin, which was considered elevated in all sediment samples. Dioxins and furans, expressed as TEQs, in sediment were highly variable and ranged from 0.57 to 409 ng/kg. The highest calculated sediment TEQs occurred in samples from stations in the Houston Ship Channel downstream of a wastewater treatment facility and an industrial outfall. Survival of an amphipod crustacean (*Ampelisca abdita*) over a 10-day exposure period was lower in sediment samples from most stations collected during summer low-flow conditions; authors concluded that this effect was likely a consequence of anoxia. Decreased survival was noted in sediment samples from three stations during winter low-flow conditions. Mysid (*Mysidopsis bahia*) survival was reduced in sediment samples collected during both summer and winter low-flow conditions relative to controls. The sediments collected from on the Site during winter low-flow conditions showed toxicity to mysids.

Arsenic was elevated in edible fish tissue from three stations within the main Houston Ship Channel, but not in edible crab tissue. Catfish from two stations had elevated levels of Aroclor 1260 and chrysene. Dioxins and furans were detected in fish and crab samples from several stations: calculated TEQs for blue catfish ranged from 0.02 to 2.31 ng/kg, for hardhead catfish ranged from 2.51 to 5.01 ng/kg, and for crab ranged from 0.14 to 5.54 ng/kg. No fish or crab deformities definitively attributable to toxin exposure were noted upon macroscopic examination.

2.3.7.3 Frank et al. (2001)

Frank et al. (2001) evaluated concentrations of multiple persistent organic pollutants in waterbird eggs in the Galveston Bay area. Several chemicals considered persistent by the authors, including dioxins and furans and PCBs, had been detected in fish and other organisms in this area, prompting this analysis of their concentrations in birds and an evaluation of potential adverse effects on birds. In addition to several areas sampled within Galveston Bay, two reference areas were included for comparison of levels of chemicals in eggs and adverse health effects. Alexander Island was the sampling location closest to the Site.

Eggs were collected from three bird species: neotropic cormorants (n = 28 eggs from four sites; n = 18 eggs from two reference sites), black-crowned night herons (n = 9 eggs from one site), and great egrets (n = 7 eggs from one site). Eggs evaluated from the two reference areas were from cormorants only. The collected eggs were evaluated for concentrations of pesticides, dioxin-like and non dioxin-like PCBs, and dioxins and furans using GC/MS. Egg extracts were evaluated for aryl hydrocarbon receptor (AhR) activity relative to that of TCDD, using a bioassay with rat hepatoma cells expressing an AhR-luciferase construct. TEQs were calculated both by the sum of TEF-weighted congener concentrations for each individual chemical and also on the basis of relative AhR-activating activity and the two types of TEQ estimates were compared. However, the authors did not specify whether TEF for mammals or birds were used for the calculated TEQ. Eggs were also examined for developmental abnormalities.

Total PCB concentrations were significantly greater ($p<0.05$) in cormorant eggs from the Alexander Island and Vingt-et-un test areas relative to control area cormorant eggs and were present at levels that may have an adverse effect on reproduction. In contrast, total PCBs in cormorant eggs from the Smith Point and Rollover Pass test areas and in heron and egret eggs from the Alexander Island test area were not significantly elevated relative to reference area egg values. PCB-153, PCB-138, PCB-180, and PCB-118 were the most common congeners detected in eggs from all three species. Statistical evaluation to compare concentrations of individual congeners was not conducted.

DDE and hexachlorobenzene (HCB) were detected in eggs from all three species in the test areas and in cormorant eggs from the reference areas. HCB was significantly elevated in cormorant eggs from Alexander Island relative to either reference area. DDE was not significantly elevated in eggs from any species or test area relative to either reference area. HCB, DDE, and total PCBs were greater in cormorant eggs from Alexander Island relative to heron and egret eggs from the same area, which are attributed by the authors to differences in diet.

Dioxin and furan, non-*ortho*-PCB, and mono-*ortho*-PCB congener concentrations were evaluated in a subset of the originally collected eggs, consisting of a total of eight cormorant eggs from three test areas, one reference cormorant egg, three test heron eggs, and three test egret eggs. Extracts from these eggs were also evaluated for AhR-activating activity using the rat hepatoma cell luciferase assay. TCDD was detected in all eggs except for the reference cormorant egg; the range was 7 to 179 pg/g wet weight. Two additional dioxin congeners, PeCDD and HxCDD, were detected in one test heron egg at concentrations of 25 and 26 pg/g wet weight, respectively. TCDF was detected in all three test heron eggs but not in cormorant or egret eggs; TCDF concentrations ranged from 6 to 12 pg/g wet weight. TCDD concentrations observed in heron and cormorant eggs were below the concentration considered by the authors to be the threshold of adverse effects in birds. However, since there are marked species differences in susceptibility to TCDD, the potential impact of these TCDD concentrations is uncertain.

In general, non-*ortho*- and mono-*ortho* PCB congeners were present in test area eggs in much greater concentrations than TCDD (3 to 4 orders of magnitude difference). Of the non-*ortho* (i.e., dioxin-like) congeners, PCB-126 was present at the highest concentration in eggs from all three species. Instrumental TEQs calculated by congener concentration analysis were in general about 30 percent greater than those obtained through the rat hepatoma cell luciferase assay, suggesting that *in vitro* activities of tissue extracts may be less than predicted by calculation of potential AhR activity using TEFs. Calculated TEQs were significantly correlated with TEQ activity measured by the bioassay. Instrumental TEQs from test area birds ranged from 136 to 452 pg/g compared to a TEQ of 67 pg/g for the single reference area cormorant egg. PCB-126 contributed the most to total calculated TEQs: PCB-126 contributed from 46 to 91 percent of the TEQ in eggs, while TCDD contributed 26 to 51

percent of calculated TEQs. The authors concluded that PCB-126 presents a greater threat to wildlife than TCDD.

2.3.7.4 Dean et al. (2009)

This study presents investigations of the relationship of dioxins and furans in water and sediment to concentrations in catfish and crab tissue using structural equation modeling (SEM) based on the assumptions of equilibrium partitioning (EqP) theory. The data used were generated by the TCEQ TMDL program and are among those data summarized in Section 2.3.2. Samples of hardhead catfish (*Ariopsis felis* L.) fillet and blue crab (*Callinectes sapidus* Rathbun) edible tissue were collected at 45 locations throughout the Houston Ship Channel from 2002 to 2004 during spring, summer, and fall. Surface sediment (0 to 5 cm) grab samples and high volume water samples were also collected at the same sites, resulting in a total of 108 synoptic hardhead catfish, sediment, and water samples, and 155 synoptic samples of each medium with blue crab. All analyses in this study were performed using tissue and sediment (and/or water) samples uniquely paired by location and date. The authors discuss the uncertainties and limitations of this approach (pairing mobile organisms to point samples of sediment and water chemistry), recognizing that grab samples of sediment and water from fixed locations may not accurately reflect exposures of mobile organisms, which is likely variable in both space and time.

Bioaccumulation factors (BAFs) and biota–sediment accumulation factors (BSAFs) were calculated as the median of the ratios of lipid-normalized tissue to water and sediment concentrations, respectively. The authors acknowledge the weaknesses of this approach, particularly because dioxin and furan concentrations in tissue were found to be only weakly correlated to lipid levels. They also acknowledge that the use of lipid normalization may be inappropriate. The values of log BAFs for individual congeners varied from 4.41 to 7.03, while those for log BSAF were all negative (–3.19 to –0.41). Given these results, the authors propose that metabolism limits the bioaccumulation of furans in both hardhead catfish and blue crab.

Dean et al. (2009) used SEM as an alternative to BAFs and BSAFs to investigate potential drivers of dioxin and furan tissue loads in addition to water and sediment concentrations.

Other parameters explored in the SEM analysis were sediment TOC, tissue lipid content, seasonality, air temperature, fish length, and weight. The results of SEM suggested that sediment chemistry contributed slightly more explanatory power than water to the overall fraction of variance of tissue concentrations explained by each model. The authors concluded that a large percentage (40 to 88 percent) of variation in bioaccumulation remains unexplained by the data and methods they used, and hypothesized that biotransformation may be the driving process governing concentrations of dioxins and furans in fish and crab tissue.

2.3.7.5 Fish Consumption Advisories

TDSHS routinely samples edible tissues of fish and crabs from several locations in Galveston Bay and the Houston Ship Channel vicinity. The agency has published several reports that provide both chemical data for edible fish and crab tissue, and an evaluation of human health risks, which provides the basis for their advisories. Related to these reports, three fish and shellfish consumption advisories have been issued by TDSHS that cover waters within the Site boundaries. Once issued, TDSHS advisories are periodically reevaluated based on new monitoring data. A chronological summary of the advisories, reevaluations, and associated risk characterization reports applicable to Site waters is provided in Table 2-14, and is summarized below.

The first advisory for this area, ADV-3 (TDH 1990), was issued in 1990 based on concerns over dioxins in catfish and blue crabs. This advisory was re-evaluated in subsequent years based on new monitoring data and continues to be in effect today. In addition, in 2001, ADV-3 was augmented by a new advisory, ADV-20 (TDH 2001b), also covering waters within the Site. ADV-20 addressed health concerns related to consumption of all species of finfish due to the presence of elevated concentrations of pesticides and PCBs. Both advisories recommend that adults eat no more than one 8-ounce meal each month from the advisory area and suggest that women of childbearing age and children not consume catfish or blue crabs from the advisory areas. In 2005, an additional advisory, ADV-28 (TDSHS 2005b), was issued for spotted seatrout from these waters due to concerns about PCBs, pesticides, and dioxins. This advisory recommends that adults limit consumption of spotted seatrout from the advisory area to no more than one 8-ounce meal per month and that

women who are nursing, pregnant, or may become pregnant, and children should not consume spotted seatrout from these waters.

2.3.7.6 Summary

Several reports providing Site-related data and interpretation in addition to the raw data available in the database are available and provide information useful to scoping the RI/FS. Conclusions and information derived from these studies include the following:

- Sediments collected from within the impoundments were contaminated with dioxins and furans, and the fingerprint of the mixture was distinct from those in sediments collected from elsewhere in the Houston Ship Channel, including stations fairly nearby and downstream. On the basis of initial fingerprinting and comparisons with dioxin and furan fingerprints at other stations, the authors conclude that "the remobilization of contaminated particles does not occur beyond the close vicinity of the pit itself" (Louchouarn and Brinkmeyer 2009, page 12). The sediments in the impoundments also contained relatively high TOC, which binds dioxins and furans, but the TOC is not sufficient to bind all the mass of the dioxin and furans in the sediments from the impoundments (Louchouarn and Brinkmeyer 2009).
- Eggs of wading and diving piscivorous birds from the Galveston Bay area are contaminated with several industrial chemicals, including pesticides, PCBs, and dioxins and furans, to levels greater than those in eggs from reference areas. PCBs contribute the greatest fraction of dioxin-like toxicity in sampled bird eggs. Comparisons between calculated TEQs and those estimated using a rat hepatoma cell assay differ by 30 percent, indicating that TEQs calculated using TEFs may overestimate the actual AhR activating potential of the chemical extracts from the eggs (Frank et al. 2001).
- Although not specifically focused on dioxin and furans, toxicity of water and sediments from throughout the Houston Ship Channel in the early 1990s was low, but was variable over time, and was greatest in summer low-flow periods. Sediments and water collected near the Site were not the most contaminated, nor the most toxic in the study (ENSR and EHA 1995).
- Available data for sediment and water chemistry from the TMDL program, and the SEM used by the authors, can be used to explain some of the variation in

bioaccumulation of dioxins and furans in edible fish and crab tissues, but much of the variation remains unexplained by environmental parameters suggesting that metabolic processes play an important role in determining tissue residues of fish and crabs. Simple congener-specific BAFs and BSAFs vary over several orders of magnitude (Dean et al. 2009).

- Elevated concentration of chemicals including pesticides, PCBs, and dioxins and furans in fish and crab tissues collected near the Site as part of the TDSHS consumption advisory program have resulted in consumption advisories in the area near the Site including an advisory to avoid consumption of catfish and crabs, due to dioxin and furan contamination that has been in place since 1990. Fish consumption advisories have also been in place and are driven by concentrations of PCBs in fish tissue. In describing the relative importance of PCBs and other chemicals in the risk assessment performed by the TDSHS (2005), the conclusions state that "in the past, dioxins have been prevalent contaminants of catfish and blue crabs, yet in the present data set dioxin contributes only modestly to the toxicity associated with consumption of blue crabs and catfish from the HSC or Upper Galveston Bay" (TDSHS 2005b).

2.4 Demographics and Human Site Use Information

As described in Section 2.2.3, current land use surrounding the Site includes mixed residential and industrial to the west of the Site and undeveloped or residential areas to the east and north of the Site. Immediately south of the Site is commercial/industrial land use; further south is the river. According to the U.S. Census Bureau,[3] the estimated population of Harris County was 3,984,349 people in 2008, with 8.8 percent of the population under 5 years of age, 28.7 percent under age 18, and 7.9 percent over 65 years old. Of the population age 5 years and older, an estimated 47.8 percent were living in the same house in 1995 and in 2000. A summary of local demographics is provided in this section.
TDSHS reports that the San Jacinto River along with nearby Upper Galveston Bay, Tabbs Bay, and the San Jacinto State Park have "many points of public access and support both recreational and subsistence fishing activities" (TDSHS 2005a). However, published information on the intensity and types of recreational activities as well as fish and shellfish harvesting activities within the immediate vicinity of the Site is limited, with only data

[3] http://quickfacts.census.gov/qfd/states/48/48201.html

consisting of general creel surveys for the greater Houston area by the Texas Department of Parks and Wildlife. A summary of available information on these and other Site uses is discussed below.

2.4.1 Demographics

Based on the 2007 census estimate, the City of Houston is the fourth largest city in the United States (USCB 2007). In 2009, the City of Houston Planning and Development Department estimated that Houston had a population of 2.2 million (CHPDD 2010). According to the 2000 census, the racial makeup of the city was a mixture of Caucasian, Hispanic, African American, and Asian. The city has the third-largest Hispanic and Vietnamese American populations in the United States (CHPDD 2009; Carter 2004). Houston has the fourth highest foreign born population in the United Sates (CHPDD 2009) at 28 percent. In nine years (i.e., from 2000 to 2009), the Hispanic population in Houston increased from 37 to 42 percent (CHPDD 2009). The Hispanic population in Houston is increasing as more immigrants from Latin American countries look for work in the area. It is estimated that about 400,000 immigrants reside in the Houston area illegally (Hegstrom 2006).

In 2007, the median household income in Houston was approximately $40,000 per year, which was below the national median household income level in the United States ($50,000) (USCB 2007). Approximately 22 percent of individuals and 18 percent of families living in Houston are living below the poverty line (USCB 2007). In addition, 33 percent of people that are 16 years and older living in Houston are unemployed (CHPDD 2009).
The Site is located in Channelview, a suburb of Houston (TSHA 1999). According to the 2006 census (USCB 2006), the population of Channelview is approximately 40,000; this represents an increase of 26 percent in the population over a 6-year period. The racial makeup of Channelview is very similar to that of Houston; however, the percentage of Hispanics in Channelview is greater (approximately 54 percent). The median household income in Channelview is slightly higher than Houston (i.e., $43,000 per year) and fewer individuals and families in Channelview are living below the poverty line (approximately 14 percent and 12 percent, respectively).

2.4.2 Harvesting Shellfish and Fish

Throughout Galveston Bay, the commercial and recreational fishing industries are substantial. Within the Site boundaries, fishing is known to occur, but the amount and frequency of fishing has not been determined.

Consumption of molluscan shellfish (clams, mussels, and oysters) taken from public fresh waters is prohibited by TDSHS. Within public salt waters, these shellfish may be taken only from waters approved by TDSHS. TDSHS shellfish harvest maps[4] designate approved or conditionally approved harvest areas. Waters within the Site boundaries are not included on these maps (TPWD 2009).

Despite current fish and crab consumption advisories (Section 2.3.7.5), fishing activity within the waters of the Site have been observed and fishers in this area are reported to collect whatever they catch (Beauchamp 2010, pers. comm.). Specifically, along the northeast side of the tip of the impoundment area, fishing is reported to be popular and people have been observed to wade out in the water on the east side, fishing and using crab cages in this area. Fishing has also been observed to occur under the I-10 Bridge, especially during warmer weather due to the shade, as well as to the south. Constraints on accessibility to the industrial area south of I-10 and to Hog Island to the south (where land consists largely of submerged sand bars) limits fishing activity in these areas (Beauchamp 2010, pers. comm.). Other points of fishing access within the Site include RV trailer parks on the east side of the river north of I-10 with access to the river and a public access area with a boat ramp at Meadowbrook Park west of the Site boundary (Beauchamp 2010, pers. comm.).

2.4.3 Other Recreational Activities

Although the lands within the Site are private, points of access available to the public occur along and within the Site boundaries and allow for a wide variety of recreational activities at the Site including picnicking, swimming, nature walks, bird watching, wading, fishing, boating, and water sports. Shoreline use and wading with the Site has been observed (Beauchamp 2010, pers. comm.). In the area to the south of the bridge, on the west side of

[4] http://www.dshs.state.tx.us/seafood/classification.shtm#maps

the river, children and adults have been reported playing along the shoreline and wading in the water, as well as fishing.

2.4.4 Potable Use of Surface Water from the Site

There are no surface water intakes within 15 miles downstream of the impoundments (TCEQ and USEPA 2006).

2.5 Ecological Resources

The Site is located in a low-gradient, tidally influenced area. Open channel, sandy shorelines, and estuarine and marine fringing wetlands are among the habitats in the lower San Jacinto River that provide feeding and nesting grounds for a variety of fish, reptiles, birds, and mammals. The habitats found at the Site and biota that could be associated with the Site is discussed in this section. Additional details are provided in Appendix B and Attachment B1.

2.5.1 Habitats

Wildlife habitats on the northern portion of the Site include shallow and deep estuarine waters, and shoreline areas occupied by estuarine riparian vegetation. A sandy intertidal zone is present along the shoreline throughout much of the Site (Figure 2-17). Minimal habitat is present in the upland terrestrial area of the Site west of the impoundments, as sand sorting activities created a denuded upland area with a covering of crushed cement and sand. The sandy shoreline of this area is littered with riprap, other metal debris and piles of cement fragments. Estuarine riparian vegetation lines the upland area that runs parallel to I-10. To the west of the central berm within the impounded area, the area is currently occupied by late successional stage vegetation, and to the east the historically impounded area is consistently submerged even at low tide.

Surface waters in the vicinity of the Site are low in salinity (1 to 5 ppt; Clark et al. 1999), and the in-water portion of the Site is primarily unvegetated with a deep (20 to 30 foot) central channel and shallow (3 feet or less) sides (NOAA 1995; Clark et al. 1999). Sediments are characterized by low organic matter content (0.2 to 3 percent in sediments sampled in the river channel adjacent to the impoundments by the TMDL study [University of Houston and

Parsons 2006]) and high sand content (22 to 42 percent sand in a sediment sample collected adjacent to the Site [ENSR and EHA 1995]).

The tidal portions of the San Jacinto River and Galveston Bay provide rearing, spawning, and adult habitat for marine and estuarine fish and invertebrate species including blue crab, drum, flounder, spot, spotted sea trout, and shrimp (Gardiner et al. 2008; Usenko et al. 2009). An estimated 34 acres of estuarine and marine wetlands are found within the Site perimeter. Throughout the broader area there are approximately 55 additional acres of freshwater, estuarine, and marine wetlands (Figure 2-17).

2.5.2 Benthic Macroinvertebrates

Species making up the benthic macroinvertebrate community spend all of most of their life cycles living in or on the sediment, often in highly localized areas. In addition, these organisms are prey for a variety of benthivorous fish and wildlife species. Benthic macroinvertebrates known to occur in the vicinity of the Site include crabs, shrimp, oysters, and clams (Broach 2010; GBIC 2010); blue crabs have been collected from the river channel adjacent to the impoundments (University of Houston and Parsons 2006). In addition, smaller species adapted to the low-salinity conditions, such as euryhaline polychaetes, oligochaetes, and amphipods, may be expected in the vicinity of the Site.

2.5.3 Fish

The fish community at the Site includes a variety of euryhaline species with various feeding strategies, including omnivores, invertivores, and piscivores. Fish species that have been listed in association with or collected from the tidal portion of the lower San Jacinto River include hardhead and blue catfish, drum, spotted sea trout, and flounder (Osborn et al. 1992; University of Houston and Parsons 2006; Gardiner et al. 2008). A list of fish species that have been collected in the vicinity of the Site or that could be expected at the Site given their distribution and habitat preferences is provided in Attachment B1 to the SLERA (Appendix B).

2.5.4 Reptiles and Amphibians

Reptiles that may be found at the Site include alligators, snakes, and turtles (Attachment B1 of Appendix B). Snapping turtles, sliders, softshells, and terrapins are among the turtle species that have been described as associated with the Trinity River National Wildlife Refuge (USFWS 2009), which is located on the other major tributary to Galveston Bay, to the northeast of the San Jacinto River. None of the amphibians that are potentially present in the region are tolerant of brackish or saline waters, with the possible exception of the southern leopard frog, so amphibians are not expected to be found at the Site.

2.5.5 Birds

A wide variety of birds, including raptors, herons, rails, pelicans, gulls, ducks, and sandpipers, use the types of habitats that are present in the vicinity of the Site (Attachment B1 to Appendix B). Dabbling ducks including gadwall and teal may winter in the vicinity of the Site. Sandpipers, egrets, and herons are wading birds that forage along shallow intertidal areas for benthic infauna, small fish, and crustaceans. Piscivores foraging in the open waters of the river include cormorants, osprey, and pelicans. Omnivores including gulls and ducks may forage at the river's edge, as well as in the water column and in the shallow benthos.

2.5.6 Mammals

The number of mammalian species that feed on aquatic prey that may potentially occur within the Site is limited. Nutria and muskrat may be expected in the vicinity in wetland areas with emergent vegetation and otter may use or move through the area while foraging for prey. Marsh rice rats may use riparian and aquatic habitats. Although mink may be present in other parts of the Galveston Bay system, the type of habitat characterizing the Site is not considered appropriate for mink. Mink prefer wetland habitats with abundant cover such as shrubby or dense vegetation and well-developed riparian zones, prefer small streams to large, broad rivers, and avoid exposed or open areas of the type that characterize the shorelines of the Site (Allen 1984). Additional mammal species, including skunk, opossum and raccoon, may use riparian areas adjacent to the river for foraging and corridors for moving across territories (Attachment B1 to Appendix B).

2.6 Cultural Resources

This section provides a description of the Site's cultural resource features and a synopsis of Site History. The USEPA is required to comply with Section 106 of the National Historic Preservation Act (NHPA) and its implementing regulations at 36 CFR 800 as part of the RI/FS activities and eventual Site Remediation strategy. This section assists the USEPA in compliance by providing a synopsis of whether National Register of Historic Places (NRHP) eligible historic properties are present in the preliminary areas of concern.

The preliminary areas of concern include all areas that could be directly and indirectly affected by remedial actions that may be required for the Site (36 CFR 800.16[d]). It is assumed that the RI/FS activities and Site remediation will not involve demolition or modification of existing buildings, bridges, or other structures. Therefore, it is not likely that those activities will affect the built environment, and the preliminary area of concern will be restricted to ground disturbance that could potentially affect archaeological deposits.

2.6.1 Historical Context

The archaeology of coastal Texas is not as well known as it is in other parts of the state. According to Ricklis (2004), "the poor understanding of areal chronology is matched by a general lack of insight into synchronic patterns of prehistoric resource use and settlement patterns." In general, though, the earliest occupation is thought to be Paleoindian. The Paleoindian period dates from around 12,000 Before Present (B.P.) to 8,000 B.P., though no dated sites are found in the coastal region (Ricklis 2004). The subsequent Archaic period lasted from 8,000 B.P. to 1,200 B.P. is characterized by adaptation to a drier climate, increase in the diversity of projectile points, and widespread trade networks. The Late Prehistoric period follows the archaic, and is "in large part, if not entirely, the archaeological correlate of the ethnically and linguistically distinct Karankawa groups" (Ricklis 2004).

In the historic era, the San Jacinto River area was the traditional homeland of Capoque or Cocos band of the Karankawa Indians, a group of at least 400 people (Himmel 1999). The Karankawa were nomadic people who hunted, fished and gathered and performed a rich ceremonial cycle. They traveled in dugout canoes between temporary campsites, made pottery, baskets, and red cedar bows; and lived in shelters made of willow poles and rush mats (Lipscomb 2002). The Karankawa are now extinct as a tribal group. After decades of

conflict with Euroamerican settlers, the last remaining group of Karankawas was annihilated in 1858 (Lipscomb 2002).

Although Spain claimed the area that is now Harris County in 1528, few Euroamericans visited the San Jacinto River area until the early 1700s when French traders from the New Orleans area headed west (Henson 2002; Jackson 2002). A 1718 map by Guillaume Delisle shows the San Jacinto area labeled "Wild and Cannibalistic Indians" (Figure 2-18). The San Jacinto River was "a zone of perennial dispute between rival Spanish and French colonial empires," and the Spanish extensively explored the area in the mid 1700s (Jackson 2002). For the next hundred years, settlements were sparse, and mostly related to military concern, due at least in part to the difficultly of travel along shallow rivers and marshy uplands (Himmel 1999). The nearest settlement to the project area was the Spanish fort El Orcoquisac, about 20 miles east on the Trinity River (Ladd 2002).

In 1821 "American Indian groups occupied all of Texas" (Himmel 1999). One year later, a group of American settlers arrived in the San Jacinto area, and over the next ten years the Euroamerican settlement increased while the Native American population declined (Henson 2002). The mostly American settlers in Texas soon came into conflict with the Mexican government, leading to the Texas Revolution.

The Revolution's Battle of San Jacinto took place approximately three miles south-southwest of the impoundments on April 21, 1836, and was "the deciding moment in the Texas Revolution" (Moore 2004). About six weeks earlier, a Texan force had been defeated at the Alamo by Mexican soldiers under General Antonio Lopez de Santa Anna (Nofi 1992). Santa Anna's soldiers pursued Texan soldiers under the command of General Sam Houston, and the two armies met just south of where Buffalo Bayou enters the San Jacinto River, on a farm owned by a widow (Henson 2002). The Texas army overcame the Mexicans in under 20 minutes, ultimately killing as many as 900 Mexican soldiers (Moore 2004). Although no part of the battle took place at or near the impoundments, Houston's soldiers may have transited the area as they crossed at Lynch's Ferry at the former town of Lynchburg on the east bank of the river south of I-10 (Moore 2004). General Santa Anna retreated from Texas in 1837, and Mexico recognized Texan independence in 1848 (Griswold del Castillo 1990).

Harris County recovered from the revolution slowly. By 1853 it had a steam mill and was the terminus for the Buffalo Bayou, Brazos, and Colorado Railway, which crossed the county to Stafford's Point to facilitate the shipment of cotton and sugar. Five other railroads followed before the Civil War (Henson 2002). Settlers before the Civil War arrived mostly from the southeastern United States, many bringing African-American slaves while settlers after the Civil War included many Midwesterners (Henson 2002).

The area around the San Jacinto River was primarily rural and agricultural for nearly another century. An aerial photo from 1944 (Figure 2-19) shows the river meandering past a small rural settlement on the east bank, with a state highway crossing near Lynch's Ferry. The new I-10 Bridge is visible in a 1957 aerial photo (Figure 2-20) and a 1967 topographic map documents increasing population density (Figure 2-21).

2.6.2 Previous Research

There are no recorded archaeological sites in the preliminary area of concern, and no part of the preliminary area of concern has been previously archaeologically surveyed. Within a mile of the preliminary areas of concern, five sites are recorded (Table 2-15). Descriptions are from the Texas Historical Commission TARL Site Forms.

Table 2-15
Recorded Archaeological Sites

Site Number	Description	Distance from Impoundments
41HR15	"Earthen mound and lithic scatter" on "old river terrace."	0.9 miles (1.5 km)
41HR27	San Jacinto Site 1. Apparently a precontact site. Currently entirely submerged.	1.0 miles (1.6 km)
41HR28	Precontact shell midden. Currently entirely submerged.	1,500 feet (450 m)
41HR407	Historic archaeological site, dates to mid-19th century. Homesite and sawmill, possible slave quarters.	1.0 miles (1.6 km)
41HR724	Scattered redeposited shell, likely not in situ. Currently entirely submerged.	2,000 feet (630 m)

Table 2-16
Archaeological Surveys

Author	Date	Title	Sites Visited within 1 mile of Impoundments
Hudson, Kay G.	1991	Archaeological Survey, Houston International Terminal, San Jacinto River, Harris County, Texas.	41HR28
McClure, W. and Leland W. Patterson	1975	Prehistoric Occupation of White Oak Bayou Watershed.	41HR15
Moore, Roger G. and Robert Travis	1994	Cultural Resources Investigations and Coordination for the San Jacinto Oil Spill Incident, Harris County, Texas	None
Carlson, Shawn Bonath	1998	Archaeological Investigations at the David G. Burnet Park (41HR407), Harris County, Texas	41HR407

The three in situ pre-contact sites (41HR15, 41HR27, and 41HR28) and the historic site (41HR407) all clearly represent occupations of the riverbank immediately adjacent to the river prior to historic and modern subsidence. Given this settlement pattern, the preliminary area of concern would have had a high probability for archaeological resources at or near the original ground surface. Industrial activities at the Site and the associated subsidence and erosion, have reduced the archaeological potential. Given the deltaic depositional environment, deeply buried sites may be present. However, meandering and repeated flooding in the pre-contact era may have also eroded such sites in the past.

2.6.3 Recommendations

No NRHP-eligible properties are documented in the area if concern. Because of the extensive disturbance to the Site and minimal ground disturbance that will likely occur for the project, it is not likely that NRHP-eligible historic properties will be affected by RI/FS or eventual Site remediation activities. A final determination on the potential effect of Site remediation activities on NRHP-eligible historic properties may be required as part of the Site FS after potential Site remediation and management strategies are better understood.

3 ASSESSMENT OF DATA QUALITY AND USABILITY

Data quality reviews were performed for compiled historical sediment chemistry, water chemistry, and tissue chemistry data. The reviews were performed prior to entering the historical data into the project database. The purpose of this review was to fully evaluate each data set and categorize the quality of the data in the database, ensuring that these data are used for appropriate purposes throughout the RI/FS process. Data quality categories are defined as follows:

- Category 1 data are of known quality and are considered to be acceptable for use in decision making for the Site. There is sufficient information on these data sets to confidently verify that the data, along with associated data qualifiers, accurately represent chemical concentrations present at the time of sampling.
- Category 2 data are of generally unknown or suspect quality. The QA/QC information shows that data quality is poor or suspect, or essential QA/QC data (e.g., surrogate recoveries, matrix spike/matrix spike duplicates) are either incomplete or do not exist.

This evaluation focused on individual analyte groups within each survey when possible. Thus a specific survey may contain all Category 1 data, all Category 2 data, or a combination of Category 1 and 2 data. In addition, data that received a Stage 1, 2A, 2B, 3, or 4 level of validation (as defined in Table 3-1) were flagged as such, providing a combined data quality category (e.g., Category 1 Stage 2B). Some data sets have been loaded into the data base and are noted as Category 2 because QA/QC information was not fully available at the time the data were loaded. As a result, Category 2 data may be classified as such simply because QA/QC information was not readily available. These data may subsequently be considered Category 1 if in-depth QA is performed, and the data are found to warrant this classification. Additional QA review of Category 2 data will be limited to those data sets deemed of importance to the RI/FS process and decisions.

3.1 Chemical Data Review Criteria

Criteria for placing data sets into categories were developed during the compilation of existing information to identify basic data qualities, not to limit data to specific program uses. Chemical data quality was assessed by evaluating the following factors:

- Traceability
- Comparability
- Sample integrity
- Potential measurement bias (i.e., accuracy, precision)

All of these factors were known or supported by existing QA/QC information (e.g., analytical methods, chain-of-custody, sample holding time, method blanks, matrix spike/matrix spike duplicates, laboratory control samples, replicates, surrogates) for Category 1 data. If supporting documentation for each factor was not available or was not reinforced by the availability of other high quality QA/QC information, data were assigned a Category 2 designation. If the acceptance criteria for any of the above factors were not satisfied for either the entire data set or a specific analyte group, data for that data set or group were generally qualified and were determined to have limited usefulness (e.g., appropriate for limited tasks such as determination of COPCs). The chemical data were reviewed by analyte group (e.g., metals, dioxins and furans, PCBs). As a result, a data set may contain all Category 1 data, all Category 2 data, or both Category 1 and Category 2.

3.2 Data Quality Assessment Results

Data quality reviews were completed for all historical data incorporated into the San Jacinto database. Data quality assessment results are summarized in Table 3-2, with details provided below.

3.2.1 Soil

There are currently no chemistry data for soils collected from the Site.

3.2.2 Sediment

Data quality reviews were completed for ten data sets, and results are provided in Appendix D-1. Two of the ten sediment surveys received a Category 1 designation, with the remaining surveys receiving a Category 2 designation. In general, insufficient QA/QC documentation was available for the eight sediment chemistry data sets to receive a Category 1 designation.

3.2.3 Groundwater

There are currently no chemistry data for groundwater collected from the Site.

3.2.4 Surface Water

Data quality reviews were completed for two data sets, and results are provided in Appendix D-2. One data set was assigned to Category 2, and the other data set was classified as Category 1. As for most of the sediment data, insufficient QA/QC documentation was available for the surface water chemistry data set classified as Category 2.

3.2.5 Air

There are currently no chemistry data for air collected from the Site. However, data quality review was completed for a TMDL study conducted within the Houston Ship Channel region and results are provided in Appendix D-3. All air quality data associated with this TMDL study were assigned to Category 2. In general, insufficient QA/AC documentation was available for the air chemistry data set.

3.2.6 Biological Tissue

Data quality reviews were completed for two data sets, and results are provided in Appendix D-4. All tissue data sets were assigned to Category 2. In general, insufficient QA/QC documentation was available for the tissue chemistry data sets.

3.3 Database Entry Quality Assurance

After the data quality assessment was completed and data were incorporated into the database, a standard database QA review was performed in which 100 percent of the results from 10 percent of the samples entered into the database were compared to the source files and reports. If errors were discovered for a given subset of the data (e.g., analyte group), that subset was then subjected to a 100 percent review before integration into the Site geodatabase. The Site geodatabase will serve as the source compendium for all environmental data.

4 CONCEPTUAL SITE MODEL

Understanding the major physical and chemical processes that control the distribution and concentrations of COPCs at the Site is gained through the development and refinement (based on the iterative evaluation of Site-specific information) of a CSM. A CSM for a contaminated Site provides a succinct depiction of the sources of contaminants, the physical-chemical processes that control chemical transport and fate over time and space, and the exposure pathways that potentially lead to exposure and adverse effects to ecological and human receptors. CSMs are a key component of the RI/FS process because they illustrate the links between Site investigation data and the assessment of risk (ASTM 1995). CSMs also establish a context for evaluating potential Site-associated sources and risk versus non Site-associated sources and risk.

Figure 4-1 is a general CSM pathway diagram for the Site showing the major sources, release mechanisms/transport pathways, exposure media, and potential human and ecological receptors of concern. This CSM is focused on the characteristics of the primary COPCs and indicator chemical group at the Site; dioxins and furans. General chemical characteristics of the other primary COPCs identified for the Site (several metals and bis-2(ethylhexyl) phthalate) are presented in Appendix E.[5]

This section is divided into three sub-sections. The physical and chemical elements of the CSM are described in Section 4.1, which is divided into four parts. Section 4.1.1 provides an overview of dioxin and furan chemical properties and behavior in the environment. Section 4.1.2 describes how the cumulative toxicity of exposure to combinations of several dioxin and furan congeners together is addressed for birds, mammals and fish. Section 4.1.3 details the dioxin and furan sources, release mechanisms, and transport processes associated with the Site, and Section 4.1.4 discusses regional and global dioxin and furan sources, release mechanisms, and transport processes. Sections 4.2 and 4.3 then discuss potential receptors of concern and exposure pathways for human an ecological receptors, respectively.

[5] Secondary COPCs will be addressed in revised project CSM descriptions if it is determined that they need to be evaluated in the baseline risk assessments.

4.1 Dioxin and Furan Chemistry, Sources, Release Mechanisms, and Transport Pathways

Following an overview of general dioxin and furan chemical behavior in the environment and the means to evaluate dioxin and furan exposure and toxicity, this section details the current understanding of the sources, release mechanisms, and transport and fate processes at the Site. Figure 4-2 illustrates some of the major physical and chemical fate and transport processes discussed below.

4.1.1 Dioxin and Furan Chemical Properties and Behavior in the Environment

Dioxins and furans are a family of polychlorinated organic chemicals with similar chemical structures. They are characterized by extremely low vapor pressures, high octanol-water and organic carbon partitioning coefficients (Kow and Koc, respectively), and extremely low water solubilities. These factors indicate a strong affinity for sediments, particularly sediments with high organic content, and for lipids within biological tissue. Although some dioxins deposited on or near the water surface will be broken down by sunlight, and a very small portion will evaporate to air, the vast majority will sorb strongly to particulate matter, including organic matter, and eventually settle to the sediment bed, where they will be subject to sediment transport processes. After they are sorbed to particulate matter or bound in the sediment organic phase, they exhibit little potential for leaching or volatilization. They are highly stable in abiotic environmental media, with persistence typically measured in decades. An environmentally significant transformation process for dioxin congeners is believed to be photodegradation of chemicals not bound to particles in the gaseous phase or at the soil-air or water-air interface (USEPA 1994).

Chemical degradation of dioxins and furans through reductive chlorination can also occur. Recent research in the San Jacinto estuary found widespread occurrence of known dioxin-degrading bacteria, *Dehalococcoides* spp., in sediments throughout the Houston Ship Channel and Galveston Bay (Louchouarn and Brinkmeyer 2009). These bacteria use polychlorinated compounds as electron acceptors in the anaerobic process of de-halorespiration (Bunge et al. 2003; Holliger et al. 1999; Adrian et al. 2000). Anaerobic, sulfate-reducing conditions and relatively high bulk organic carbon levels appear to be needed for enhanced microbial dioxin degradation (Fu et al. 2001). Louchouarn and

Brinkmeyer (2009) reported that anaerobic, sulfate-reducing conditions are present at and below 10 cm in all Houston Ship Channel and Galveston Bay sediments sampled.

Nationally, sediments are considered to be a sink for dioxins (USEPA 2000a). Dioxins entering surface waters partition rapidly to particulates, and preferentially to the organic carbon fractions in suspended solids, and are then transported and/or deposited with bedded sediments. Black carbon (carbon-rich soots and soot-like material) is believed to offer more binding Sites for organic materials but its relative abundance and composition is highly variable; it generally comprises less than 10 percent of the TOC pool in aquatic sediments (Koelmans et al. 2006). The presence of strong sorbing phases such as black carbon and other carbon matrices limit mobility and bioavailability of dioxins and furans and other organic compounds (e.g., PAHs). Koelmans et al. (2006) report that black carbon reduced uptake in organisms by up to two orders of magnitude.

The concentrations of freely dissolved concentrations of contaminants in surface waters and in the sediment biologically active zone, rather than bulk sediment concentrations, determine ecological effects and biological uptake. Contaminants in the near-surface, biologically active and/or physically mixed zone of the sediments, including sediments containing large proportions of pulp mill wastes, may move between solid and aqueous phases and be remobilized from the sediment bed by sediment resuspension and porewater - surface water exchange. Once in the water column, upstream or downstream contaminant transport can occur. Direct biological uptake can also occur from surface and suspended sediments, porewater and surface water. Partitioning between suspended solids and surface and porewater depends on the relative chemical concentrations, organic carbon levels and composition, and the dissolved surface water fraction, as well as reaction kinetics and the partitioning behavior of individual dioxin congeners. These factors are Site- and often sample-specific in the environment. For samples collected from the waste impoundments and the Houston Ship Channel, Louchouarn and Brinkmeyer (2009) modeled porewater concentrations considering both TOC (two-phase model) and amorphous organic carbon and black carbon as separate sorbents (three-phase model). They found that the two-phase model was more conservative in predicting porewater concentrations (i.e., suggesting the two-phase model overestimates porewater concentrations). This effect was greatest at lower dioxin levels. They also note that for samples with very high dioxin levels (e.g., those from

the waste impoundments), the sorption capacity of the sediments is exceeded, resulting in very high estimates of dissolved dioxins and furans (greater than 1 pg/L), whereas in most areas, the sediment sorption capacity is estimated to result in dissolved fractions less than 0.1 pg/L.

Tetrachlorinated dioxin and furan congeners may bioaccumulate in aquatic food webs and associated bird and mammal species (ATSDR 1998); more recent literature confirms that other congeners have limited potential to bioaccumulate (USEPA 2008). The principal route of exposure is through the ingestion of contaminated food, as opposed to respiration across gill surfaces for fish or aquatic invertebrates. However, dioxins have been detected in waters, making them potentially available for biological uptake, even at very low concentrations. Certain benthic organisms accumulate dioxins from water at the water–sediment interface and through intake of phytoplankton, zooplankton, and suspended particulate materials that may contain higher concentrations of these chemicals than the surrounding water. Additional discussion of exposure routes and pathways for human and ecological receptors is provided in Section 4.2 and 4.3.

Finally, the bioavailability of dioxins may also be dependent on rates of sediment resuspension and remobilization (Wenning et al. 2004), which will be evaluated as part of the fate and transport evaluation noted below (Section 6.1.5).

4.1.2 Dioxin and Furan Toxicity

Dioxins and furans (polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans) are two groups of structurally similar, tricyclic, almost planar, organic compounds that exhibit similar physical and chemical properties. There are 75 dioxins and 135 furans called *congeners,* which are differentiated by the number and position of chlorine atoms in each congener. Many animal studies have established that there is a distinct difference in the toxic effects among dioxin and furan congeners and that 2,3,7,8-TCDD is the most toxic of the congeners to mammals (USEPA 2000a) and is considered the most toxic to birds and fish as well. Seventeen of the dioxin and furan congeners (seven dioxins, ten furans) exhibit what is termed “dioxin-like” toxicity. These 17 congeners have chlorine atoms present in the 2,3,7, and 8 positions on the ring structure of the molecule and are more toxic than other

congeners with fewer chlorine atoms or with chlorine atoms in different positions on the ring structure.

The magnitude of toxicity of each of the 17 dioxin and furan congeners with dioxin-like toxicity are related to the toxicity of 2,3,7,8-TCDD by TEFs. The magnitude of toxicity of each of these 17 dioxin and furan congeners can be related to the toxicity of 2,3,7,8-TCDD using a congener-specific TEF. The concentration of each congener is converted to equivalent concentrations of 2,3,7,8-TCDD by multiplication with its TEF, and all the TEQs for individual congeners (the product of each congener and its TEF) are added to compute the total toxic equivalency of the mixture to 2,3,7,8-TCDD. The resulting total TEQ concentration provides the metric of exposure to "dioxin-like" compounds. Certain PCB congeners exhibit an ability to bind to the same biochemical receptors as the most toxic of the dioxin and furan congeners, and their toxicity is considered to be additive with dioxin and furan toxicity. These "dioxin-like" PCBs also have TEF values for birds, mammals and fish. TEFs for mammals developed by the World Health Organization (Van den Berg et al. 2006) and for fish and birds (Van den Berg et al. 1998) will be used in this risk assessment to estimate the cumulative toxicity of the PCB congeners exhibiting dioxin-like toxicity (Table 4-1).[6]

The mammalian TEFs in Table 4-1 have been recommended for use in human health risk assessments by USEPA (2009). Dioxin and furan congeners without chlorine atoms in the 2, 3,7, and 8 positions are assigned a TEF of zero and cannot be evaluated using TEQ methodology because they lack a common mechanism of toxicity.

4.1.3 Site-Related Dioxin and Furan Sources

The impoundments at the Site received pulp mill wastes in the mid-1960s and are presumed to be the major source of COPCs at the Site. Major physical changes that resulted in the exposure of the wastes deposited within the impoundments to surface waters and the distribution of contaminated material into nearby surface sediments. Land subsidence

[6] PCB congeners will be evaluated in initial sediment samples, including those collected from within the impoundments, and will be analyzed in all sediment samples and tissue, if appropriate, according to the decision process described in Section 1.7.2 of the final Sediment SAP (Integral and Anchor QEA 2010) and Section 1.5 of the draft Tissue SAP.

resulting from regional groundwater withdrawal in the 1960s and 1970s contributed to the sinking of the impoundments. As a result of this event, contaminated material was distributed and became distributed and potentially accessible to ecological receptors and to people at the Site. Material from the berm and from within the impoundment was subject to mobilization and redistributed by erosion resulting from tidal and river currents. Dredging activities in the area may have affected the Site. Mobilization of materials by dredging may have released sediment-associated contaminants to the water column that would have settled to the bottom. Determining the spatial extent of sediment contaminants from the impoundments is one issue that will be addressed in the RI/FS.

Human and ecological receptor contact with contaminated sediments currently exposed within the boundary of the impoundments is also potentially ongoing. A TCRA designed to stabilize the waste material in the impoundments, restrict public access, and minimize the continuing release of wastes to the Site will take place in 2010. The physical/chemical elements of this CSM presume the successful implementation of the TCRA and CSM focuses on the fate and transport of contaminants released to the Site from the impoundments prior to the TCRA.

Given the hydrophobic nature of dioxins and furans and their affinity to be associated with sediment particles, qualitative and quantitative descriptions of hydrodynamics and sediment transport are very important because these physical processes provide the foundation for understanding chemical fate and transport processes in the Site. A Technical Memorandum on Chemical Fate and Transport is being developed that will address the physical modeling and data requirements (Sections 6 and 8). The results of this effort will greatly inform the refinement of the physical CSM for the Site.

At present, the existing sediment dioxin and furan from the area of the Site as well the physical setting of the impoundments within the San Jacinto River can be used to describe a preliminary physical CSM. First, the impoundments were constructed on the inside bend of a natural river oxbow, in an area historically consisting of marshlands (e.g., Figure 2-1). This area was likely a zone of sediment accretion rather than erosion with hydrodynamic energy being directed through the main river channel in the far eastern portion of the Site (i.e., along the outside bend of the oxbow). Second, although there are significant spatial nature

and extent data gaps to be filled as part of the RI/FS, analysis of existing data shows a decrease in sediment dioxin concentrations moving away from the waste impoundments (see Figure 4-3). Finally, Louchouarn and Brinkmeyer (2009) reported the results of a fingerprinting analysis of dioxins and furans located in the impoundments, their immediate vicinity, and further afield in the San Jacinto River and the Houston Ship Channel. They graphically presented ratios of TCDD/OCDD versus TCDF/OCDF for each sample to show differences in the characteristics of dioxin mixtures among sediment samples, and thereby to address source inputs to the Houston Ship Channel and vicinity. This particular dioxin compositional analysis shows a decrease in sediment dioxin concentrations from the waste impoundments as well.

4.1.4 Global and Regional Dioxin and Furan Sources, Release Mechanisms, and Transport Pathways

Dioxins have never been purposely manufactured. They are anthropogenically and naturally produced through combustion, bleached paper production, polyvinyl chloride (PVC) production, ink/dye production, metal smelting, or as trace impurities or incidental by-products in chlorophenols, chlorinated herbicides, and commercial Aroclor (PCB) mixtures (ATSDR 1998). Examples of combustion and incineration that may lead to the formation of dioxins include waste (hazardous, medical) incinerators, cement kilns, boilers and industrial furnaces, vehicle emissions, fossil fuel power plants (e.g., coal), and backyard burning (e.g., refuse piles, burn barrels). Dioxins are naturally produced from forest fires, volcanic eruptions, and sedimentary deposits. Currently the largest source of dioxins to the environment is from combustion (USEPA 2006a). Absent a local source (such as the Site waste impoundments), the global source of dioxins and furans in environmental media is generally atmospheric deposition, which has been shown to be a factor in this Region (Section 2.3.5). When released into the air, some dioxins may be transported long distances, even around the globe. In the atmosphere, it has been estimated that 20 to 60 percent of 2,3,7,8-TCDD in the air is in the vapor phase. Sunlight and atmospheric chemicals break down a very small portion of the dioxins, but most will be deposited on land or water (ATSDR 1998) and ultimately be transported downgradient.

Given the long-term generation of dioxins as manufacturing by-products around the world, atmospheric transport, and the general recalcitrance of the molecules, it is expected that some inputs of dioxins to the San Jacinto River system other than from the waste impoundments have occurred. Historically deposited dioxins still present in the river are expected to be predominantly sorbed to sediments.

Figure 4-4 includes a general representation of the regional sources, release mechanisms/transport pathways of dioxins and furans that are additional to the atmospheric inputs. These include industrial effluents, publicly owned treatment works, stormwater from the full range of upland land uses, direct runoff, and surface water and sediment transport into the Site from both upstream and downstream in the San Jacinto River as a function of both river and tidal flows, including infrequent storm surges which may be important in moving large amounts of sediment. It is documented that the nearby Houston Ship Channel is contaminated with dioxins and furans from local industrial and municipal effluents and runoff, as well as atmospheric deposition (University of Houston and Parsons 2006).

4.2 Human Health Site Conceptual Model

For exposure to occur, a complete exposure pathway must exist. A complete pathway requires the following elements (USEPA 1989):

- Source and mechanism for release of constituents
- Transport or retention medium
- Point of potential human contact (exposure point) with the affected medium
- Exposure route at the exposure point

If any one of these elements is missing, the pathway is not considered complete. For example, if human activity patterns relative to the location of an affected exposure medium prevent human contact, then that exposure pathway is not complete. A simple CSM of the release and exposure pathways at this Site is illustrated in Figure 4-4. Figure 4-5 presents a CSM exposure diagram for human receptors based on our current understanding of exposure media, routes of exposure, and potential human receptors for the Site. Further description of the CSM for human exposures is provided below.

4.2.1 Human Health Receptors

Four potential human receptors have been identified for evaluation in the BHHRA to be conducted for the Site as part of the RI/FS process: a recreational fisher, a subsistence fisher, a recreational visitor, and a trespasser. Fishers include children or adults who gather fish from within the Site boundaries either by boat, fishing from along the riverbanks, or wading into the river to fish; fishers are assumed to eat the captured aquatic species. Recreational visitors include people interacting with Site media while swimming, picnicking, or playing along the shoreline, but not consuming fish. Both fishers and recreational visitors are assumed to be residents living in the vicinity of the Site and accessing the Site regularly throughout the year over the duration of their residency. Although recreational visitors may consume fish from the Site that were caught by someone else, exposures by the recreational visitor to contaminants consumed in fish will not be considered directly, but will be considered in the BHHRA in the context of total risks for the fisher receptors.

Signs of trespassers have also been reported along some portions of the Site, particularly under the I-10 Bridge. These individuals may come in contact with Site media in ways similar to the fishers and recreational visitor, but the frequency of their visits and total exposure duration is expected to be much less than the residential-based fishers and recreational visitor. Fishers and recreational visitors are expected to encounter higher exposures than trespassers would encounter. Consequently, if remediation is necessary and the Site is remediated to levels that are safe for fishers and recreational visitors, it will also be safe for trespassers.

4.2.2 Human Health Exposure Pathways

Exposure pathways are defined as the physical ways in which chemicals present in exposure media may come in contact with human receptors. The following potential exposure routes for human receptors are considered in the CSM exposure diagram for human receptors (Figure 4-4):

- Ingestion or dermal contact with chemicals in sediments
- Ingestion of fish and shellfish[7]

[7] Several fish and shellfish potentially consumed by people at the Site are included among the species for which consumption advisories are in place (Section 2.3.7.5).

- Ingestion or dermal contact with chemicals in surface water
- Ingestion or dermal contact with chemicals in soils
- Inhalation of chemicals in air (i.e., gases or particulates)

The frequency and duration of exposures to chemicals in each exposure medium will vary depending on the types of activities associated with each receptor group. Exposure pathways are considered potentially complete and significant if the exposure occurs frequently over an extended duration and the exposure medium represents a significant potential source of Site-related contaminants. Exposure pathways are considered potentially complete, but minor, if the exposure occurs infrequently, over a short duration, or if the exposure medium represents a minor potential source of Site-related contaminants. In Figure 4-5, consumption of fish by recreational visitors is the only incomplete exposure pathway identified. As noted above, this pathway may occur, but will be evaluated separately for the fisher receptor groups.

For the fishers and recreational visitor, potentially complete and significant exposures to Site media are expected to occur primarily via direct contact with sediments or soil (ingestion and dermal) and, for the fishers, also through consumption of aquatic organisms (i.e., fish and shellfish) that are exposed to Site-related contaminants in the sediments. Exposures to these media by trespassers are expected to be minor. Exposures to contaminants in surface water and air are expected to be minor for all groups of potential Site visitors.

4.3 Ecological Site Conceptual Model

The ecological CSM is described in detail in the SLERA (Appendix B) and summarized in this section. The ecological CSM connects the sources and transport pathways described above in Section 4.1 to ecological receptors that may be expected at the Site. The CSM facilitates evaluation of the completeness and significance of exposure to contaminants of concern in each potentially affected environmental medium (Figure 4-6). A more detailed description of specific exposure routes considered to be the most important to each receptor is provided in Figure 4-6. Below is a synopsis of the receptors selected for evaluation in the BERA, followed by a discussion of the details conveyed by Figure 4-6.

4.3.1 Ecological Receptors

Fish and wildlife may be expected to use the habitats present in the vicinity of the Site, including open waters, riparian shorelines, and estuarine and marine wetlands (Section 2.5). From the lists of species that may be present at the Site seasonally or year-round, receptor surrogates were selected to represent the potential exposures to Site-related chemicals. Ecological receptor surrogates are considered to be representative of the trophic and ecological relationships for several other species, as described in Appendix B. In selecting receptor surrogates for the Site, the following criteria were considered:

- Receptor is or could potentially be present at the Site
- Receptor is representative of one or more feeding guilds
- Receptor is known to be either sensitive or potentially highly exposed to COPCs at the Site
- Life history information is available in the literature or is available for a similar species that can be used to inform life history parameters for the receptor

Given the identification of sediments and surface water as primary environmental media of concern for the fate and transport of Site-related chemicals, receptors were chosen that are aquatic-dependent or use aquatic resources to a substantial extent, because these are expected to be the types of organisms with the most potential to be exposed to chemicals associated with the impoundments.

The following surrogate receptors were chosen from each of the major fish and wildlife taxa expected to be present at the Site. Ecological and life history information is provided for each of these receptors in the SLERA accompanying this Work Plan (Appendix B):

- Benthic macroinvertebrate community
- Bivalve molluscs
- Fish
  - Gulf killifish (*Fundulus grandis*): benthic omnivore
  - Black drum (*Pogonias cromis*): benthic omnivore
  - Southern flounder (*Paralichthys lethostigma*): benthic piscivore
- Reptiles

  - Alligator snapping turtle (*Macrochelys temminckii)*: omnivore

- Birds
  - Neotropic cormorant (*Phalacrocorax brasilianus*): piscivorous diving waterbird
  - Great blue heron (*Ardea herodias*): wading bird
  - Spotted sandpiper (*Actitis macularius*): invertivorous, sediment-probing bird
  - Killdeer (*Charadrius vociferous*): terrestrial invertivore

- Mammals
  - Raccoon (*Procyon lotor*): omnivore, uses riparian and terrestrial habitats
  - Marsh rice rat (Oryzomys palustris): omnivorous, seasonally variable diet, uses riparian, aquatic, and wetland habitats

4.3.2 Ecological Exposure Pathways

The complete exposure pathways and relevant exposure routes for fish, invertebrates and aquatic-dependent wildlife include direct contact with contaminated water, sediments or soils; ingestion of contaminated water, sediments, soils or prey that have been exposed to contaminated media, and respiration (for aquatic species) see Figure 4-6.

5 STUDY ELEMENTS AND DATA NEEDS

The evaluation of existing data (Section 3) and development of the CSMs are the basis for identifying the additional information that is required to address the objectives of the RI/FS. Each of the objectives will be addressed by a specific Study Element, as described in this section. Although data may inform more than one study element, the organization of the RI/FS into four principal Study Elements provides the framework for effectively communicating how the RI/FS will address each objective, and for planning data collection and analyses, as follows:

- Study Element 1: Nature and Extent Evaluation, to characterize the nature and extent of contamination of sediments and soils and to assess groundwater quality.
- Study Element 2: Exposure Evaluation, to evaluate ecological and human health risks from exposure to COPCs in soil, sediment, water and biota.
- Study Element 3: Physical CSM and Fate and Transport Evaluation, to better describe and characterize the physical processes governing the fate and transport of Site-related COPCs.
- Study Element 4: Engineering Evaluation, to support design of remedial actions, including removal Site-related contaminated sediments and the construction of remedial alternatives.

Data gaps for each Study Element are identified in this section. In Section 5 the specific approach for addressing each of the listed data gaps is described; Section 8 describes the schedule of project deliverables, including SAPs for collection of additional data to address the data gaps identified below.

5.1 Study Element 1: Nature and Extent of Contamination

The nature and extent investigation addresses the COPCs that were defined in the Sediment SAP (Integral and Anchor QEA 2010).[8] COPCs are classified as either primary or secondary. Primary COPCs are those that will be evaluated in the baseline risk assessments. Secondary COPCs are those for which additional information is needed to determine whether they will be evaluated in the baseline risk assessments. Chemicals other than the primary and

[8] The process and data used to identify COPCs is provided in Appendix C.

secondary COPCs will not be evaluated further in this RI/FS (Integral and Anchor QEA 2010).

Information on the nature and extent of primary COPCs in abiotic media resulting from releases of materials from the impoundments is required for the evaluation of remedial alternatives in the FS. The horizontal and vertical distribution and extent of Site-related COPCs in sediment and soils must be described to inform how active remedial approaches and potential for natural recovery processes will achieve remediation goals for the affected media at the Site, and post-remediation recontamination potential. In addition, the possibility that groundwater quality is affected by the Site must be evaluated. Specific data gaps to be addressed by Study Element 1 are described below. Additional information on COPC concentrations in soil sediment and tissue to support the exposure assessment is addressed by Study Element 2.

5.1.1 Soil Data Gaps

There are currently no data to describe the chemistry of soils on the Site, but the Site history and CSM suggest that sediments from within the impoundments may have been transferred to the sand-sorting area of upland portion of the property west of the impoundments. Therefore, appropriate soil data for characterization of the nature and extent of contamination in area on this upland represents a data gap for Study Element 1. This data gap will be addressed by collection of soil data in the upland area using a sampling design that will produce accurate and representative estimates of COPC concentrations in surface soil. Project specific data quality objectives (DQOs) addressing Study Element 1 for soil, and a SAP designed to achieve these DQOs will be developed and presented in the forthcoming soil SAP.

5.1.2 Sediment Data Gaps

Available sediment data from the Site indicate the presence of elevated concentrations of COPCs within and in the vicinity of the waste impoundments, but the data are limited in their spatial location and depth, and many data are qualified because complete QA records are not available (Section 3). Specific limitations of these data include:

- The low spatial density will lead to uncertainty in defining a cleanup boundary if

additional sediment chemistry data are not collected.

- The absence of sufficient subsurface COPC measurements, except adjacent to the I–10 Bridge, will lead to a large uncertainty in the depth of contamination and therefore in the sediment depths and quantities to be addressed by remedial alternatives.
- Limitations on the number of samples and the number of analyses of COPCs in upstream background samples limit the accuracy and precision with which background conditions can be characterized, leading to undesirably high uncertainty in comparisons of Site and background conditions.

These data gaps will be addressed by the collection of sediment data using a sampling design that will produce representative estimates of COPC concentrations throughout the area within the preliminary Site perimeter. Measurement of subsurface sediments at multiple locations within this area will provide information necessary to evaluate preliminary remediation goals (PRGs) and remedial alternatives. Project-specific DQOs addressing Study Element 1 for sediment, and a SAP designed to achieve these DQOs were developed and presented in the sediment SAP (Integral and Anchor QEA 2010).

5.1.3 Groundwater Data Gaps

Available groundwater data exists in the form of private and public well information from the region and from wells near the Site, see Section 2.2. Site-specific groundwater chemistry data have not been collected. Additional information on groundwater hydrology and groundwater quality is needed to confirm or refine the groundwater CSM described in Section 2.2. As previously discussed in Section 2.2, the physical properties of both COPCs and the Site hydrogeology indicate it is very unlikely that Site-related impacts to groundwater are present. Nevertheless, local groundwater data will be obtained to determine whether any Site-related impacts are present. To confirm the groundwater CSM described in Section 2, some strategically designed monitoring wells are planned to be completed and monitored during the RI. Three nests of monitoring wells are planned. The nested wells will be located such that lateral and vertical groundwater gradients can be measured. The gradient data can be used to determine local groundwater flow direction and characterize potential groundwater/surface water interaction. The wells will also be used to obtain representative groundwater samples to assess groundwater chemistry and to

determine if shallow groundwater quality has been affected by the use of the former impoundments. Section 6.1.5 further describes the plan for groundwater assessment.

5.2 Study Element 2: Exposure Assessment

USEPA guidance requires that an RI include evaluation of baseline risks to human and ecological receptors. "Baseline" in this context refers to the conditions at the Site before remediation takes place. As such, baseline conditions provide a point of reference for evaluation of the no action alternative in the FS, and for post-remedial Site evaluation. Baseline human and ecological risk assessments will be performed for the RI. Study Element 2 addresses the information needs to perform the evaluation of exposures under baseline conditions.

For human receptor groups, primary exposure to Site-related COPCs may include direct contact (ingestion and dermal) with soils and sediments or indirect contact through consumption of aquatic organisms (i.e., fish and shellfish) that are exposed to the sediments. People may also be exposed through direct contact (ingestion and dermal) with surface water or through inhalation of COPCs as particulates or vapors in air, but exposures via these media and routes are expected to be minor or non-existent. Exposure of people to COPCs via groundwater is unlikely (Section 2.2.6); groundwater chemistry collected for Study Element 1 will provide the information required to confirm this assumption. Ecological receptors may be exposed to COPCs through ingestion of sediment, soils, water, and their food; through direct contact with sediments and water; and through respiration in the aquatic environment (Appendix B). Benthic invertebrates and fish may be exposed to groundwater via contact with porewater, but these exposures will be evaluated using biological tissue chemistry, so therefore no direct measures of porewater or groundwater chemistry are needed to assess exposure to ecological receptors. Finally, Study Element 2 addresses those data and processes governing the bioaccumulation of COPCs in fish and invertebrate tissue, which will be needed to calculate risk-based PRGs (Section 7) and may also be used in the risk evaluation.

Additional information on the chemistry of sediment, soil, and biological tissue are needed to perform the exposure evaluation and baseline risk assessments. Information on the

chemistry of both abiotic and biological media is needed for evaluation and characterization of processes governing bioaccumulation. Specific data gaps to be addressed by Study Element 2 are detailed below.

5.2.1 Soil Data Gaps

Additional information on the concentrations of COPCs in soil potentially impacted by Site sediments is needed to reliably characterize baseline exposures and risks to people and ecological receptors coming into contact with Site soil. Additional information on the concentrations of COPCs in soils at locations in the terrestrial portions of the Site north of I–10, where human use activities are expected to occur and where terrestrial birds and mammals may be expected is needed to reliably characterize exposures and risks associated with contact with Site soils. Project-specific DQOs addressing Study Element 2 for soil, and a SAP designed to achieve these DQOs, will be developed and presented in the forthcoming soil SAP.

5.2.2 Sediment Data Gaps

Available data for chemicals of interest (COIs) in the sediments within the impoundments indicate the presence of dioxins and furans, several metals and bis-2(ethylhexyl) phthalate at levels that are of potential concern to ecological and human health, and magnesium as potentially of concern to ecological health (Appendix B; Appendix C); these chemicals are the primary COPCs for the baseline risk assessments. In addition, several SVOCs and VOCs could not be ruled out from further evaluation in the baseline risk assessments, and were retained as secondary COPCs for the ERA. PCB congeners, some of which are considered to have additive toxicity with dioxins and furans, also have never been measured in sediments from the impoundments.

For the baseline risk assessments, additional data for sediments within the impoundments are required to characterize sediment exposures and risks in this part of the Site. Available sediment chemistry data are insufficient, however, elsewhere on the Site to characterize specific types of exposures of ecological receptors and people to COPCs with the degree of reliability needed for the baseline risk assessments. Moreover, the focus of existing data on areas near the impoundments and I-10 Bridge prevents accurate assessment of area-weighted

exposure estimates; the lack of additional spatial characterization of contamination would therefore lead to possible bias and high uncertainty in exposure estimates and risk estimates for the Site as a whole.

Data gaps to be addressed by Study Element 2 include concentrations of these COPCs in sediments from specific areas of the Site:

- Shallow intertidal sediments in wildlife foraging areas, and beach sediments in human use areas on Site.
- Shallow intertidal sediments from at least one wildlife foraging area upstream of the Site and beach sediments in at least one human use area upstream of the Site to characterize background exposure conditions.

Sediments collected to fill these data gaps will also be useful in the evaluation of bioaccumulation processes. Stations for sampling of tissue will be co-located with these and with stations for characterization of nature and extent of contamination in sediment collected as part of Study Element 1. Project-specific DQOs addressing Study Element 2 for sediment, and a SAP designed to achieve these DQOs, were developed and presented in the sediment SAP (Integral and Anchor QEA 2010).

5.2.3 Water Data Gaps

Available data for water are limited, with only ten samples collected from within the Site in the available data set, and only dioxins and furans analyzed in these samples. Because water chemistry in the brackish estuarine of the Site is highly variable both temporally and spatially, empirical characterization of water chemistry is complex and would require a prohibitively high number of samples. Human exposures via water may be low relative to exposures resulting from ingestion of contaminated sediment and tissue from the Site because people are not expected to ingest substantial quantities of water from the Site. Although fish and invertebrates may be exposed to contaminants in water, evaluation of exposures to these ecological receptors will be through measurement of contaminants in their tissue (for organic COPCs), through concentrations of COPCs in bulk sediment, or through evaluation of the total dose ingested as a result of ingestion of contaminated media. Mammals are unlikely to ingest water at the Site. For birds, the fraction of the ingested dose

of any COPC due to ingestion of water, when ingestion of prey and contaminated sediment are considered, is expected to be minor.

Nevertheless, estimates of COPC concentrations in water are needed to address ecological exposures, both for the risk assessment and to understand processes controlling bioaccumulation of COPCs into tissues. Therefore, the concentration of dioxins and furans in water are considered a data gap. The approach to estimating water quality will be presented in the Technical Memorandum on Fate and Transport Modeling as discussed in Section 6.1.5 and the uses of these estimates in the ecological exposure evaluation are addressed in Section 6.4.3.

5.2.4 Tissue Data Gaps

Tissue chemistry data have not been collected within the Site since 2004, and the available data set consists of only 38 samples of edible fish and crab tissue (Section 2.3.6). Baseline risks associated with ingestion of contaminated tissues from the Site cannot be accurately characterized with the available tissue chemistry data. Information on the concentrations of COPCs in fish and shellfish tissue is needed to reliably characterize exposures and risks to people who eat fish caught at the Site, risks to fish and aquatic invertebrates using tissue-based effects levels (for organic COPCs), and to wildlife that consume fish in their diet. Expected data gaps to be addressed by Study Element 2 include concentrations of COPCs in the following types of tissue samples:

- Edible tissue of fishes that have home ranges comparable to part or all of the area of the in-water portion of the Site
- Edible tissue of shellfish likely to spend a significant portion of their lives on the Site
- Whole fish in species that are likely to spend a significant portion of their lives on the Site, can be highly exposed to sediment contaminants and are of size classes that can be eaten by other ecological receptors to characterize exposure to piscivorous fish and wildlife and to the fish themselves
- Tissue of benthic invertebrates to characterize exposure to ecological receptors due to ingestion of prey
- Tissue of bivalve molluscs to address risk to this receptor

Collecting some of these tissue samples (particularly samples of species with small home ranges) at stations where sediments are being collected will facilitate evaluation of tissue-sediment bioaccumulation relationships, if they exist. Other factors that affect chemical bioavailability and uptake (e.g., sediment carbon content) will be considered in the evaluation of bioaccumulation. All relevant tissue, sediment, and water data will be analyzed to develop Site-specific bioaccumulation functions, if possible.

Project-specific DQOs addressing Study Element 2 for biological tissue, and a SAP designed to achieve these DQOs, will be developed and presented in the forthcoming Technical Memorandum on Bioaccumulation, and Tissue SAP.

5.3 Study Element 3: Physical CSM and Fate and Transport Evaluation

Development of the physical CSM and conducting a chemical fate and transport evaluation depend on data and information related to: 1) hydrodynamics; 2) sediment transport; and 3) chemical fate and transport.

Hydrodynamic data needs are:

- Bathymetry and geometry
- River flow rates
- Current velocities
- Water surface (tidal) elevation
- Wind speed and direction
- Salinity

Data and information related to sediment transport are:

- Magnitude and composition of sediment loading in the river
- Bulk bed properties, including grain size distribution and dry density
- Bed type delineation (i.e., areas of cohesive and non-cohesive bed sediment)
- Erosion properties of cohesive bed sediment
- Net sedimentation rates
- Suspended sediment concentrations in the water column

Data and information for chemical fate and transport are:

- Magnitude of chemical loading in the river
- Site-specific parameters for kinetic processes (e.g., partition coefficients, volatilization rates)
- Spatial distributions (horizontal and vertical) of bed chemical concentrations
- Water-column chemical concentrations
- Groundwater quality data at the Site

Most of the hydrodynamic, sediment transport, and chemical fate and transport data discussed above will be used during a computer modeling study that will be conducted for the Site area. The details of data requirements, and related field studies, for the fate and transport modeling study will be included in a forthcoming technical memorandum that will fully describe the modeling study.

5.4 Study Element 4: Engineering Design Evaluation

Engineering data are required to support the development and evaluation of remedial alternatives in the FS as well as to support the design of the selected remedy. The aspects of the engineering evaluation that require additional data include:

- Evaluation of dredging methods and potential water quality impacts associated with dredging
- Evaluation of methods for handling sediment after dredging, potentially including dewatering methods, the sizing of settlement areas and the ultimate consolidation of dredged sediment
- Evaluation of sediment capping methods
- Evaluation of soil strength and consolidation potential in areas where any potential containment systems may be built

To address data gaps related to dredgability and materials handling, geotechnical data will be required from representative sediment samples collected within the river. Index parameters (i.e., moisture content or total solids, grain size, Atterberg limits and specific gravity) will provide information to evaluate the behavior of sediments to be dredged. These data will be used to consider the appropriate size and types of dredge equipment, expected pumping and

dredge production rates, sediment dewatering processes, estimated sediment bulking during dredging, and anticipated pre- and post-dredge sediment volumes. Sampling methodology to evaluate dredgability and dredge material handling is described in more detail in the SAP and the FSP (Integral and Anchor QEA 2010).

Geotechnical data gaps will be addressed by obtaining sediment samples and completing geotechnical laboratory tests on those samples, as described in the SAP. A series of borings advanced from the upland and from a barge will be used to collect samples. These borings will be advanced at multiple locations to provide a representative characterization of the subsurface sediment profile.

Strength data will be used to evaluate the bearing capacity and slope stability for the design, construction, and viability of any potential containment systems. Vane shear and consolidated-undrained triaxial (CU triax) test results will be used directly as measures of sediment strength. Standard penetration test (SPT) blow counts and Atterberg limits test results will be correlated to sediment strength using standard-of-practice geotechnical engineering reference sources (e.g., Federal Highway Administration and TXDOT geotechnical manuals).

Settlement data will be used to estimate the magnitude and duration of expected settlement under the footprint of any potential containment systems. The results of this evaluation will be used for planning the crest elevation of the berms and the top elevation of any potential containment systems. Consolidation test results will be used as a direct measure of sediment compressibility. Atterberg limits and moisture content data will be used to correlate expected compressibility parameters using similar standard-of-practice geotechnical engineering references as described above.

Permeability data will be used to evaluate potential fate and transport mechanisms within any potential containment systems. Permeability will be directly measured by the permeability test. Permeability can also be correlated with data reported from the triaxial shear strength test and loosely correlated with grain size data that will be collected.

6 REMEDIAL INVESTIGATION APPROACH

According to USEPA (1998) guidance, the objective of the RI/FS is "to gather information sufficient to support an informed risk management decision regarding which remedy appears to be most appropriate for [the Site]." Accordingly, the approach to the RI targets and prioritizes the practical information identified in Section 5 that will be required to effectively plan a removal action that will reduce risks from human and ecological exposures to COPCs to acceptable levels. The RI approach considers the urgency of risk management at this Site, as articulated by USEPA in the 2009 UAO, by accelerating decisions, such as the selection of COPCs (Appendix C) in a manner that is thorough, conservative and efficient, to quickly facilitate the Site evaluation and development of remedial action alternatives with relevant and sound information. The approach to the RI is centered on the following functional themes derived from the evaluation of existing data (Section 2) and development of the CSM (Section 4):

- Pulp mill wastes placed in the impoundments in 1965 and 1966 are the source of hazardous chemicals of interest to the RI/FS.
- Site history and the CSM, existing chemistry data for sediments collected from within the impoundments and additional information identifying those chemicals potentially occurring in bleached kraft pulp mill wastes from the 1960s provide a sufficient basis for determination of COPCs for both aquatic and upland portions of the Site at the outset of the RI/FS. Methods, information resources, and data used in the analysis to determine COPCs are documented in Appendix C.
- Dioxins and furans congeners are an indicator chemical group that is diagnostic of chemical releases from the impoundments to the San Jacinto River systems and is likely to dominate Site-specific risks to humans and ecological receptors. Dioxins and furans are an appropriate indicator chemical group for the RI because of their toxicity, their elevated concentrations in impoundment sediments relative to upstream sediments, their distinctive fingerprint associated with the Site (Louchouarn and Brinkmeyer 2009), their environmental persistence and their potential to be transported away from the source (USEPA 1988a). As such, remedial actions taken to address unacceptable risks associated with dioxins and furans are highly likely to effectively remove or eliminate risks due to other COPCs, unless otherwise indicated by the RI results.

- Because COPCs may accumulate in biological tissue, and unacceptable risks to people and ecological receptors are likely to derive largely from ingestion of contaminated food, the ability to accurately predict concentrations of COPCs in tissues using information on abiotic media (sediment and water) is important to defining remediation goals for sediments and related media.
- The Site is located in an area influenced by municipal, commercial, and industrial activities. Chemical contaminants generated outside the Site may be transported into the Site by physical or biological means. Evaluation of risks and remedial actions will consider those influences.
- The environment surrounding the Site is physically dynamic, with sediment and water transported across the Site by the physical action of the river and tidal flows. Characterization of these processes, and their role in the long-term character and degree of contamination at the Site, is critical to determine the appropriate remedial action(s). Basic information on the physical processes connecting the Site to the surrounding areas, and on the levels of chemical contamination in upstream areas, is needed for risk management decisions.

This section provides an overview of the following primary tasks to be performed as part of the RI:

- Site characterization, including characterization of the physical system and nature and extent of contamination in abiotic media and biological tissue
- Characterization of background concentrations of COPCs in abiotic media and biological conditions, and in particular conditions upstream of the Site
- Characterization of ecological risks
- Characterization of human health risks

Each of these sub-sections below describes the approach and types of information to be developed in support of these tasks. Additional details on the conceptual basis, study design sampling and analytical methods, and data evaluation approach for each task will be provided in subsequent deliverables, according to the schedule in Section 8. Additional deliverables anticipated for this RI include the following:

- Bioaccumulation Memorandum and Tissue SAP

- Fate and Transport Modeling Memorandum and Addendum to the Sediment SAP
- Soil SAP
- Groundwater SAP

A Sediment SAP has been drafted in consultation with the USEPA, and it addresses the conceptual basis and methods required to address the sediment data gaps identified in Section 5. Because the draft sediment study design has been completed, a greater level of detail on the study design is provided in this section than for other media. Development of detailed design information for the other components is currently in progress.

6.1 Site Characterization

Physical and chemical measurements will be made both to characterize the Site empirically and also to support evaluations of transport processes, evaluations of bioaccumulation processes, and engineering design. Measurements will be made within preliminary Site perimeter and also within the area. Measurements of sediment and tissue chemistry, and estimated water-column chemical concentrations in these areas will be used to evaluate the primary determinants and effects of exposure to the COPCs.

6.1.1 Sediment

The purpose of investigating chemicals in sediment is to determine the nature and extent of potential contamination to characterize sediment-related exposures of aquatic life, aquatic-dependent wildlife, and people who use the Site and identify any unacceptable risks associated with the contamination and to evaluate potential remedies. To meet these goals, surface sediment from throughout the Site, including upstream and downstream from the waste impoundments, will be collected from three types of areas:

- Submerged sediment throughout the Site, which represents a potential exposure route to benthic macroinvertebrates and some fish and crabs
- Shallow water sediment in locations available to foraging wildlife
- Beaches that may be used by people for fishing or recreation

Subsurface sediment will be collected at selected locations within the Site to evaluate the depth of elevated concentrations of COPCs and to collect geophysical information needed to

evaluate remedial alternatives. Subsurface sediment will also be collected at representative beaches that may be used by people, to evaluate exposure that may result from digging activities.

Sediment will be collected from within the waste impoundment area to characterize the chemical profile of material released from this location, as well as to determine the depth and width of contamination remaining in the impoundments. This information will be used to characterize the contribution of COPCs from the waste impoundment to other sediments within the Site. Sediment will be collected from locations within the area that are upstream of the Site itself. Data from these locations will be used to evaluate background conditions and to calculate incremental risk related to exposure of COPCs originating at the waste impoundments.

Details of the sediment sampling design for Site characterization are presented in the sediment SAP. Primary elements of this design are:

- Surface sediment sampling and analysis of primary COPCs at 26 locations in and near the impoundments on a 500-foot (152-m) grid, at 1 location in the channel immediately south of I-10 and toward the western side of the preliminary Site perimeter, and at 4 locations along the eastern perimeter of the original impoundments. Additional sediment from these 31 locations will be archived for later analysis of secondary COPCs, if necessary. Primary and secondary COPCs will be measured at an additional 13 locations on the 500-foot (152-m) grid, at 2 locations near the impoundment, and at 2 locations south of I-10. These samples will provide data for the nature and extent, exposure, and fate and transport analyses. Data from locations from within the impoundment area (seven stations), will allow characterization of waste materials and will be used for analysis of potential human exposures within the impoundments (along with existing data) as well as other objectives related to Study Elements 1 to 4. Data from the two locations south of I-10 will provide information on possible prop scour or possible dredging disturbances.
- Surface sediment sampling and analysis of primary COPCs at an additional 15 locations within the Site boundary, on a 1,000-foot (305-m) grid (with some distance adjustments at two stations south of I-10 to place stations within the river rather than on land). These samples will provide data for the nature and extent, exposure, and

fate and transport analyses. Additional sediment from these stations will also be archived for possible future analyses of secondary COPCs.

- Collection of cores and analysis of primary COPCs at 12 locations within approximately 1,000 feet (305 m) of the impoundment and at 2 locations south of I-10. Additional sediment from these stations will also be archived for possible future analyses of secondary COPCs. These samples will provide data for the nature and extent evaluation and for dredgability assessments. Data from the two locations south of I-10 will provide information on possible prop scour or possible dredging disturbances.
- Collection of surface samples and analysis of primary and secondary COPCs at 11 locations upstream of the Site but downstream of the channelized portion of the San Jacinto River, to allow estimation of local background conditions for the nature and extent, exposure assessments, and fate and transport analysis.
- Collection of intertidal sediment samples at 45 locations in three different human exposure areas on five beaches near the Site to evaluate potential human exposure and whether the beaches represent different exposure conditions for human receptors. Surface and subsurface sediment samples will be collected at all 45 stations at each of the five beaches. Twenty-five of the surface intertidal sediment samples will be analyzed for primary COPCs, with additional sediment archived for possible future analysis of secondary COPCs. Surface sediment samples from the remaining 20 stations will be archived for future analysis of primary and/or secondary COPCs, if necessary.
- In addition, half of the subsurface samples collected at Stations SJSH026 through SJSH035 will initially be analyzed for primary COPCs; the archived subsurface sediment samples from the other half of these stations and all of the subsurface samples from the other two beaches will be archived for possible future analysis of primary and/or secondary COPCs, if necessary.
- Collection of intertidal sediment samples for analysis of primary COPCs at ten locations upstream of the Site, but downstream of the channelized portion of the San Jacinto River, for evaluation of human exposures under upstream background conditions. Surface and subsurface sediment samples will be collected at all 10 stations at this beach. Half of the surface intertidal sediment samples will be analyzed for primary COPCs. The other half of the surface and all of the subsurface samples

will be archived for possible future analysis of primary and/or secondary COPCs, if necessary. Surface samples from these stations will also be used to evaluate ecological exposures.

- Collection of intertidal samples from six locations at two ecological exposure areas on the Site and three locations at one ecological exposure area upstream for characterization of exposure of ecological receptors such as wading birds. These samples will be analyzed for primary COPCs. Additional sediment from these stations will be archived for possible future analyses of secondary COPCs, if necessary.
- Sediment borings at 17 locations and VSTs at 18 locations in the impoundment and in locations around the perimeter berms. Measurements of sediment engineering characteristics (strength and settlement behavior) will be used to support Study Element 4.

Surface sediment samples collected for the nature and extent evaluation will also be used to support the evaluations of exposure of aquatic receptors, chemical fate and transport, and sediment dredgability. Samples collected to support exposure assessments for humans and wildlife and to support remedial alternatives are more specialized in purpose and location and will be collected in nearshore shallow areas.

6.1.2 Surface Water Investigation

Although available surface water data are limited, current concentrations of COPCs in surface water within the Site are comparable to those at upstream locations (Section 2.3.4). In addition to analysis of exposures using sediment and tissue data from the Site, chemical fate and transport modeling and other Site-specific data may be used with appropriate COPC partition coefficients, to predict dissolved COPC concentrations in surface water and porewater. To address exposures, these estimated values would be used to evaluate direct exposure of aquatic receptors to surface waters and incorporated into a bioaccumulation model to estimate exposure of higher trophic level organisms and people (exposures to porewaters are addressed by other means, i.e., tissue concentrations in biota, and the dermal absorption model for people). If large uncertainties in risk assessment results are due to the use of these estimates, then confirmatory sampling of surface water quality conditions may

be considered in a future phase of Site investigation. The need for direct assessment of porewater as a means to understand the role of surface water in fate and transport will be determined as a result of more detailed conceptual models that will be performed as a component of phases1 and 2 of the fate and transport analysis (Section 6.1.6).

6.1.3 Biota Investigation

Development of information on the chemistry of biological tissues, as affected by the Site, includes an empirical component in which new tissue chemistry data are collected, and a modeling effort in which the empirical tissue chemistry, as well as related information on the environment in which organisms were exposed, are analyzed to determine whether empirical models to predict tissue chemistry can be developed. Additional empirical information on tissue chemistry is needed for the evaluation of exposure to any receptor that consumes invertebrates or fish, and for the evaluation of risk to invertebrates and fish themselves. Some of the risk analyses anticipated will require tissue collections upstream. Evaluations leading to one or more statistical models to predict tissue chemistry data are needed to support development of risk-based PRGs, and to determine which environmental media plays the greatest roles in exposure and risk for ecological and human receptors. The approach to addressing data gaps for tissue is described generally below. Additional specific information on this subject, and supporting analyses, will be provided in the Technical Memorandum on Bioaccumulation. The DQOs for collection of additional data, as well as the sampling design and all related methods, will be provided in the Tissue SAP.

6.1.4 Tissue Sampling and Analysis

The specific design for tissue sampling is still under development and will be addressed in a tissue SAP to be submitted in June 2010. However, the evaluation of existing data and the determination of the overall approach to the RI provide the basis for identification of specific tissue data gaps relating to the exposure assessment (Section 5.2.4) and specification of some design details:

- Tissue samples will be collected to address the data gaps identified in Section 5.2.4, which relate to the need for exposure assessment. To improve the efficiency of the study design, tissue samples will be collected to serve multiple objectives of Study Element 2, to the maximum extent possible.

- Tissue samples, particularly for small home range receptors, will be collected at sub-set of locations where sediment samples have been collected, to the extent practicable. Tissue samples will not be collected at all sediment sampling locations, but the stations for tissue sampling will be selected to reflect the range of potential sediment exposures of the targeted species, and to provide the appropriate level of statistical certainty for the intended applications in the RI.
- Species to be collected during tissue sampling will be those selected as ecological receptors, or those known to be used by people.
- Tissue samples will be collected to maximize their usefulness in comparisons with existing information (e.g., University of Houston and Parsons 2006), particularly in the human health risk assessment.
- Limited tissue sampling will occur upstream of the Site (with a level of effort no greater than that of the upstream sediment samples to be collected for the exposure assessment) for the purposes of evaluating exposure and risks in upstream background areas.

Tissue samples will be collected to support Study Element 2, exposure evaluation, which relates to the baseline human and ecological risk assessments. To identify analytes for tissue samples collected according to this SAP, analyses of sediment data is required, as follows. Results of sediment chemical analyses from the sediment sampling conducted in May 2010 will be generated prior to the performance of tissue sampling. Once validated chemistry data are available for sediments, results for secondary COPCs will be evaluated for frequency of detection in sediments and for statistical correlation with dioxins and furans in sediment that are representative of the wastes in the impoundments (i.e., one or more of the most common congeners in waste-related sediments). Those secondary COPCs never detected in sediment will not be considered in the risk assessments, and will therefore not be measured in tissue. This approach is conservative because several sediment samples are from directly within the waste impoundments. Those secondary COPCs that are detected at least once and that statistically correlate with representative dioxin and furan congeners will not be evaluated in tissue, because any risk associated with a secondary COPC that correlates with representative dioxins and furans is likely to be addressed by sediment remediation performed to address risk due to dioxins and furans. As noted for sediment COPCs in the Sediment SAP, these decision rules apply unless additional information indicates that a COPC may be present at

elevated levels in tissues on Site as a result of exposure to the waste in the impoundments. For example, PCB congeners may be evaluated in tissue, even if they correlate with dioxins and furans, because of the possibility that their toxicity is considered additive with that of dioxins and furans for some endpoints in some species.

Approaches to analyses of the tissue chemistry data are described in Sections 6.3 and 6.4.

6.1.5 Groundwater Investigation

During the RI, groundwater quality at the Site will be investigated, both in the shallow (unconfined) and Upper Chicot Aquifer zones. Information regarding the groundwater investigation scope, methodology and DQOs will be provided in a Groundwater SAP. At this time, it is anticipated that 3 pairs of nested wells (i.e., monitoring the shallow and Upper Chicot Aquifer zones in the same region of the Site) will be installed to obtain groundwater samples and evaluate groundwater quality. In addition, the wells will enable quantification of hydrogeologic characteristics at the Site, such as vertical groundwater flow, if any, localized groundwater flow magnitude and direction, and physiochemical interaction between the San Jacinto River and groundwater.

6.1.6 Chemical Fate and Transport Analysis

The evaluation of chemical fate and transport within the Site will use a combination of data (empirical) and modeling analyses and will be used to address data gaps related to Study Element 3, as well as to provide estimates of water chemistry to address data gaps related to Study Element 2. The primary objectives of the chemical fate and transport analysis are:

1. Develop (CSMs) for sediment transport and chemical fate and transport;
2. Develop and apply quantitative methods (i.e., computer models) that can be used as a management tool to evaluate the effectiveness of various remedial alternatives; and
3. Answer specific questions about chemical fate and transport processes.

Additional information on chemical fate and transport at the Site, and supporting analyses, will be provided in the Technical Memorandum on Fate and Transport Modeling which will be accompanied by a SAP for sampling to address data gaps specific to Study Element 3. A description of the general approach and sequence of events follows:

Evaluating chemical fate and transport will be accomplished using a phased approach because of the complex interactions between the waste impoundments area and the San Jacinto River. A phased approach will produce the most efficient method for studying chemical fate and transport. Three phases for the fate and transport study are proposed, with the primary tasks of each phase described below. Note that decision points occur near the end of Phases 1 and 2; these decision points will be used to refine and adjust the study design as needed, which will help to maximize efficiency and cost-effectiveness.

6.1.6.1 Phase 1: Data Analysis and Hydrodynamic Modeling

Phase 1 consists of data analysis and hydrodynamic modeling and includes the following tasks:

- Compile and analyze available data related to: 1) hydrology and hydrodynamics; 2) sediment transport and geomorphology; and 3) chemical fate and transport
- Identify data gaps and design field studies to fill those gaps
- Develop preliminary CSMs for: 1) sediment transport; and 2) chemical fate and transport
- Determine primary study questions that need to be answered by modeling and additional analysis to support the RI study
- Conduct field studies to support hydrodynamic modeling
- Analyze hydrodynamic data
- Develop and calibrate hydrodynamic model
- Use hydrodynamic model as a diagnostic tool to:
  - Develop insights about sediment transport and chemical fate and transport within the Site and nearby areas
  - Answer primary study questions related to hydrodynamics
- Refine CSMs for sediment transport and chemical fate and transport
- Refine design of Phase 2 as necessary

6.1.6.2 Phase 2: Sediment Transport Modeling and Analysis

Phase 2 consists of sediment transport modeling and analysis and includes the following tasks:

- Conduct field studies to support sediment transport modeling
- Analyze sediment transport data
- Develop and calibrate sediment transport model
- Conduct sensitivity/uncertainty analysis to evaluate model reliability
- Use sediment transport model as diagnostic tool to
  - Develop insights about sediment transport and chemical fate and transport within the Site and nearby areas
  - Evaluate sediment stability during floods and over multi-year periods
  - Answer primary study questions related to sediment transport
- Refine CSMs for sediment transport and chemical fate and transport
- Determine if Phase 3 is needed
- Refine design of Phase 3 as necessary

6.1.6.3 Phase 3: Chemical Fate and Transport Modeling and Analysis

Phase 3 consists of chemical fate and transport modeling and analysis and includes the following tasks:

- Conduct field studies to support chemical fate and transport modeling
- Analyze chemical fate and transport data
- Develop and calibrate chemical fate and transport model
- Conduct sensitivity/uncertainty analysis to evaluate model reliability
- Use fate and transport model as diagnostic tool to
  - Develop insights about chemical fate and transport within the Site area
  - Evaluate the rate of natural recovery throughout the study
  - Answer primary study questions related to chemical fate and transport
- Refine CSM for chemical fate and transport

Conducting a fate and transport study will produce management tools that can be used to evaluate and compare current and future conditions in the Site. The development of hydrodynamic, sediment transport, and chemical fate and transport models will make it possible to understand how chemicals are transported throughout the Site, to address uncertainties about partitioning of chemicals from sediments to water, and to describe the

ultimate fate of these chemicals. Results of the chemical fate and transport model will include predictions of chemical concentrations in the water column and sediment bed. In addition, the models can be used to quantitatively evaluate the effectiveness of potential remedial actions. A detailed description of the modeling study, including field studies, will be provided in a technical memorandum that is currently being prepared.

6.1.6.4 Bioaccumulation and Food Web Analysis

COPCs were identified for further evaluation in the RI if they may be bioaccumulative. Models to predict chemical concentrations in tissue are required for development of PRGs (Section 6.4) and for interpretation of sediment and water chemistry when tissue data do not exist. A Site-specific evaluation of bioaccumulation will be performed to determine whether models to predict COPC concentrations in tissue can be derived. Both statistical and mechanistic models will be evaluated. Such a model, or models, will provide a means to quantify uncertainty associated with predictions of tissue concentrations.

A technical memorandum addressing bioaccumulation modeling will be developed and will be submitted with the Tissue SAP, in June 2010. The memorandum will include a discussion of the literature that provides relevant data or analyses (e.g., Dean et al. 2009), an evaluation of relevant approaches to modeling and will indicate a selected approach and related analytical steps. The technical memorandum will relate directly to the tissue study design.

6.1.7 Source Evaluation

To determine the proportional contribution of COPCs from the waste impoundment to sediments throughout the Site, the chemical fingerprint of sediment in the impoundments will be determined. In addition, five sediment samples and several cores will be collected from the impoundment area to allow the range of conditions within the impoundments to be assessed. These sediment samples will be collected to support the nature and extent evaluation. All primary and secondary COPCs will be measured in these sediment samples.

Sediment samples from throughout the area of the Site, including the source characterization samples from the impoundment, will be evaluated using an unmixing method (non-negative matrix factorization [Lee and Seung 1999]). This method will identify different dioxins and

furan patterns that are likely to have produced the dioxin and furan pattern observed in Site sediments. These patterns may be associated with particular sources, and statistical similarity measures will be used to evaluate the relationship(s) between patterns and sources. Sediment samples collected from within the impoundments will be used in this analysis to represent the dioxin and furan pattern of waste material that was deposited in the impoundments. The unmixing analysis, and interpretation of the results in terms of sources, will then be used to produce an estimate of the proportion of source-related material in each Site sample, and in each upstream sample. The pattern of dioxin and furan congeners is expected to allow source material contributions to other sediment samples to be identified and quantified, based on the patterns seen in available data, where tetrachlorinated congeners are relatively elevated in samples from the impoundments (Louchouarn and Brinkmeyer 2009).

6.2 Background/Reference Area Characterization

Sediment and tissue data collected from locations within the San Jacinto River upstream of the Site will be used to characterize background conditions. In addition, evaluation of the potential for the Site to have affected groundwater will include consideration of background groundwater conditions. Background conditions will be evaluated because programs under the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) ordinarily do not remediate to concentrations below background, and risks related to background concentrations of COPCs should be evaluated (USEPA 2002d). The information collected from upstream background locations will provide context for the evaluations of nature and extent, exposure, and risk that will be conducted at the Site, and will be used to support development of PRGs.

As described in USEPA (2002d), contamination at a CERCLA site may be due to releases from the CERCLA site itself, as well as contamination from other sources, including natural and/or anthropogenic sources that are not related to the Site under investigation. According to the OSWER guidance, background is a factor that should be considered in risk assessment and risk management at CERCLA sites. Consistent with this, the broad goal of a background evaluation in the context of an RI/FS is to estimate the levels of chemicals that would exist in environmental media at the Site in the absence of CERCLA-related releases of hazardous

chemicals from the Site or releases from other point sources of contamination within the Site.

Background conditions are particularly salient in the case of the San Jacinto River Waste Pits Site. This is because of the urbanized and industrialized regional setting, and the fact that the portion of the San Jacinto River occupied by the Site is influenced by many human activities occurring across the upstream watershed and in the San Jacinto River estuary. Extensive details on the local and regional setting of the Site were discussed in earlier sections of this Work Plan.

To achieve a consistent understanding of the background, the following definitions provided in USEPA (2002d) are adopted for this RI/FS:

- **Background**—"Substances present in the environment that are not influenced by releases from a site and are usually described as naturally occurring or anthropogenic.
    1. ***Naturally occurring*** – substances present in the environment in forms that have not been influenced by human activity; and,
    2. ***Anthropogenic*** – natural and human-made substances present in the environment as a result of human activities (not specifically related to the CERCLA site in question)."
- **Reference Area—**"The area where background samples are collected for comparison with samples collected on site. The reference area should have the same physical, chemical, geological, and biological characteristics as the Site being investigated, but has not been affected by activities on the Site…. Background reference areas are normally selected from off-site areas, but are not limited to natural areas undisturbed by human activities."

Various statistical techniques for characterizing background levels of COPCs—ranging from point values (e.g., estimates of background central tendency [CT] and upper background threshold values), to hypothesis testing to compare whether background and Site data are drawn from the same population—may be appropriate for different purposes in the RI/FS process. Background CT estimates can be used, for example, to compare an average exposure point concentration (EPC) for an area of interest within a site—frequently estimated using a

95 percent upper confidence limit (UCL) on the mean exposure area concentration—with the background CT estimate. Background threshold values are often estimated using an upper percentile, an upper prediction limit, or an upper tolerance limit. Background threshold values can be applied in point-by-point comparisons of single concentrations measured within a site with the upper bound of the background concentration range. A background threshold value can also be used to define a "not-to-exceed" value that can be used in establishing PRGs (Singh and Singh 2007). Finally, parametric or non-parametric statistical hypothesis testing can be used as a more robust tool for comparing concentrations from a site, or subareas of a site, with background concentrations. Data for individual samples collected from upstream that are determined to be substantially influenced by the Site using methods outlined in the Section 6.1.5 will not be included in calculations of statistics used to represent background conditions. For this RI/FS, several potential uses of background information have been identified:

- **Risk Characterization—**Background concentrations will be used for comparison purposes in the risk characterization section of the baseline risk assessment. Per USEPA (2002d) direction, USEPA policy recommends an approach for baseline risk assessments that involves addressing site-specific background issues in the risk characterization step of the risk assessment process. Specifically, USEPA (2002d) states that "the COPCs with high background concentrations should be discussed in the risk characterization, and if the data are available, the contribution of background to site concentrations should be distinguished."
- **PRG Development—**Background values provide information that is relevant for risk management and establishing PRGs that will be evaluated in the FS. For example, if a risk-based threshold for a given chemical in sediment was determined to be 10 mg/kg, but the background sediment chemical concentration within the Site estimated from upstream chemistry was 100 mg/kg, the PRG would likely be set to background. Many different statistical techniques for comparing background and Site concentrations may be relevant in the context of PRG development.
- **Cleanup Area Delineation—**As part of the FS, cleanup areas will be defined. One method for this is "hilltopping." This is the process of identifying specific areas that must be remediated within a larger cleanup area to achieve a remediation goal. Hilltopping involves sequentially "removing" values, beginning with the highest concentration and working downward, until the average concentration in the cleanup

area reaches the remediation goal. In this process, a "replacement value" must be assumed for those stations that are "removed" in the process. Use of a background value as the replacement value is one potential approach of many that could be employed in the FS process.

- **Remedy Selection**—Hypothesis testing to compare background and site concentrations may be relevant in the context of remedy selection. For example, hypothesis testing to compare background and hypothetical sediment cleanup scenarios could be used in the FS to evaluate whether post-cleanup chemical concentrations would be similar to background or to evaluate the relative risk reduction among cleanup options.
- **Long-term Monitoring Post Remedy**—Background values are one possible metric for evaluating remedy performance based on long-term monitoring results after the remedy is implemented, including but not limited to areas where monitored natural attenuation is the selected remedy.
- **Potential Cap Material Selection**—Background levels such as the 95 percent upper confidence limit (95UCL) of the mean could be among the criteria for selecting capping material.

6.3 Baseline Human Health Risk Assessment

The primary objective of the BHHRA is to evaluate potential adverse health effects attributable to exposure to Site-related contaminants under pre-remediation, or baseline conditions. The results of the risk assessment will facilitate Site management decisions. The results of the BHHRA are likely to overestimate actual risks in order to provide a conservative basis for risk management decisions. The secondary objective of the risk assessment is to assist in the development of PRGs (Section 7.4), or the determination of institutional controls, if necessary, that are protective of people who are potentially exposed to Site-related contamination. To achieve these goals, the risk assessment will be conducted in accordance with national and state guidance, which are cited throughout this section.

Section 4.2 (Human Health Site Conceptual Model) provides important background information for the BHHRA technical approach. The technical approach described in this section consists of the following:

- Evaluation of data usability (Section 6.3.1)
- Screening and selection of COPCs (Section 6.3.2)
- Exposure assessment (Section 6.3.3)
- Toxicity assessment (Section 6.3.4)
- Risk characterization (Section 6.3.5)
- Uncertainty analysis (Section 6.3.6)

An important design component of this BHHRA is a comparison of risks associated with consumption of fish and shellfish caught at the Site versus risks associated with consumption of fish and shellfish caught at other locations regionally throughout the Houston Ship Channel and upstream from the Site. This comparison will provide critical perspective on fish consumption risks associated with regional chemical sources that will not be addressed by remediation at the Site. It is discussed in Section 6.3.5.3.

The 2009 UAO requires that approaches to the exposure and toxicity evaluations be provided to USEPA in two technical memoranda preceding delivery of the USEPA review draft of the BHHRA report: Toxicological and Epidemiological Studies Memorandum and Exposure Assessment Memorandum. Likely to impact the approach and performance of the exposure and toxicity assessments is USEPA's plan to finalize its dioxin toxicity reassessment by December 2010. The possible impact on approaches to the BHHRA, particularly on the toxicity assessment, is addressed in Section 6.3.4.2. Additional specific information on the approaches to be used to characterize regional and upstream human exposures and risks will be addressed in the Exposure Assessment Memorandum. The technical memoranda to support the BHHRA are planned according to the schedule provided in Section 8. The results of all components of the BHHRA will be presented in a comprehensive report, also delivered according to the schedule presented in Section 8.

6.3.1 Data Usability

Historical data were evaluated to determine quality using the information available in the associated reports (Section 3). Evaluation of data for the samples collected during the RI will be conducted according to the SAPs for the individual media (sediment, tissue, and soil). The results of the data usability analysis will be presented in the risk assessment report. In

performing calculations to support the risk evaluation, duplicate field sample results will be averaged before use in the risk assessment. All results flagged with R qualifiers (indicating rejection of data) will be excluded from use in the risk assessment. For calculation of media concentrations for COPCs other than dioxins and furans, results flagged with a "U" qualifier will be addressed as appropriate, considering the size of the data set and the number of non-detected results, consistent with USEPA's QA/G-9 guidance (USEPA 2000c). Possible methods include substituting half the detection limit for non-detected results, using the maximum value of the data set, and imputing substitution values using the robust probability plotting method of Helsel (2005).

Two approaches will be used for calculation of 2,3,7,8-TCDD TEQ concentrations: either one-half the sample quantitation limit (SQL) or zero will be assigned to non-detected results for individual congeners. The results of both approaches will be presented in the risk assessment.

6.3.2 Screening and Selection of COPCs

Appendix C presents the sediment COPC screening process. The basis for the screening process was sediment samples collected from within the waste impoundment area because, based on the Site history and CSM; the materials within the original impoundments are considered the source of contamination of sediment, soils, and water at the Site. The screening process also considered the potential for bioaccumulation in tissues. Thus, the chemicals identified as COPCs for sediment will also be considered COPCs for soil and tissue (if they are bioaccumulative). Other media will not be evaluated quantitatively for human exposures (see Section 4.2). Chemical forms will be considered in the risk assessment. For example, mercury will be assumed to be in inorganic forms in soil and sediment and in the form of methylmercury in fish and shellfish tissue.

6.3.3 Exposure Assessment

An exposure assessment estimates the type and magnitude of human exposure to COPCs identified at a Site. Subjects that must be considered during the exposure assessment include the CSM, EPCs, and contaminant intakes. An Exposure Assessment Memorandum,

submitted according to the schedule in Section 8, will address each of these subject areas, as discussed below.

6.3.3.1 Conceptual Site Model

The current understanding of human receptors and exposure pathways at the Site is discussed in Section 4.2. The exposure routes that will be evaluated quantitatively include the following:

- Ingestion of and dermal contact with sediment by fishers and recreational visitors
- Ingestion of and dermal contact with soil by fishers and recreational visitors
- Consumption of fish and shellfish by fishers[9]

Exposures to other media are considered minor and will be evaluated qualitatively. The CSM will be re-evaluated if necessary as the understanding of the Site increases during the course of Site investigation activities. If additions or deletions to the list of exposure routes are deemed appropriate, they will be discussed in the Exposure Assessment Memorandum.

6.3.3.2 Exposure Point Concentrations

To estimate the magnitude of exposure for each of the receptors described above, a representative concentration of each COPC present in a medium, (i.e., EPC) must be calculated. An EPC is a conservative estimate of the chemical concentrations in a medium that a receptor is likely to contact over time (USEPA 1989). Because of the uncertainty associated with estimating a true average concentration, USEPA (1992) recommends calculating the 95UCL of the arithmetic mean concentration in the exposure area. USEPA provides multiple guidance documents for computing 95UCLs (USEPA 2002a, 2006b). Values for the 95UCLs will be computed to represent EPCs as appropriate for the statistical distribution of the data set. The lesser of the 95UCL or the maximum concentration for each COPC in a data set will be used as the EPC for each exposure area.

Baseline data from relevant historical investigations and data from the RI field investigations will be included in EPC calculations. Data will be grouped into appropriate exposure areas,

[9] Evaluation of human exposures will include the use of tissue chemistry data for one or more aquatic species currently the subject of consumption advisories.

such as the impoundment area or the area adjacent to the upland portion of the property west of the impoundments, considering both the statistical characteristics of the data sets and facilitation of risk management and future land use decision-making.

The Exposure Assessment Memorandum will provide the following information relative to EPCs:

- Determination of exposure areas based on evaluation of statistical characteristics of data sets and risk management considerations
- Sample station locations and sample identification numbers for the data set for each exposure area
- Statistical description of each data set (e.g., summary statistics, distribution testing)
- Determination of appropriate method for calculation of EPC for each data set, including how non-detected results will be handled for each chemical and medium
- EPC concentrations for each exposure area

The Exposure Assessment Memorandum will also address the specific calculations and uses of background and regional exposures in the risk evaluation, and will address developing policy as articulated as a result of the dioxin reassessment being conducted by USEPA.[10]

6.3.3.3 Intake Estimates

To quantify exposure, human intake levels resulting from exposures to COPCs are estimated using exposure algorithms and assumptions. Exposure estimates for ingestion and dermal exposures represent the daily dose of a chemical taken into the body averaged over the appropriate exposure period, expressed as milligrams of chemical per kilogram of body weight per day. The primary source for the exposure algorithms used in this evaluation is USEPA (1989) although other supplemental risk assessment guidance documents also will be used (e.g., USEPA 2004, TAC 350.74-75). The generalized equation for calculating chemical intakes is shown below:

$$I = \frac{EPC \times CR \times EF \times ED \times F \times ABS}{BW \times AT} \qquad \text{(Eq. 6-1)}$$

Where:

[10] http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=209690

I = intake, the amount of chemical taken in by the receptor (mg/kg body weight-day)

EPC = exposure point concentration, the chemical concentration contacted over the exposure period at the exposure point (e.g., mg/kg sediment)

CR = contact rate, the amount of affected medium contacted per unit time or event (e.g., sediment ingestion rate [mg/day])

EF = exposure frequency, describes how often exposure occurs (days/year)

ED = exposure duration, describes how long exposure occurs (year)

F = intake fraction, fraction of medium contacted that is assumed to be from the contaminated source (unitless)

ABS = absorption factor, an adjustment factor to account for relative absorption of a chemical from the medium of interest compared to absorption from the exposure medium in the toxicity study used to derive the toxicity value (unitless)

BW = body weight, the average body weight over the exposure period (kg)

AT = averaging time, period over which exposure is averaged (days)

The variables shown in the exposure algorithm above are called exposure factors and vary depending on the receptor population being evaluated. Each receptor population (i.e., fishers and recreational visitor) will be characterized by a number of parameters unique to the receptor population and the exposure pathway. Several regulatory agency and literature sources will be considered when deriving parameter values, including but not necessarily limited to the following:

- Risk Assessment Guidance for Superfund (RAGS) Volume I Part A (USEPA 1989)
- RAGS Volume I Part B – Development of Risk-Based Preliminary Remediation Goals (USEPA 1991)
- RAGS Volume I Part C – Risk Evaluation of Remedial Alternatives (USEPA 1991)
- Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors (USEPA 1991)
- Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure (USEPA 1993)
- Soil Screening Guidance: User's Guide (USEPA 1996)
- Exposure Factors Handbook (USEPA 1997a)
- Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites

(USEPA 2002c)

- RAGS Volume I Part E – Supplement Guidance for Dermal Risk Assessment (USEPA 2004)
- Child-Specific Exposure Factors Handbook (USEPA 2008)
- Texas Administrative Code sections containing exposure equations and parameters (TAC 350.74-75)

Exposure factors specific to each receptor and chemical intake equations specific to each exposure pathway will be provided in the Exposure Assessment Memorandum. For example, consumption rates for fish and shellfish will be described in the memorandum. A wide range of values for fish ingestion rates are available from various sources including, but not necessarily limited to, USEPA (2000b, 2010), TCEQ (2003) and TDSHS (2005a), which will require a detailed analysis of applicability and validity for the BHHRA.

The exposure factors will include values for a reasonable maximum exposure (RME) scenario and a CT scenario for each receptor, as defined by USEPA (1989), and will be calculated using data generated by the Site investigations. The RME scenario is a combination of high-end and average exposure values that is used to represent the highest exposure that reasonably could occur. The CT scenario is based on average estimates of exposure. The RME scenario provides a conservative estimate of exposure that is plausible but is still well above the average exposure level, while the CT exposure provides a conservative estimate of typical exposure for most individuals within a population and is useful for comparing with the RME. Exposure estimation under both conditions will provide additional risk characterization information for the risk management and remediation decision making process.

6.3.4 Toxicity Assessment

The purpose of a toxicity assessment is to evaluate the relationship between the extent of exposure to a contaminant and the increased likelihood and/or severity of adverse effects. Standard procedures for assessing and quantifying the toxicity of the COPCs will be applied in the risk assessment (USEPA 1989). These procedures will include identifying toxicity values for cancer and non-cancer health effects and summarizing other relevant toxicity

information. The Toxicological and Epidemiological Studies Memorandum, submitted according to the schedule in Section 8, will summarize the relevant literature on the COPCs and the toxicity criteria used in the BHHRA.

6.3.4.1 Toxicity Criteria

Potential risks of cancer and non-cancer health effects from exposure to Site-related chemicals will be evaluated using quantitative toxicity values. As recommended by USEPA (2003b) and consistent with TCEQ (2009) guidance, the toxicity values that will be used in these analyses are, in order of preference, values available in USEPA's Integrated Risk Information System (IRIS),[11] then USEPA's Provisional Peer Reviewed Toxicity Values (PPRTVs) from the Office of Research and Development/National Center for Environmental Assessment/Superfund Health Risk Technical Support Center.[12] If neither IRIS toxicity values nor PPRTVs are available, then toxicity values may be obtained from other documented sources, such as the Agency for Toxic Substances and Disease Registry's (ATSDR) Minimal Risk Levels.[13] Cancer and non-cancer toxicity values that will be used in the risk assessment will be provided in the Toxicological and Epidemiological Studies Memorandum.

To assess carcinogenic health effects, cancer slope factors (CSFs) are used to assess oral and dermal exposures. CSFs are upper-bound estimates of the carcinogenic potency of chemicals that are used to estimate the incremental risk of developing cancer, corresponding to a lifetime of exposure at the levels estimated in the exposure assessment. In standard risk assessment procedures, estimates of carcinogenic potency reflect the conservative assumption that no threshold exists for carcinogenic effects (i.e., that any exposure to a carcinogenic chemical will contribute an incremental amount to an individual's overall risk of developing cancer). The CSF values recommended by USEPA are conservative upper-bound estimates of potential risk. As a result, the "true" cancer risk is unlikely to exceed the estimated risk calculated using the CSF, and may be as low as zero (USEPA 1986).

[11] Available at http://www.epa.gov/ncea/iris/.
[12] Values available through USEPA's preliminary remediation goal (PRG) database, which is available at http://www.epa.gov/reg3hwmd/risk/human/index.htm.
[13] Available at http://www.atsdr.cdc.gov/mrls/index.html.

Carcinogen toxicity values that will be used in the risk assessment likely will vary in the type of data used to calculate the CSFs and the strength of the evidence supporting the values. Chemicals for which adequate human data are available are categorized as "known human carcinogens," while other values with varying levels of supporting data may be classified as "likely human carcinogens," "suggestive of human carcinogenicity," "not likely to be carcinogenic," or, perhaps, data may be inadequate to make a determination of carcinogenicity.

The potential for non-cancer health effects from long duration exposures via ingestion or dermal contact is evaluated by comparing the estimated daily intake with a chronic oral reference dose (RfD). USEPA (1989) defines the RfD as an estimate of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime. These toxicity values represent average daily exposure levels at which no adverse effects are expected to occur during chronic exposures. RfDs reflect the underlying assumption that systemic toxicity occurs as a result of processes that have a threshold (i.e., that a safe level of exposure exists and that toxic effects will not be observed until this level has been exceeded).

The RfDs for many of the non-carcinogenic chemicals are based on laboratory animal studies. Variations in the strength of the underlying data are reflected in the uncertainty factors used to calculate the toxicity values and the confidence ratings assigned to the toxicity values. Uncertainty factors are used in the derivation of RfDs to account for limitations in the underlying data and are intended to ensure that the toxicity value calculated based on the data will be unlikely to result in adverse health effects in exposed human populations. The magnitude of the total uncertainty factor used for a particular chemical varies depending on the nature and the quality of the available toxicity data.

Assessment of dermal exposures relies on modified oral toxicity values. Route-to-route extrapolation assumes that after a chemical is absorbed into the bloodstream, the health effects are similar regardless of whether the route of exposure is oral or dermal. This assumption may be employed for some chemicals with pharmacokinetic characteristics that are similar regardless of route of administration; however, for many chemicals, factors such as absorption, metabolism, distribution, and elimination vary by exposure route, leading to

substantial differences in toxicity. The reliability of route-to-route extrapolation is another source of uncertainty that must be considered when interpreting the risk assessment results.

6.3.4.2 Toxicity of Dioxins and Furans

Relevant general information on the assessment of toxicity of dioxins and furans, use of TEFs and calculation, uses and meaning of the TEQ for both human and ecological receptors is provided in the discussion of the CSM in Sections 4.2 and 4.3. For the evaluation of toxicity to people, the CSF for 2,3,7,8-TCDD is applied to the TEQ to estimate potential risks associated with exposure to dioxins and furans. This process is consistent with TAC 350.76(e), except that the Van den Berg et al. (2006) TEFs represent an update to the TEFs recommended in the Texas Administrative Code.

A slope factor developed by USEPA (1985) Office of Health and Environmental Assessment will be used for calculating cancer risks. A draft USEPA (2000a) reassessment of dioxin and furan toxicity and slope factors has been issued, but is still undergoing external peer review. USEPA plans to release a completed toxicity reassessment by the end of 2010, subject to further consideration of the science.[14] If the dioxin reassessment is finalized in time its conclusions will be incorporated into the Toxicological and Epidemiological Studies Memorandum or the BHHRA. In any case, the findings of the draft reassessment (USEPA 2000a) and more recent evaluations of dioxin and furan toxicity will be addressed by the Toxicological and Epidemiological Studies Memorandum. The use of alternative slope factors for 2,3,7,8-TCDD will be examined in the uncertainty analysis (Section 6.4.5.3). The oral CSF will be evaluated for use as a surrogate for the dermal toxicity factor. Because HEAST does not provide an RfD for 2,3,7,8-TCDD, ATSDR's chronic method reporting limit (MRL) will be used for assessing non-cancer health effects.

6.3.5 Risk Characterization

Quantitative estimates of exposure and toxicity are combined to yield numerical estimates of potential health risks. Baseline risks at the Site will be evaluated in accordance with USEPA (1989) guidance. Risk characterization also involves interpreting and qualifying the derived risk estimates. As appropriate, and consistent with guidance, risks will be summed across chemicals and pathways. The methods that will be used are described below.

[14] Discussed at http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=209690.

6.3.5.1 Calculation of Cancer Risks

The cancer risk estimates derived using standard risk assessment methods are characterized as the incremental probability that an individual will develop cancer during his or her lifetime due to exposure to Site-related chemicals resulting from the specific exposure scenarios evaluated in the BHHRA. The term incremental reflects the fact that the calculated risk associated with Site-related exposure is in addition to the background risk of cancer experienced by all individuals in the course of daily life. Cancer risk estimates are expressed as unitless values reflecting the probability that an individual will develop cancer at some point over a lifetime as a result of exposure at the levels assumed during the BHHRA. Excess (incremental) lifetime cancer risks for the ingestion and dermal exposure pathways will be calculated using the following equation:

$$Cancer\ Risk = Intake\left(\frac{mg}{kg \cdot day}\right) \times CSF\left(\frac{mg}{kg \cdot day}\right)^{-1} \qquad \text{(Eq. 6-2)}$$

Because cancer risks are assumed to be additive, risks associated with simultaneous exposure to more than one carcinogen in a given medium will be combined to estimate the total cancer risk associated with each exposure pathway (USEPA 1989; TCEQ 2008). Where exposures may occur through multiple exposure pathways, total cancer risks for each exposure pathway will be summed to determine the total cancer risk for the potentially exposed population.

6.3.5.2 Calculation of Non-Cancer Risks

In contrast with carcinogenic effects, potential non-cancer health effects are not expressed as a probability. Instead, non-carcinogenic health risks are characterized as a simple ratio between Site intake and the non-cancer RfD (Section 6.3.5.2). If receptors are exposed to levels less than or equal to the RfD, no adverse health effects are expected. Exposures above the RfD do not necessarily mean that adverse human health effects will occur, but rather that further evaluation is required.

To evaluate non-cancer risks, the ratio of the average daily intake to the RfD is calculated as the hazard quotient (HQ). If the value of the HQ is less than or equal to one, no adverse

health effects are expected. If the value of the HQ is greater than one, then further risk evaluation is needed. The HQ will be calculated using the following equation:

$$HQ = \frac{I}{RfD} \qquad \text{(Eq. 6-3)}$$

Where:

HQ	=	hazard quotient (dimensionless)
I	=	average daily intake (mg/kg-day)
RfD	=	reference dose for the COPC (mg/kg-day)

As an initial evaluation of aggregate risks, the HQs will be summed for all chemicals in each exposure pathway to determine a non-cancer hazard index. Such an approach reflects a conservative method for estimating non-cancer health risks because the non-cancer health risks associated with chemicals that affect different target organs are unlikely to be additive. If any hazard indices are found to exceed one, chemicals will be grouped into categories affecting the same target organ, and hazard indices will be recalculated by target organ.

6.3.5.3 Background Risk Comparisons

Natural and anthropogenic background sources of COPCs, other than those of the Site, may affect chemical concentration in samples collected from the Site. If these levels exceed risk-based concentrations, it is necessary to differentiate between the Site-related and background-related sources in order to properly characterize risks related to sources originating from the Site and, if appropriate, develop Site-specific cleanup levels. Concentrations of COPCs in samples collected from the Site will be compared to COPC concentrations in samples collected from background areas using applicable statistical approaches outlined in guidance (e.g., USEPA 2002b).

Capture and ingestion of fish/shellfish consumption is expected to be a significant exposure pathway at the Site. Risks will be calculated for the fish/shellfish consumption pathway based on Site and both upstream and regional background tissue concentrations, and the incremental difference between the Site and background risks will be computed. The background tissue EPCs will be calculated using data representative of the Houston Ship Channel as well as locations upstream of the Site. The comparison between Site risks and

background risks will be a critical component in understanding Site risks relative to regional risks and it will be important in evaluating remedial alternatives.

The comparison of Site risks to background risks will not necessarily be conducted for soil or sediment exposure pathways for two reasons. First, the risks associated with these pathways are not expected to be as significant as the risks associated with the fish/shellfish consumption pathway. Second, the organisms consumed by people at the Site, and fish in particular, are mobile and can therefore bring chemical contamination to the Site. If this is occurring, it is important to evaluate both risk and remedial options in the context of quantitative information on the influence of background on Site risks, so that the actual reductions in exposure that may be attributable to remedial actions can be specifically addressed.

6.3.6 Uncertainty Analysis

The exposure assessment involves the use of a number of variables, assumptions, and factors that vary over time and across populations. The accuracy of the assumed values is therefore associated with varying degrees of uncertainty. For example, actual values of exposure factors such as the daily rate of soil or sediment ingestion are expected to vary from individual to individual. In addition, review of the technical literature shows that measuring soil or sediment ingestions rates is technically challenging and poses the potential for measurement errors and uncertainties. Because of these uncertainties, the assumptions in the risk assessment are selected so as to conservatively present potential risks. Furthermore, USEPA (1995, 2000d) guidance requires that risk assessments include an uncertainty analysis that allows risk managers to understand the reliability and representativeness of the risk estimates.

Comparison of the CT and RME risk results is one method of evaluating variability of risks at the Site. In addition, a semi-quantitative evaluation of the uncertainties associated with the results will be presented along with an estimate of the influence of each uncertainty (e.g., whether the uncertainty would tend to lead to an over- or underestimation of potential risks can be addressed qualitatively). The BHHRA report will summarize and discuss each source of uncertainty in both the exposure assessment and the toxicity assessment, identifying which sources are considered most important. A sensitivity analysis will be conducted to

evaluate the impact of using alternative values for the key parameters contributing most to uncertainty.

The combined results of the comparison of CT and RME results, the semi-quantitative evaluation, and the sensitivity analysis will provide risk managers important perspective on the risk results and the degree of uncertainty associated with the results, allowing risk managers to evaluate whether a more quantitative analysis of uncertainty and variability is required. For some sites, probabilistic analysis can provide a more complete and transparent characterization of the risks and uncertainties than is possible using the point estimate approach described in this Work Plan (USEPA 2001). In probabilistic risk assessment, probability distributions are assigned for one or more exposure parameters to yield an output probability distribution for the exposure estimate distribution, from which an upper-bound value representing an exposure at approximately the 95th percentile of the distribution is selected to represent the RME. The uncertainty analysis will provide a discussion of whether a probabilistic risk assessment approach would add critical information to the Site decision making process.

6.4 Baseline Ecological Risk Assessment

The BERA will produce Site-specific estimates of ecological risks, refining the conservative preliminary estimates presented in the SLERA (Appendix B). The SLERA provides general information on the ecology, habitats, and ecological receptors that are or may be present at the Site; provides a generalized ecological CSM; discusses the basis for the screening process for selection of COPCs using the available data for the Site and screening level assessment endpoints; and describes the rationale for selection of receptor surrogates. The SLERA includes an attachment that provides a listing of ecological receptors potentially at the Site, and an attachment that provides a general description of the toxicity of dioxins and furans to benthic macroinvertebrates, reptiles, fish, birds, and mammals. Appendix C documents the considerations, data, and analyses performed to select COPCs for the RI. This section describes the approach to conducting the BERA, including assessment endpoints, measures of exposure and effects, risk questions, and application of the data generated by studies described in Section 5.1 to characterize risk to ecological receptors. It provides an overview

of how results of the BERA will be presented. The receptor surrogates to be addressed directly by the BERA are discussed briefly in Section 4.3.1, and are listed in Table 6-1.

6.4.1 Assessment Endpoints and Risk Questions

An assessment endpoint is "an explicit expression of the environmental value to be protected, operationally defined as an ecological entity and its attributes" (USEPA 2003b). Assessment endpoints indirectly communicate the effect of interest, for each receptor group, that will be addressed by the risk assessment. Clear assessment endpoints guide the direction of the risk assessment and tools to be used in the analysis and communicates the meaning of the results to be generated by the BERA.

The SLERA (Appendix B) uses screening level assessment endpoints to provide the basis for conservative judgments to select COPCs; assessment endpoints for the BERA are selected for accuracy rather than conservatism. The final USEPA guidance for conducting ERAs (USEPA 1999) emphasizes population level concerns: "Superfund's goal is to reduce ecological risks to levels that will result in the recovery and maintenance of healthy local populations and communities of biota." Therefore, for the BERA, the attributes of populations, rather than individuals, are the subject of the assessment endpoints. Although this approach is consistent with guidance and generally with societal goals, (i.e., other than for endangered species, environmental management is not usually concerned with the health of individual organisms) application of population-level assessment endpoints can present practical challenges in CERCLA programs. For example, evaluation of trends in wildlife populations using field studies can take many years. Moreover, the vast majority of literature that is available for interpretation of exposures to toxic chemicals reports on individual endpoints, such as survival, growth, and reproduction of the individuals tested by the study. Those that do report on populations often do so for Site-specific field investigations, which often do not have broad applications because exposures are to a mixture of multiple chemicals unique to the Site studied, and which limits the applicability of the result elsewhere.

To overcome these practical challenges for the Site BERA, assessment endpoints reflecting the concern of risk management with the preservation of populations were selected, recognizing that analyses and technical resources (e.g., toxicity literature) to be used may

address effects on individuals. This approach is consistent with USEPA guidance on the development of assessment endpoints (USEPA 2003a).

Table 6-2 lists each receptor category, the assessment endpoints to be addressed for that receptor, and the risk questions for each. This table illustrates the conceptual links between the assessment endpoints and the lines of evidence to be used to address each. It also captures the scope of overall approaches to be used in the BERA. The remainder of this section reviews the assumptions captured by the ecological CSM, and describes the measurements, methods, and tools to be used to address each risk question for each receptor category, addressing each of the following:

- Measures of exposure
- Measures of effects
- Characterization of risk and uncertainty

6.4.2 Ecological Conceptual Site Model

Ecological receptors and exposure pathways at the Site are discussed in Section 4.3 of this Work Plan; Section 4 of the SLERA (Appendix B) provides the assumptions that guide the approach to exposure assessment and defines the terminology employed in the text below. In this context, the receptors and exposure routes that will be evaluated quantitatively include the following:

- The benthic macroinvertebrate community exposed through direct contact with the benthic environment (sediment, porewater, and surface water)
- Bivalve molluscs exposed through direct contact with the benthic environment (sediment, porewater, and surface water)
- Fish (in all feeding guilds) exposed through ingestion of sediment and food, and respiration of water
- Reptiles exposed through ingestion of sediment or soils, water and food
- Birds (in all feeding guilds) exposed through ingestion of sediment or soils, water (for seabirds only), and food
- Mammals exposed through ingestion of sediment or soils and food

Other routes of exposure, such as inhalation of contaminated particulate matter by terrestrial mammals, are considered minor or incomplete, and will not be addressed by the measures of exposure to be used in the BERA (Figure 4-6).

6.4.3 Measures of Exposure

According to the CSM, aquatic receptors may be exposed to COPCs through respiration (e.g., via transport of dissolved chemicals across the gills), ingestion, and direct contact. In many cases, the specific route of exposure cannot be discerned from the available literature, or it is not important to the interpretation of the potential for toxicity, because exposures in the literature are expressed simply as concentrations in water, sediment, or organism tissue (see Appendix B, Section 4). Therefore, measures of exposure selected for the BERA to address aquatic receptors include concentrations of COPCs in the following general categories:

- Surface water (mg/L)
- Bulk sediment (mg/kg dry weight [dw])
- Tissue of whole fish, or benthic macroinvertebrates (mg/kg wet weight [ww]; mg/kg lipid weight)
- Bird egg tissue (mg/kg ww; mg/kg lipid weight), estimated from concentrations in diet of birds

Exposures to birds, mammals, and reptiles occurring through respiration (inhalation) or dermal absorption will not be evaluated in the BERA, as discussed in Section 6.4.2 and in the SLERA. Therefore, measures of exposure selected for the BERA to address terrestrial receptors will be the concentrations of COPCs in the following general categories:

- Surface water (mg/L)
- Sediment (mg/kg dw)
- Soils (mg/kg dw)
- Tissue of whole fish (mg/kg dw)
- Tissue of benthic organisms (mg/kg dw)
- Bird egg tissue (mg/kg ww; mg/kg lipid weight), estimated from concentrations in diet of birds

For all applications, concentrations of COPCs in water will be estimated using a model (Section 6.1.5); the approach will be described in a technical memorandum on Fate and Transport Modeling (Section 8). Concentrations of dioxins and furans, as TEQs, in bird eggs are needed to evaluate risk to birds, and will be estimated from concentrations in the birds' food; ingestion rates of birds, as mg/kg-d, will also be estimated and compared to TRVs. Methods to perform this estimation are under review, and will be addressed in the Bioaccumulation Technical Memorandum (Section 8).

For the exposure assessment in the BERA, a model to combine several of these metrics for evaluation of exposure to fish is described in Section 6.4.3.1. Dose calculations from combinations of one or more of these metrics for evaluation of exposure to terrestrial receptors exposed via ingestion of multiple media are described in Section 6.4.3.2. Statistics of these categories of information that will be used to represent EPCs for each of these media are described generally for aquatic and terrestrial receptors in Section 6.4.3.3.

6.4.3.1 Aquatic Life

To evaluate exposure of fish through ingestion, concentrations of COPCs in each ingested medium (food and sediment) will be compared to the toxicity reference value (TRVs) expressed as dietary concentrations (mg/kg diet). Where multiple prey types are likely to be ingested by a fish (e.g., small fish and invertebrates), the concentration in the overall diet will be calculated using the following algorithm:

$$[COPC]_{diet} = \sum f1[COPC]_1 + f2[COPC]_2 + fn[COPC]_n \qquad \text{(Eq. 6-4)}$$

Where:

$[COPC]_{diet}$ = concentration of the COPC in the overall diet (µg/kg ww)

$[COPC]_{1...n}$ = concentration of the COPC in the prey items 1 through n (µg/kg ww)

$f_{1...n}$ = fraction of prey items 1 through n in the overall diet (unitless), based on mass, the sum of which does not exceed 1

This method is primarily applicable to the assessment of exposure of fish to metals and PAHs, because reliable TRVs expressed as critical tissue residues (CTRs) for metals and PAHs are often not available for these compounds. USEPA (2007b) cautions against the use of CTRs for assessment of risk to aquatic organisms from exposure to metals (with the exception of

organometals such as tributyltin and methylmercury), unless a toxicologically valid residue-response relationship supports the use of the CTR threshold. PAHs are metabolized by fish and may not appear in tissues, even though ingested PAHs could have adverse effects (e.g., Meador et al. 2006).

6.4.3.2 Aquatic-dependent Wildlife

To estimate exposures to birds, mammals, and reptiles, the cumulative daily dose to each wildlife receptor through ingestion of food and water, including incidental soil or sediment ingestion, will be calculated using the general:

$$Daily\ Dose = \frac{\left(\left(FIR \times C_{food} \times ABS_{food}\right) + \left(WIR \times C_{water}\right) + \left(SIR \times C_{sed} \times ABS_{sed}\right)\right) \times AUF}{BW} \qquad \text{(Eq. 6-5)}$$

Where:

Daily Dose =	COPCs ingested per day via food, water, and sediment (mg/kg bw/day)
FIR =	food ingestion rate (kg food dw/day)
C_{food} =	concentration in prey items (mg/kg food dw)
ABS_{food} =	bioavailable fraction absorbed from ingested prey items (unitless)
WIR =	water ingestion rate (L water/day)
C_{water} =	concentration in water (mg/L water)
SIR =	sediment ingestion rate (kg sediment dw/day)
C_{sed} =	concentration in sediment (mg/kg dw)
ABS_{sed} =	bioavailable fraction absorbed from ingested sediment (unitless)
AUF =	area use factor (unitless); fraction of time that a receptor spends at the Site relative to the entire home range
BW =	species body weight (kg)

Exposure factors (e.g., ingestion rates, dietary preferences, and body weights) will be evaluated for each species based on data compiled in the USEPA's *Wildlife Exposure Factors Handbook* (USEPA 1993) and other ERAs conducted within USEPA Region 6. Food ingestion rates may be estimated using the equations presented in Nagy (2001) or derived from literature reports on the life histories of the receptor surrogate species.

6.4.3.3 Exposure Statistics

USEPA guidance (USEPA 1997a) directs ecological risk assessors to consider an exposure profile for each receptor, which can include an expression of the range, the probability distribution, or other representations of exposures. For each of the measures of exposure listed for both terrestrial and aquatic receptors, statistics to express exposure may include the following:

- The concentration in an individual sample. This metric is often used for sediments and water to characterize exposure to benthic and fish.
- An expression of the CT of the data for a COPC in any given media. The best expression of the CT will be dictated by the distribution of the data. Candidates include the median, arithmetic mean, or geometric mean. Other statistics may be used to express the CT in the BERA, as appropriate.
- An expression of the RME concentration. For the mean, the selection of the metric for the RME will depend on the characteristics of the data. Candidates include the maximum concentration, the 95 UCL of the mean, and the 90th percentile.

The choice of the measure of exposure depends on the risk question, the risk analysis method, and the degree of uncertainty in the overall risk calculation that is considered acceptable. In the final iterations of the risk analysis, probabilistic risk calculations based on characterization of the statistical distribution of one or more exposure parameters may be performed as a way of clearly assessing the effect of uncertainties on the risk estimate. In this case, exposure will be expressed as a probability distribution that is appropriate to the level of detail and amount of information available for the exposure media or exposure metric of interest. Decisions about where to apply this method will be made during the analysis phase of the BERA.

6.4.4 Measures of Effects

Consistent with the discussion of assessment endpoints in Section 6.4.1, measures of effects on ecological receptors will address changes in survival, growth, or reproduction resulting from exposure to one or more COPCs. This approach is a function of the toxicity information likely available in the literature to interpret ecological exposure estimates for the Site. For invertebrates, the literature and some benchmarks address higher levels of

organization such as populations and communities. Effects measures that address individual or higher level effects relating to population level impacts will be used if they are available; all effects measures will be related to the assessment endpoints, which address population-level environmental values. These approaches are reflected in the risk questions in Table 6-2.

For the San Jacinto River Waste Pits BERA, Site-specific exposure estimate will be interpreted on the basis of TRVs available in the literature.

6.4.4.1 Toxicity Reference Values

When using published toxicity literature to establish measures of effect, the specific effects measure depends on the experimental design that was used. For example, a toxicity study may provide a threshold dose above which a reduction in the hatchability of bird eggs occurs. In this case, the effect is reproduction, and the measure is the lowest observed adverse effect level (LOAEL) at or above which effects are observed. TRVs, which encompass both LOAEL and no observed adverse effects level (NOAEL) values, can be expressed in several ways. TRVs to be used in the BERA include the following:

- Bulk sediment concentration (mg/kg) for the benthic macroinvertebrate community
- Concentrations in water (mg/L) for fish
- CTR values for dioxin and furan compounds (or other organics) expressed as concentration in whole clams (mg/kg ww or lipid)
- CTR values for dioxin and furan (or other organics) compounds expressed as concentrations in whole fish (mg/kg ww or lipid)
- Concentrations of metals in media ingested by fish (mg/kg)
- Daily ingested dose (mg/kg-d) for reptiles and mammals for all COPCs, and for birds for COPCs other than dioxins and furans

The types of individual effects measures to be derived from the literature will be limited to those clearly relating to population-level effects. These are generally the survival, growth, and reproduction of tested individuals. Studies documenting an effect of a toxicant on an endpoint that is clearly related by the authors of the study to survival, growth, or reproduction will be used (e.g., a developmental endpoint that is clearly related to the

reduced survival of young). Studies addressing unrelated endpoints (e.g., cellular or biochemical alterations or gene expression) will not be used to establish TRVs for the BERA, because these effects cannot be related to population-level assessment endpoints.

6.4.4.2 Species Sensitivity Distributions

Generally, individual TRVs from the literature will be compared directly to Site-specific exposure estimates. In these cases, the TRV will be selected to provide the best representation of the receptor on the basis of taxonomy and the lifestage tested relative to those of the Site-specific receptor. Use of literature-based TRVs to interpret Site-specific exposures results in uncertainty when the literature reports a TRV developed for one species (e.g., duck) and it is used to interpret exposures of another species (e.g., great blue heron). To address uncertainty in the applicability of a TRV to the risk assessment, one or more cumulative distribution functions derived from multiple effects-level metrics with a species, or species sensitivity distributions (SSDs) derived from may be developed using multiple literature values for multiple species may be developed.

Within-species cumulative distribution functions and SSDs allow consideration of the variation in dose-response of a given chemical across several life stages or species that have been tested; SSDs and have been successfully developed for dioxins and furans (e.g., Steevens et al. 2005) and other chemicals. SSDs allow the risk assessor to evaluate an individual receptor within the context of its broader ecological or taxonomic group. For instance, if an exposure estimate to a particular COPC exceeds a TRV generated for mammals, then further analysis of the distribution of available TRVs, using an SSD, can be used to determine whether only one mammal species, or multiple mammal species or genera are likely to be affected at the exposure level. The meaning of a single-species cumulative distribution functions or of an SSD depends on the data quality and the types of inputs; each will be interpreted according to the specific information included in the distribution. For suitable toxicity data, additional toxicity metrics (e.g., EC_{10}) for individual taxa may also be derived from data for one or more studies, and used to improve the precision of risk statements. All studies providing TRVs will be evaluated for quality and applicability of these methods prior to development of single species cumulative distribution functions or SSDs, and related decisions will be clearly documented. The use of these types of distribution functions or

development of additional metrics (such as the EC_{10}) will allow for more detailed characterization of the risks and uncertainties of effects of COPCs at the Site.

A method to extrapolate TRVs between species on the basis of the difference in body weights between the two species, called allometric scaling, has been used at some Sites. However, the technical basis for extrapolation of TRVs between species based on body size is not as well established for ecological receptors as it is for extrapolations relating to human health risk assessment (i.e., rat to human extrapolations), where it is most widely applied. Because of uncertainty in the use of allometric models to scale TRVs between species, particularly for birds, extrapolations on the basis of body size will not be used to estimate or derive measures of effects when species-specific TRVs are not available.

6.4.5 Characterization of Risk and Uncertainty

Each risk question represents an independent line of evidence that will be applied to address risks to each receptor. All lines of evidence involve the evaluation of the exceedance of an (TRV) by exposures that may occur on the Site (Table 6-2). Factors contributing to the interpretation of the exceedance include the adverse effect(s) represented by the TRV exceeded or the SSD, and the type of threshold exceeded (i.e., LOAEL, NOAEL, EC_{10}). A statement of risk that incorporates all lines of evidence for a given receptor, and addresses qualitative and/or quantitative analysis of uncertainty, will be provided in the risk characterization.

COPC and receptor-specific HQs will be calculated for the initial evaluation of risk. If the HQ indicates that the COPC is present at levels at the Site that could result in an unacceptable risk, the exposure and effects levels may be compared probabilistically, which will provide a more accurate indication of the probability of adverse effects in the risk statement. Coupled with information about the severity of the potential effect, the risk statement for each receptor will address the type, severity, and likelihood of adverse effects on assessment endpoints. When risks of exposure to a chemical are considered unacceptable, the incremental risk relative to background will be evaluated.

6.4.5.1 Calculation of Hazard Quotients

To determine the HQ for ecological receptors, the ratio of the exposure estimate to the TRV will be calculated. If the value of the HQ is less than or equal to one, no adverse health effects are expected. If the HQ is greater than one, additional analyses or studies are warranted. The HQ will be calculated using the following equation:

$$HQ = \frac{E}{TRV} \qquad \text{(Eq. 6-6)}$$

Where:

HQ	=	Hazard quotient
E	=	Estimated exposure
TRV	=	Toxicity reference value for the COPC

Units used for of exposure estimates and for the TRV may vary among lines of evidence, but must be the same for the numerator and denominator in the HQ equation. Individual HQs will be calculated for each chemical, with the exception of dioxins-like compounds, for which exposure and toxicity to fish birds and mammals can be integrated for multiple chemical congeners (Section 4). Additivity of toxicity and risk for an individual receptor exposed to multiple chemicals (other than dioxins and furans) will not be considered or reported.

6.4.5.2 Probabilistic Risk and Uncertainty

Estimating parameter values used in exposure and risk models is associated with uncertainty. The BERA will include an uncertainty analysis to provide risk managers information on the reliability and representativeness of risk estimates. Some uncertainties will be addressed by making assumptions or representing exposures to be somewhat conservative, (i.e., to overestimate risk). However, the BERA should also represent a realistic portrayal of baseline risk at the Site, so the BERA will not employ extreme conservatism or use methods that compound conservative uncertainties.

For the qualitative uncertainty evaluation, each type of uncertainty will be listed, and each qualified as to whether it results in an over- or underestimation of risks. The BERA will discuss which sources of uncertainty have the greatest effect on uncertainty.

When calculated HQ is greater than one, a probabilistic risk analysis may be used to provide a more complete and transparent characterization of risks and uncertainties than is possible using a HQ alone. As for the BHHRA, a probabilistic risk assessment requires that probability distributions are assigned for one or more exposure parameters to yield an output probability distribution for the exposure estimate distribution. From this distribution, a value representing a certain likelihood of exposure can be derived, allowing a more specific expression of risk as the likelihood of adverse effects. TRVs can also be represented as a probability distribution in a probabilistic analysis.

6.4.5.3 Addressing Population Level Assessment Endpoints

Population level assessment endpoints have been selected for the BERA, consistent with USEPA guidance (USEPA 2003a), but TRVs from the available literature providing measures of effects are likely to generally represent individual-level endpoints (i.e., those related to survival, growth and reproduction of individual organisms), particularly for birds and mammals (e.g., Appendix B, Attachment B2). Population-level effects can be addressed using simple population models (such as Leslie matrices) where the toxicity literature provides the means to address one or more relevant life stages. Derivation of cumulative distribution functions for toxicity data for a single species will also allow the risk statement to provide conclusions about the population level effect (e.g., the EPC is at a level that causes no effect in 90 percent of individuals in this age class).

In some cases, population level assessment endpoints may need to be addressed qualitatively, on the basis of the toxicity data that provides the TRV. For example, if there is only one acceptable toxicity study reporting a 20 percent reduction in hatchability of bird eggs at the LOAEL, the HQ will be interpreted in the context of the uncertainties of the exposure assessment and the source of the TRV to state whether a potential effect on the population exist. Population level effects will be considered negligible for receptors and COPCs if HQs are less than one.

6.4.5.4 Characterization of Background Risks

Background ecological risks will be characterized in two ways: based on upstream background conditions, and based on regional conditions. Both types of evaluations will be performed to provide perspective on risks associated with the Site, and will allow an

assessment of the incremental risks due to the Site. An incremental increase in risk relative to background can potentially be directly affected by controls at the Site. In cases where incremental risk is evaluated, it will be evaluated for both upstream background and regional background for comparison to Site risks.

Background risks will not be calculated for all receptors and COPCs, but will be performed when the BERA concludes that there is an unacceptable risk to an assessment endpoint from a COPC. Therefore, evaluation of risks in upstream background areas will be conducted using the same general lines of evidence as for evaluation of Site specific risks, but may use existing data sets, or may require estimation of parameters that will be measured on Site. Where estimated EPCs are used, related uncertainties will be documented and addressed in the comparison.

Data collection to address ecological exposures in upstream areas has been specified in the Sediment SAP (Integral and Anchor QEA 2010). Whether upstream background samples of other media are collected will be determined by the DQOs presented in the Soil SAP and Tissue SAP.

7 FEASIBILITY STUDY APPROACH

7.1 Feasibility Study Process

The FS will be submitted in accordance with the schedule contained in the scope of work (SOW). The FS process will be sequenced as follows and explained in more detail later in this section. It includes the following eight steps:

1. Develop Remedial Action Objectives (RAOs)
2. Identify Potential Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered Criteria (TBC)
3. Define Preliminary Remediation Goals
4. Identify and Characterize Management Areas
5. Identify and Screen Remedial Technologies
6. Develop and Screen Alternatives
7. Complete a Comparative Evaluation of Alternatives
8. Select Preferred Alternative

7.2 RAOs

RAOs will be developed for the Site based on the conclusions of the RI and the developed CSM. The RAOs will be aimed at protecting human health and the environment and will focus on the media and contaminant(s) of concern, exposure route(s) and receptor(s). The RAOs coupled with the ARARs and risk assessment will be used to develop the PRGs.

7.3 Preliminary Identification of ARARs

A complete list of potential ARARs will be developed for the Site. The ARARs will fall into one of three classifications:

- **Location-specific**. These requirements provide restrictions on activities based on the Site characteristics or its environment.
- **Chemical-specific**. These requirements are health- or risk-based concentration limits or ranges for specific hazardous substance, pollutants, or contaminants in various environmental media.
- **Action-specific**. These requirements are controls or restrictions on particular types of activities such as hazardous waste management or wastewater treatment.

In addition, TBCs, which include non-promulgated criteria, guidance, and proposed standards issued by federal or state governments, will also be listed for the Site. Although TBC compliance is not mandatory, TBCs may provide guidance on how to carry out certain actions or requirements.

7.4 PRG Development

PRGs for sediment and soils provide the foundation for the development and evaluation of remedial alternatives. Several different factors play a role in the development and refinement of Site-specific PRGs:

- Risk-based concentrations
- Background conditions
- Risk reduction prioritization
- Mass removal goals
- ARARs

The data and information generated by the RI will be used to derive PRGs for sediment and soil.

PRGs are primarily risk-based and are intended to achieve targeted levels of risk reduction at the relevant scale of exposure for a given risk scenario or receptor. Risk based PRGs are then evaluated with respect to constraints imposed by ARARs, background chemical concentrations and the technical and economic feasibility of particular remedial approaches. The process of developing PRGs therefore starts with development of Site-specific protective concentration levels (PCLs) in abiotic media that meet the target risk levels over a relevant scale of exposure for a given receptor and/or risk scenario. For humans and each different ecological receptor, separate PCLs will be generated for different exposure routes, such as direct contact, sediment ingestion, and ingestion of food items that have bioaccumulated COPCs for the Site. PCLs are not developed for full exposure scenarios that involve exposure to multiple media (e.g., ingestion of fish and sediment). Methods for conducting the baseline risk assessments that produce these PCL values are described in Sections 5.3 and 5.4. Exceedance of a cumulative target risk level within a given exposure unit potentially can be addressed through remediation to several different PCLs for different chemicals (e.g.,

equivalent risk reduction may be achieved through remediation of a large area of moderately elevated concentrations of one chemical or a small area of highly elevated concentrations of a different chemical). If applicable, several different sets of equally effective PCLs (in terms of risk reduction) will be carried forward for further consideration in the FS. The initial risk-based PRG for each chemical will be the minimum PCL for any receptor (human or ecological) and any exposure route.

For sediment, the initial PRGs will be compared to the concentration of each COPC in background sediment. Depending on the type of PRG and how it will be applied, comparisons to different types of background statistics would be warranted.

Remediation of Site sediment to concentrations below background is not required by USEPA under CERCLA (USEPA 2002b). If the initial PRG for any COPC is statistically significantly lower than the mean background concentration, the PRG will be set equal to the relevant background value.

During the detailed evaluation of remedial alternatives (described in Section 7.9), feasibility constraints may be identified that make achievement of a PRG unlikely or impossible. Affected PRGs may then be revised to accommodate these constraints. Two ways in which the PRGs may be revised include:

- Revision or reprioritization of target risk levels. For example, a revised PRG may be selected that meets the target risk level for human exposures, but exceeds the risk level for an ecological receptor.
- Development of a PRG based on mass removal goals rather than on concentration. This approach would lead to direct determination of a remedial area boundary based on optimization of mass removal relative to feasibility constraints.

If a PRG is revised in either of these (or other) ways, the overall response action may include restoration activities in addition to remedial activities. Instead of revising the PRGs, feasibility constraints may also be addressed by applying a combination of remedial approaches, such as institutional controls on Site access in addition to the use of removal or isolation technologies. All of these decisions are within the purview of risk managers and will be made in close consultation with USEPA.

7.5 Identify and Characterize Management Areas

The Site will be subdivided into management units based on the following factors:

- Physical: water depth, sediment dynamics, structures, slopes, sediment gradation, and other related factors will be identified.
- Chemical: chemical concentrations will be compared against PRGs to identify differing levels of contamination.
- Biological: resources within the Site will be identified. Certain habitats or biological resources may warrant substantially different remediation approaches, levels of effort, time frames, or other tradeoffs. For example, in some areas, the environmental costs may outweigh the environmental benefits of cleanup.

The unique management areas will be the basis for developing alternatives. In addition, the areas and volumes will be used to help screen technologies and evaluate alternatives.

7.6 Identify and Screen Remedial Technologies

USEPA guidance for contaminated sediment remediation identifies "three major approaches: Monitored Natural Recovery (MNR), in-situ capping, and sediment removal by dredging or excavation" for addressing sediment sites (USEPA 2005b). The technologies considered in the FS will therefore focus on the following (or a combination of the following):

- MNR or Enhanced MNR
- In situ capping
- Dredging combined with the following auxiliary technologies:
  - Transport
  - Materials handling (i.e., treatment)
  - Disposal

Each technology is discussed in more detail below. In addition, during the FS, each technology will be evaluated on USEPA's Threshold Criteria (overall protection of human health and the environment; compliance with ARARs), Primary Balancing Criteria (long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through

treatment; short-term effectiveness; implementability; cost) and Modifying Criteria (state/support agency acceptance; community acceptance).

7.6.1 Monitored Natural Recovery

Per USEPA's sediment remediation guidance (USEPA 2005b), MNR is a remedy for contaminated sediment that typically uses ongoing, naturally occurring processes to contain, destroy, or reduce the bioavailability or toxicity of contaminants in sediment. MNR may rely on a wide range of naturally occurring processes to reduce risk to human and/or ecological receptors. These processes may include physical, biological, and chemical mechanisms that act together to reduce the risk posed by the contaminants. Depending on the contaminants and the environment, this risk reduction may occur in a number of different ways including destruction (degradation or transformation) of chemicals, reduced mobility or toxicity, burial, and/or dispersion. A variation of MNR is enhanced MNR where one of the driving mechanisms (usually burial) is accelerated. A common method of enhanced MNR is the placement of a thin layer of sediment over the affected area.

The FS will assess the degree and spatial extent to which MNR or enhanced MNR can be expected to be a suitable remedy that meets the RAOs. This will involve modeling of chemical fate and transport within and around the Site to determine how quickly and to what level chemical concentrations in surface sediments where organisms and people are exposed can be expected to decrease over time. The chemical fate and transport model being developed will be used to assist with MNR modeling. To the extent that this model is not available, other models or estimation methods may be employed. This modeling will be supported by a thorough evaluation of empirical information to determine whether MNR has occurred historically. This information may include (but is not limited to) evaluations of sediment samples taken over time and evaluations of concentration profiles in cores. The timeframes for acceptable MNR or enhanced MNR will be set to be consistent with appropriate guidance.

7.6.2 Capping Technologies

In situ caps isolate contaminated sediments from the environment by use of natural or constructed products. Caps consist of two main components:

1. Chemical isolation component. This portion of the cap reduces the flux of the solids and dissolved contaminants to the overlying water column to acceptable levels. The chemical isolation component is typically made of naturally occurring sands or gravels. Additives such as organoclay or other products have been used to help sequester more mobile dissolved contaminants.
2. Erosion protection component. This portion of the cap protects the chemical isolation component from erosion. The gradation and thickness of this layer is such to resist potential erosive forces such as currents, waves, or propeller wash. The erosion protection layer can be constructed from either be naturally occurring gravels or boulders or manufactured products (e.g., cement).

The FS will review various capping technologies and present the advantages and disadvantages of each. The FS will also focus on likely placement techniques for each component. Screening will be used to focus the probable cap technologies and account for the following factors:

- Sediment strength and stability
- Site constraints for a cap, such as slopes, water depths, and currents
- Presence of structures, such as piers, piling, and outfalls, as well as debris
- Navigational constraints
- Short-term water quality impacts during construction
- Erosive environment
- Equipment availability
- Capping production rates

7.6.3 Dredging Technologies

Dredging technologies are used to dislodge and remove contaminated sediments from the waterbody for subsequent transport and disposal. Dredging can be accomplished either using mechanical or hydraulic means. The FS will review the dredging technologies commonly used for contaminated sediment remediation projects in the Gulf Coast. Screening will be used to focus the probable dredge technologies and account for the following factors:

- Sediment strength and grain size
- Depth of contamination

- Dredge area constraints such as slopes, water depths, and currents
- Presence of structures, such as piers, piling, and outfalls, as well as debris
- Navigational constraints
- Short-term water quality impacts during construction
- Equipment availability
- Support equipment and materials required
- Dredging production rates
- Volume of excess water produced that will need to be managed

Dredging will be coupled with a number of auxiliary water quality controls and technologies including transportation, treatment, and disposal. Each of those controls and technologies is discussed in more detail below.

7.6.3.1 Water Quality Controls

As dredging occurs, measures will likely be required to minimize and/or contain potential water quality impacts. These potential controls include implementation of dredging best management practices (BMPs), permeable and/or low permeability silt curtains, a barge de-water treatment system(s), use of geotubes, and/or use of settling basins. In addition, a system for sheen and spill prevention and response will be developed. BMPs could include adjustments to dredging techniques and/or equipment, operation times, and production rates. Screening of water quality controls will focus on the following factors:

- Sediment physical properties, such as grain size, water content, and plasticity
- Geotechnical properties of the sediment subgrade
- Dredging technology used
- Dewatering technology and location (i.e., upland or on barge)
- Predicted water quality impacts associated with dredging
- Volume of excess water produced that will need to be managed
- River hydrodynamic conditions
- Water depth
- Navigational constraints
- Potential secondary impacts associated with implementation of proposed controls (e.g., adverse water quality impacts cause by installation or operation of the control)

- Timeline for implementing the control(s)
- Permitting requirements

7.6.3.2 Dredge Material Handling (Transportation and Treatment) Technologies

7.6.3.2.1 Transportation Technologies

After the material is dredged, the sediment will need to be handled and transported before disposal. Transport technologies include pipelines, barges, trucks, rail cars, and combinations of the above. An offloading facility may also be required in some combinations where the sediment has to be transferred from the water to upland. Screening of transportation technologies will focus on the following factors:

- Sediment physical properties, such as grain size, water content, and plasticity
- Volume of excess water produced
- Sediment bulking potential
- Removal technology used
- Site access
- Production rates
- Equipment availability
- Short-term water quality impacts during construction
- Navigational constraints
- Size and configuration of offloading facility
- Disposal Site location
- Disposal Site material requirements
- Disposal Site permits

Transportation technologies that are sustainable will be promoted to the extent practicable, including those that:

- Minimization of air toxics emissions and greenhouse gas production
- Conserve natural resources and energy

7.6.3.2.2 Treatment Technologies

The FS will identify treatment technologies for screening and inclusion in the alternatives. Per USEPA guidance (USEPA 2005a) "in-situ treatment, is currently under development and may become a viable alternative in the future." Based on previous contaminated sediment experience nationally and in Region 6 sediment treatment considered in the FS will be limited to ex-situ technologies:

1. Physical treatment: physical force is applied to the sediment or water. Examples of physical treatment include separation technologies such as geotubes, hydrocyclones, gravity separation, or filtration.
2. Chemical treatment: chemical reactions bring about changes to the sediment or water. Chemical treatment is commonly used in conjunction with physical treatment to enhance contaminant removal or immobilization.

On the basis of past experience, treatment technologies are anticipated to consist only of dewatering or stabilization/solidification. Dewatering removes excess water from the dredged material. Stabilization/solidification immobilizes contaminants in sediment using chemical treatment. The reaction occurs with the use of such materials as cement, fly ash, or other similar materials. A beneficial side effect of the reaction is the improved handling characteristics of the sediment. Screening of treatment technologies will focus on the following factors:

- Sediment physical properties, such as grain size, water content, and plasticity
- Volume of excess water produced
- Removal and transport technology used
- Production rates
- Equipment availability
- Short-term water quality impacts during construction
- Disposal Site location
- Disposal Site material requirements

7.6.4 Disposal Technologies

Disposal could be on-site within a potential containment system or off-Site. Off-site disposal of the sediment dredged from the Site would need to be at a permitted Subtitle C or Subtitle D landfill, as appropriate.

Disposal at an on-site potential confined disposal facility will require dewatering and capping. Sediment would be placed within the potential confined disposal facility either mechanically or hydraulically. The sediment would be allowed to settle. The carriage water would be discharged back to the San Jacinto River after the appropriate settling time necessary to meet discharge requirements. Geotubes may be a remedial option used to facilitate settling.

Disposal at an off-site landfill will likely require dewatering, offloading, and transport by truck or rail to the landfill. The offloading could occur at the Site, but may also be at an off-site location.

Screening of on-site and off-site disposal technologies will focus on the following factors:

- Sediment physical properties, such as grain size, water content, and plasticity
- Removal, dewatering, and transport technology used
- Availability of potential waste handling areas
- Equipment availability
- Disposal site characteristics (area and depth)
- Disposal site location
- Disposal site material requirements
- Risk associated with off-site transport

7.7 Develop and Screen Alternatives

Using the list of qualified technologies determined during the screening process, a limited number of cleanup action alternatives will be developed. Each alternative will consist of an assembly of specific actions that would be taken in each management area to address the RAOs and PRGs. As required by the National Contingency Plan (NCP), a No Action alternative will be used as a baseline for evaluating and comparing the other alternatives.

The alternatives will be based on the qualified technologies, the cleanup action characteristics, the RAOs and PRGs, and current and future Site use requirements.

The FS will provide the following information on each alternative:

- Summary of the rationale behind each alternative developed
- Scope of each alternative including the technologies used and anticipated sequencing:
  - Remedial areas, volumes, depths and thicknesses, and other pertinent quantity estimates
  - Equipment and labor to be used
  - Materials to be used
  - Upland facility requirements (staging areas, transfer facility, disposal Site, haul routes, etc.)
  - Likely durations and schedule

The FS will screen each of the alternatives against the following criteria:

- **Effectiveness**. Each alternative will be evaluated regarding how well the alternative meets the RAOs and ARARs; how well the alternative reduces mobility, volume, and toxicity; and how well the alternative provides safety to workers, the public, and the environment during construction.
- **Implementability**. Each alternative will be evaluated with regard to its technical feasibility, the availability of necessary resources, and the administrative feasibility.
- **Cost**. The cost of each alternative will be estimated by determining the present worth of each alternative considering direct and indirect capital costs, as well as long-term maintenance and monitoring costs. Per USEPA guidance the FS-level cost estimate will be within the range of -30 to +50 percent (USEPA 1993). MIMC and IP may also factor in other financial considerations including, but not, limited to risk management, insurance costs, and costs associated with marine and upland operation interruptions.

7.8 Comparative Evaluation of Alternatives

The FS will assess each alternative against the nine CERCLA criteria described below. The results will be compared to identify the key tradeoffs between them. This comparative

evaluation will provide sufficient information to adequately evaluate the alternatives. The No Action alternative will be used as a baseline for the comparisons.

As part of the comparative analysis, each alternative will be ranked for how well it meets each of the criteria. Rankings will be as follows:

- High: alternative meets all of the requirements of a criterion
- Medium: alternative meets most, but not all of the requirements of a criterion
- Low: alternative meets only some of the requirements of a criterion

The nine criteria are:

- Threshold Criteria
  - Overall protection of human health and the environment
  - Compliance with ARARs
- Primary Criteria
  - Long-term effectiveness and permanence
  - Reduction of toxicity, mobility, and volume through treatment
  - Short-term effectiveness
  - Implementability
  - Cost
- Secondary Criteria
  - State and tribal acceptance
  - Public acceptance

An overview of the threshold and primary criteria is presented below. The Secondary Criteria will be assessed following receipt of USEPA comments on the Draft FS.

7.8.1 Threshold Criteria

Each alternative must meet the two threshold criteria discussed in this section.

7.8.1.1 Overall Protection of Human Health and the Environment

This criterion provides an overriding evaluation on the adequacy of the alternative to protect human health and the environment and what measures are required to make the alternative adequate. This criterion will draw on other criteria assessments, especially long-term effectiveness and permanence and short-term effectiveness.

7.8.1.2 Compliance with ARARs

The criterion will determine if the alternative is compliant with all federal and state ARARs. If an ARAR cannot be met, the basis for justifying a waiver will be presented.

7.8.2 Primary Criteria

7.8.2.1 Long-term Effectiveness and Permanence

The highest ranking will be assigned to those alternatives that demonstrate permanence of the actions proposed, stability of the sediments, and lowest potential for recontamination. Determination of long-term effectiveness of combined alternatives will be conducted including, as relevant, sediment and water quality thresholds related to sediment chemical concentrations, sediment resuspension, advective/diffusive flux from sediments to surface water, and fate and transport to biota. Various methods for evaluation of capping effectiveness could include comparison of porewater concentrations to surface water criteria and establishment of Site-specific risk-based sediment criteria consistent with the risk assessment. Although these methods will be considered, these example methods do not necessarily have to be used in the FS.

7.8.2.2 Reduction of Toxicity, Mobility, and Volume through Treatment

The highest ranking will be assigned to those alternatives that provide the greatest reduction (collectively) in the mobility, volume, and toxicity of contaminants. The impacts of the alternatives are focused on the effectiveness at reducing the ability of contaminants to move by advection or diffusion, the volume of contaminated sediment in the Site after construction, and the toxicity of contaminants in the sediment to ecological or human receptors.

7.8.2.3 Short-term Effectiveness

The highest ranking will be assigned to those alternatives that present the least risk to workers and have the fewest water quality, quality of life, biota, and operational impacts.

In keeping with the goal of enhancing the environmental benefits of the selected remedial alternative, technologies and practices that are sustainable and consistent with project needs will be promoted, including:

- Employment of renewable energy and energy conservation and efficiency approaches
- Use of cleaner fuels, diesel emissions controls and retrofits, and emission reduction strategies
- Use of water conservation and efficiency approaches
- Incorporation of sustainable site design
- Use of reused or recycled industrial materials within regulatory requirements
- Requirements for recycling or reuse of materials generated at or removed from the Site
- Use of environmentally preferable purchasing
- Support of greenhouse gas emission reduction technologies
- Use of Environmental Management System (EMS) practices, such as reducing the use of paper by moving to fully electronic transmittal of project documents and implementation of waste reduction and recycling programs at all work Sites.

7.8.2.4 Implementability

Implementability will focus on technical and administrative feasibility and availability of materials and equipment. The highest ranking for technical feasibility will be those alternatives that demonstrate technologies with proven project performance, are available from multiple contractors/vendors, and offer the highest reliability and the least risk of delay. The highest ranking for administrative feasibility will be those alternatives that require the least amount of agency coordination and action. Alternatives that minimize permit and access agreements will be more administratively feasible. The highest ranking for availability will be those alternatives using technologies that are available from multiple contractors or vendors, where the need for specialized equipment and/or labor is minimized, and the risk from delay is minimized.

7.8.2.5 Cost

The highest ranking for cost will be alternatives with the lowest present worth cost. Costs will include direct and indirect capital costs, as well as long-term maintenance and monitoring costs. Per USEPA guidance the FS-level cost estimate will be within the range of -30 to +50 percent (USEPA 1993).

7.9 Select Preferred Alternative

The FS will provide a detailed description of the preferred alternative that was determined to best fulfill the evaluation criteria.

8 RI/FS SCHEDULE

The schedule for deliverables related to the RI/FS for this Site is provided by Figures 8-1a and 8-1b. This schedule was developed in consultation with the USEPA, and reflects the following considerations:

- The schedule conforms in content and prioritization to the schedule provided by the 2009 UAO except that the numbers of days between submittals is presented in standard business days, not calendar days, and that a Preliminary Chemical of Concern (PCOC) Memorandum will not be submitted, because COPCs have already been identified.
- Time shown in the schedules for review by the USEPA is estimated. Deviations from the schedule, due to the review process are possible and will impact the deliverable dates of subsequent documents. Deviations from this schedule will be discussed with USEPA as required.
- The 2009 UAO requires submittal of monthly progress reports, which are not shown in Figures 8-1a and 8-1b.
- Each monthly progress report, starting July 15, 2010, will include the most current version of the project schedule.

9 REFERENCES

Adrian, L., U. Szewzyk, J. Wecke, and H. Görisch, 2000. Bacterial Dehalorespiration with Chlorinated Benzenes. Nature 408:580-583.

Allen, A.W., 1984. Habitat Suitability Index Models: Mink. FWS/OBS-82/10.61 Revised. May. U.S. Fish and Wildlife Service, Western Energy and Land Use Team, Fort Collins, CO.

Anchor QEA, LLC, 2009. Health and Safety Plan San Jacinto River Waste Pits Superfund Site. Prepared for McGinnes Industrial Maintenance Corporation, International Paper Company, and U.S. Environmental Protection Agency, Region 6. Anchor QEA, Ocean Springs, MS.

ASTM, 1995. Standard Guide for Developing Conceptual Site Models for Contaminated Sites. E 168995. American Society for Testing and Materials, West Conshohocken, PA.

ATSDR, 1998. Toxicological Profile for Chlorinated Dibenzo-*p*-Dioxins. Draft Report. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry. December 1998.

Baker, J.I., and R.A. Hites, 2000. Is combustion the major source of polychlorinated dibenzo-*p*-dioxins and dibenzofurans to the environment? A mass balance investigation. Environmental Science & Technology 34:2879-2886.

Beauchamp, R., 2010. Personal communication (telephone conversation with P.N. Tomlinson, Integral Consulting Inc., Seattle, WA, on January 12, 2010, regarding observed recreational activities in vicinity of SJRWP). Texas Department of State Health Services, Austin, TX.

Bright, D.A., W.J. Cretney, R.W. Macdonald, M.G. Ikonomou, and S.L. Grundy, 1999. Differentiation of Polychlorinated Dibenzo-*p*-Dioxin and Dibenzofuran Sources in Coastal British Columbia, Canada. Environmental Toxicology and Chemistry 18:1097-1108.

Broach, L., 2010. Personal communication (email correspondence with D. Rudnick, Integral Consulting Inc., Seattle, WA, on January 13, 2010, regarding shellfish species

expected to be found in the lower San Jacinto River). Texas Commission on Environmental Quality, Austin, TX.

Bunge, M., L. Adrian, A. Kraus, M. Opel, W.G. Lorenz, J.R. Andreesen, H. Görisch and U. Lechner, 2003. Reductive dehalogenation of chlorinated dioxins by an anaerobic bacterium. Nature 421:357-360.

Carlson, S.B., 1998. Archaeological Investigations at the David G. Burnet Park (41HR407), Harris County, Texas. Moore Archaeological Consulting, Report of Investigations No. 204. Report on file at the Texas Historical Commission.

Carter, J., 2004. FDIC Announces Release of Vietnamese Language Version of Money Smart Program. Federal Deposit Insurance Corporation. Money Smart Press Release dated February 11, 2004.

CHPDD, 2009. Houston's Comparison with Major U.S. Cities. City of Houston Planning and Development Department, Public Policy Division, Houston, TX. April.

CHPDD, 2010. Demographics. City of Houston Planning and Development Department, Public Policy Division, Houston, TX. Accessed on: March 9, 2009. http://www.houstontx.gov/planning/Demographics/dem_links.htm

Clark, R.D., T.J. Minello, J.D. Christensen, P.A. Caldwell, M.E. Monaco, and G.A. Matthews, 1999. Modeling nekton habitat use in Galveston Bay, Texas: An approach to define essential fish habitat (EFH). NOAA/NOS Biogeography Program, Silver Spring, MD, and NMFS, Galveston, TX. 70 pp.

Dean, K.E., M.P. Suarez, H.S. Rifai, R.M. Palachek, and L. Koenig, 2009. Bioaccumulation of Polychlorinated Dibenzodioxins and Dibenzofurans in Catfish and Crabs along an Estuarine Salinity and Contamination Gradient. Environmental Toxicology and Chemistry 28(11):2307-2317.

ENSR, 1995. Houston Ship Channel Toxicity Study Project Report. Prepared for the City of Houston, TX. ENSR Consulting and Engineering, Houston, TX. June.

ENSR and EHA, 1995. Houston Ship Channel Toxicity Study. Prepared for the City of Houston, Houston, TX. ENSR Consulting and Engineering, Houston, TX and Espey, Huston and Associates, Austin, TX.

Fan et al., 2006. Fate and Transport of 1278-TCDD, 1378-TCDD, and 1478-TCDD in Soil-Water Systems. Science of the Total Environment 371 (2006) 323-333.

Fetter, C.W., 1994. Applied Hydrogeology 3rd Edition. Prentice Hall, Upper Saddle River, NJ. 1994.

Frank, D.S., M.A. Mora, J.L. Sericano, A.L. Blankenship, K. Kannan, and J.P. Giesy, 2001. Persistent Organochlorine Pollutants in Eggs of colonial Waterbirds from Galveston Bay and East Texas, USA. *Environmental Toxicology and Chemistry* 20(3):608-617.

Freeze and Cherry, 1979. Groundwater. Prentice-Hall, 1979.

Fu, Q.S., A.L. Barkovskii, and P. Adriaens, 2001. Dioxin cycling in aquatic sediments: the Passaic River estuary. Chemosphere 43:643-648.

Gardiner, J., B. Azzato, and M. Jacobi (eds), 2008. Coastal and Estuarine Hazardous Waste Site Reports, September 2008. Seattle: Assessment and Restoration Division, Office of Response and Restoration, National Oceanic and Atmospheric Administration. 148 pp.

GBIC, 2010. Shrimp and Crabs. Galveston Bay Information Center, Galveston, TX. Accessed at http://gbic.tamug.edu/ss/pubs/shrimpcrabs.pdf Accessed on January 7, 2010.

Griswold del Castillo, R., 1990. *The Treaty of Guadalupe Hidalgo: A Legacy of Conflict*. University of Oklahoma Press. Norman, OK.

Hegstrom, E., 2006. Shadows Cloaking Immigrants Prevent Accurate Count. February 21, 2006. Houston Chronicle, Houston, TX.

Helsel, D.R., 2005. Nondetects and data analysis: statistics for censored environmental data. John Wiley & Sons, Inc., Hoboken, NJ.

Henson, M.S., 2002. Harris County. In *Handbook of Texas Online.* Electronic document accessed February 2010. http://www.tshaonline.org/handbook/online/articles/HH/hch7_print.html.

Himmel, K.F., 1999. *The Conquest of the Karankawas and Tonkawas: 1821-1859*. Texas A&M University Press. College Station, TX.

HGAC, 2010. http://www.h-gac.com/rds/water_quality/surface_water_monitoring_data.aspx

Holliger, C., G. Wohlfarth, and G. Diekert, 1999. Reductive dechlorination in the energy metabolism of anaerobic bacteria. FEMS Microbiology Reviews, 22:383-398.

Hudson, K.G., 1991. Archaeological Survey, Houston International Terminal, San Jacinto River, Harris County, Texas. Cultural Resources Services, Inc. Report of Investigations 91-2. Report on file at the Texas Historical Commission.

Integral Consulting Inc. and Anchor QEA, LLC, 2010. Sediment Sampling and Analysis Plan. Prepared for McGinnes Industrial Maintenance Corporation, International Paper Company, and U.S. Environmental Protection Agency, Region 6. Integral Consulting, Seattle, WA, Anchor QEA, Ocean Springs, MS.

Jackson, C.C., 2002. San Jacinto River. In *Handbook of Texas Online*. Electronic document accessed February 2010. http://www.tshaonline.org/handbook/online/articles/SS/rns9.html.

Koelmans A.A., M.T.O. Jonker, G. Cornelissen, T.D. Bucheli, P.C.M. Van Noort, and O. Gustafsson, 2006. Black Carbon: The Reverse of its Dark Side. Chemosphere 63:365-377.

Koenig, L., 2010. Personal Communication (telephone conversation with D. Rudnick, Integral Consulting Inc., Seattle, WA, on March 12, 2010, regarding sediment PCB data for San Jacinto). Texas Commission on Environmental Quality.

Ladd, K., 2002. El Orcoquisac. In *Handbook of Texas Online*. Electronic document accessed February 2010. http://www.tshaonline.org/handbook/online/articles/EE/hve49.html.

Lee, D.D., and H.S. Seung, 1999. Learning the Parts of Objects by Non-negative Matrix Factorization. *Nature* 401:788-791.

Lester, J., and L. Gonzalez, 2005. Briefing Paper on Galveston Bay Plan Action Items Freshwater Inflow and Bay Circulation. Houston Advanced Research Center, Galveston Bay Status and Trends Project. Funded by the TCEQ, Galveston Bay Estuary Program. July 2005. Available at http://galvbaydata.org/Portals/2/projects/reports/docs/BriefingPaper%20Inflows_Circ.pdf

Lipscomb, C.A., 2002. Karankawa Indians. In *Handbook of Texas Online*. Electronic document accessed February 2010. http://www.tshaonline.org/handbook/online/articles/KK/bmk5_print.html.

Louchouarn, P., and R. Brinkmeyer, 2009. Fate of Dioxin in the Houston Ship Channel and Evaluation of Natural Remediation Processes. Prepared for Texas Commission on Environmental Quality, Total Maximum Daily Load Program, Austin, TX. Texas A&M University at Galveston, Galveston, TX.

McClure, W. and L.W. Patterson, 1975. Prehistoric Occupation of White Oak Bayou Watershed. *Houston Archaeological Society Newsletter*, No. 48. Houston Archaeological Society. Houston, TX.

Meador, J.P., F.C. Sommers, G.M. Ylitalo, and C.A. Sloan, 2006. Altered growth and related physiological responses in juvenile Chinook salmon (*Onchorhynchus tshawytscha*) from dietary exposure to polycyclic aromic hydrocarbons (PAHs)/

Moore, R.G., and R. Travis, 1994. Cultural Resources Investigations and Coordination for the San Jacinto Oil Spill Incident, Harris County, Texas. Moore Archaeological Consulting, Report of Investigations No. 132. Report on file at the Texas Historical Commission.

Moore, S.L., 2004. Eighteen Minutes: The Battle of San Jacinto and the Texas Independence Campaign. Republic of Texas Press. Dallas, TX.

Nagy, K.A., 2001. Food Requirements of Wild Animals: Predictive Equations for Free Living Mammals, Reptiles and Birds. *Nutr. Abstr. Rev. B* 71:21R -32R.

NOAA, 1995. San Jacinto River Bathymetric Survey H10619, June 13 – September 13, 1995. National Oceanic and Atmospheric Administration.

NOAA, 2005. http://www.srh.noaa.gov/hgx/hurricanes/hurr_clim.htm

Nofi, A.A., 1992. *The Alamo and the Texas War for Independence: Heroes, Myths, and History*. Second Da Capo Press, New York.

Orion, 2009. Analytical Results for Sediment Samples from the Water Front of Sneed Shipbuilding. Orion Diving and Salvage.

Osborn, M., P. Chai, A. Green, J. Lin, C. Loeffer, A. Morgan, P. Rubec, S. Spanyers, and A. Walton, 1992. Fisheries: In Status and Trends of Selected Living Resources in the Galveston Bay System. GBNEP-19.C. Loeffer and A. Walton (eds). Galveston Bay National Estuary Program, Webster TX.

Ricklis, R.A., 2004. Prehistoric Occupation of the Central and Lower Texas Coast. In *The Prehistory of Texas*, ed. T. Pertulla, pp. 155-180. Texas A&M Anthropology Series No. 9.

Singh, R., and A.K. Singh, 2007. ProUCL Version 4.0 Technical Guide. J.M. Nocerino (ed.). EPA/600/R-07/041. NTIS PB2007-107919. 4/30/2007. TIP #07-52, Published Report. U.S. Environmental Protection Agency, Washington, DC.

Steevens, J.A., M.R. Reiss, and A.V. Pawlisz, 2005. A Methodology for Deriving Tissue Residue Benchmarks for Aquatic Biota: A Case Study for Fish Exposed to 2,3,7,8-Tetrachlorodibenzo-p-Dioxin and Equivalents. *Integrated Environmental Assessment and Management* 1(2):142–151.

Strahl, A., 2010. Personal communication (telephone conversation and subsequent email exchange with D. Rudnick, Integral Consulting Inc., Seattle, WA, on January 7, 2010, regarding data discrepancies between hard copy and electronic data for Site Screening Investigation report). Texas Commission on Environmental Quality, Austin, TX.

TCEQ, 2003. Guidance for Assessing Texas Surface and Finished Drinking Water Quality Data, 2004. Texas Commission on Environmental Quality, Office of Compliance and Enforcement, Monitoring Operations Division, Surface Water Quality Monitoring Program, Austin, TX. August 15.

TCEQ, 2008. Risk Levels, Hazard Indices, and Cumulative Adjustment. RG-366/TRRP-18. Texas Commission on Environmental Quality, Austin, TX. October

TCEQ, 2009. Toxicity Factors and Chemical/Physical Parameters. RG-366/TRRP-19. Texas Commission on Environmental Quality, Austin, TX. Revised March 2009.

TCEQ, 2010. DRAFT 2010 Guidance for Assessing and Reporting Surface Water Quality in Texas. Prepared by Surface Water Quality Monitoring Program Monitoring and Assessment Section Water Quality Planning Division, Texas Commission on Environmental Quality.

TCEQ and USEPA, 2006. Screening Site Assessment Report San Jacinto River Waste Pits, Channelview, Harris County, Texas. TXN000606611. Texas Commission on Environmental Quality and U.S. Environmental Protection Agency.

TDH, 1990. Fish and Shellfish Consumption Advisory. ADV-3. Texas Department of Health, Austin, TX. September 19.

TDH, 1997. Health Consultation for Consumption of Seafood from Houston Ship Channel and Upper Galveston Bay. Texas Department of Health, Austin, TX.

TDH, 2001a. Health Consultation Houston Ship Channel and Tabbs Bay, Harris County, Texas. Texas Department of Health, Austin, TX.

TDH, 2001b. Fish and Shellfish Consumption Advisory ADV-20. Texas Department of Health, Austin, TX. October 9.

TDSHS, 2005a. Characterization of Potential Health Risks Associated with Consumption of Fish or Blue Crabs from the Houston Ship Channel, the San Jacinto River (Tidal Portions, Tabbs Bay, and Upper Galveston Bay). Texas Department of State Health Services, Seafood and Aquatic Life Group, Policy, Standards, and Quality Assurance Unit and Regulatory Services Division, Austin, TX.

TDSHS, 2005b. Fish and Shellfish Consumption Advisory ADV-28. Texas Department of State Health Services, Austin, TX. January 27.

TDSHS, 2007. Quality Assurance Project Plan. Texas Department of State Health Services, Austin, TX.

TDSHS, 2007. Standard Operating Procedures and Quality Control/Assurance Manual. Texas Department of State Health Services, Seafood and Aquatic Life Group, Austin, TX.

Texas Historical Commission, 2010. Guidelines for Cultural Resource Management Reports. Electronic document accessed February 2010. http://www.thc.state.tx.us/rulesregs/RulesRegsPDF/CTAguidelines.pdf.

TNRCC, 1999. Surface Water/Groundwater Interaction Evaluation for 22 Texas River Basins. Prepared by Parsons Engineering Science, Inc., Austin, TX. July 1999.

TPWD, 2009. 2009-2010 Texas Commercial Fishing Guide. Texas Parks and Wildlife, Austin, TX.

TSHA, 1999. The Handbook of Texas Online. Texas State Historical Association, University of North Texas, Denton, TX.

TWDB, 2010. http://www.twdb.state.tx.us/publications/reports/GroundWaterReports/GWDatabaseReports/GWdatabaserpt.htm

University of Houston and Parsons, 2006. *Total maximum daily loads for dioxins in the Houston Ship Channel*. Contract No. 582-6-70860, Work Order No. 582-6-70860-02. Quarterly report No. 3. Prepared in cooperation with the Texas Commission on Environmental Quality and the U.S. Environmental Protection Agency. University of Houston and Parsons Water & Infrastructure. Available at: http://www.tceq.state.tx.us/assets/public/implementation/water/tmdl/26hscdioxin/26-all-data-compiled-q3-fy06.pdf.

University of Houston and Parsons, 2009. Total Maximum Daily Loads for PCBs in the Houston Ship Channel. Contract No. 582-6-60860. Work Order No. 528-6-60860-19. Draft Final Report. Prepared in cooperation with the Texas Commission on Environmental Quality and the U.S. Environmental Protection Agency. University of Houston and Parsons Water & Infrastructure.

URS, 2010. Data Usability Summary. Surface Water and Sediment Samples. San Jacinto River Waste Pits Superfund Site, Channelview, Harris County, Texas. Prepared for Texas Commission on Environmental Quality, Austin, Texas. Project No: 25335373. URS Corporation, Houston, TX.

Usenko, S., B. Brooks, E. Bruce, and S. Williams, 2009. Defining Biota-Sediment Accumulation Factors for the San Jacinto River Waste Pits, Texas Project Work Plan and QAQC Procedures. Center for Reservoir and Aquatic Systems Research and the Department of Environmental Science, Baylor University. September 2009.

USAF, 2006. Remedial Investigation Report, Bellows Hardfill (LF23) Bellows Air Force Station, Oahu, Hawaii. April 2006.

USCB, 2006. 2006 Census. U.S. Census Bureau, Washington, DC.

USCB, 2007. American Community Survey. U.S. Census Bureau, Washington, DC

USEPA, 1985. Health Assessment Document for Polychlorinated Dibenzo-p-Dioxins. EPA 600/8-84-014F. Available online at: http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=38484. U.S. Environmental Protection Agency, Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office. Cincinnati, OH.

USEPA, 1986. Guidelines for Carcinogen Risk Assessment. EPA/630/P-03/001B. Risk Assessment Forum, U.S. Environmental Protection Agency, Washington, DC.

USEPA, 1988a. Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.

USEPA, 1988b. U.S. EPA/Paper Industry Cooperative Dioxin Screening Study. EPA-440/1-88-025. U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Washington, DC.

USEPA, 1989. Risk Assessment Guidance for Superfund (RAGS): Volume 1 – Human Health Evaluation Manual (Part A), Interim Final. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.

USEPA, 1991. Risk Assessment Guidance for Superfund (RAGS): Volume 1 – Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals), Interim. Office of Emergency and Remedial Response, Washington, DC. EPA/540/R-92/003.

USEPA, 1992. Supplemental guidance to RAGS: Calculating the concentration term. Office of Solid Waste and Emergency Response. Washington, DC. 9285.7081

USEPA, 1993. Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure. EPA/600-D-93-901. November 4.

USEPA, 1994. Estimating Exposure to Dioxin-like Compounds, Volume II: Properties, Sources, Occurrence and Background Exposures. Review Draft. EPA/600/6 88/005Cb. U.S. Environmental Protection Agency, Washington, DC.

USEPA, 1995. Policy for risk characterization at the U.S. Environmental Protection Agency. U.S. Environmental Protection Agency, Science Policy Council, Washington, DC. March.

USEPA, 1996. Soil Screening Guidance: User's Guide. Publ. No. 9355.4-23. Office of Solid Waste and Emergency Response, Washington, DC. July.

USEPA, 1997a. Exposure Factors Handbook - Volume 1. General Factors. U.S. Environmental Protection Agency, National Center for Environmental Assessment, Office of Research and Development, Washington, DC; Versar Inc., Exposure Assessment Division (Springfield, VA). EPA/600/P-95/002Fa. August.

USEPA, 1997b. Health Effects Assessment Summary Tables. FY 1997 Update. 9200.6-303 (97-1). EPA-540-R-97-036. PB97-921199. U.S. Environmental Protection Agency, Office of Research and Development, Office of Emergency and Remedial Response, Washington, DC. July.

USEPA, 1998. Guidelines for Ecological Risk Assessment. EPA/630/R-95/002F. U.S. Environmental Protection Agency, Washington, DC.

USEPA, 1999. Ecological Risk Assessment and Risk Management Principles for Superfund Sites, Final. OSWER Directive # 9285.7-28 P. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC.

USEPA, 2000a. Exposure and Human Health Reassessment of 2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TCDD) and Related Compounds. U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC. EPA/600/P-00/001Cb. September.

USEPA, 2000b. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories. EPA 823-B-00-007. Office of Water, U.S. Environmental Protection Agency, Washington, DC. November.

USEPA, 2000c. Guidance for Data Quality Assessment, Practical Methods for Data Analysis, EPA QA/G9. Office of Environmental Information, Washington, DC. EPA/600/R-96/084. July.

USEPA, 2000d. Risk Characterization Handbook. EPA 100-B-00-002. Prepared for the U.S. Environmental Protection Agency. Prepared by EPA's Science Policy Council, Risk

Characterization Implementation Core Team. U.S. Environmental Protection Agency, Office of Research and Development, Office of Science Policy, Washington, DC.

USEPA, 2001. Risk assessment guidance for Superfund (RAGS): volume III—part A: process for conducting probabilistic risk assessment. EPA-540-R-02-002. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.

USEPA, 2002a. Calculating upper confidence limits for exposure point concentrations at hazardous waste sites. Office of Solid Waste and Emergency Response. Washington, DC. 9285.6-10.

USEPA, 2002b. Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites. OSWER 9285.6-07P. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Office of Emergency and Remedial Response. April.

USEPA, 2002c. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24. Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, DC. December.

USEPA, 2002d. Role of Background in the CERCLA Cleanup Program. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. OSWER 9285.6-07P. April 26, 2002.

USEPA, 2003a. Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs). Attachment 1-3: Evaluation of Dermal Contact and Inhalation Exposure Pathways for the Purpose of Setting Eco-SSLs. OSWER Directive 92857-55. November 2003.

USEPA, 2003b. Human Health Toxicity Values in Superfund Risk Assessments. Memorandum from Michael B. Cook, Director of Office of Superfund Remediation and Technology Innovation to Superfund National Policy Mangers, Regions 1 – 10. Directive 9285.7-53. December.

USEPA, 2004. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). Office of Superfund Remedial and Technology Innovation, U.S. Environmental Protection Agency, Washington, DC.

USEPA, 2005a. Contaminated Sediment Remediation Guidance for Hazardous Waste Sites. EPA-540-R-05-012. OSWER 9355.0-85. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC.

USEPA, 2005b. USEPA Contract Laboratory Program Functional Guidelines for Chlorinated Dioxin/Furan Data Review. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.

USEPA, 2006a. An Inventory of Sources and Environmental Releases of Dioxin-Like Compounds in the United States for the Years 1987, 1995, and 2000. EPA/600/P-03/002F. U.S. Environmental Protection Agency, National Center for Environmental Assessment, Washington, DC.

USEPA, 2006b. On the Computation of a 95% Upper Confidence Limit of the Unknown Population Mean Based Upon Data Sets with Below Detection Limit Observations. EPA/600/R-06/022. Office of Research and Development, National Exposure Research Laboratory, Environmental Sciences Division, U.S. Environmental Protection Agency, Las Vegas, NV. March.

USEPA, 2008. Framework for Application of the Toxicity Equivalence Methodology for Polychlorinated Dioxins, Furans, and Biphenyls in Ecological Risk Assessment. EPA 10/R-0 /00-200.USEPA, 2008b. Child-Specific Exposure Factors Handbook. EPA/600/R-06/096F. National Center for Environmental Assessment, Office of Research and Development, Washington, DC, September.

USEPA, 2009. Recommended Toxicity Equivalency Factors (TEFs) for Human Health Risk Assessments of Dioxin and Dioxin-Like Compounds: External Review Draft. Risk Assessment Forum, U.S. Environmental Protection Agency, Washington, DC. September 1.

USEPA, 2009b. Unilateral Administrative Order for Remedial Investigation/Feasibility Study. U.S. EPA Region 6 CERCLA Docket No. 06-03-10. In the matter of: San Jacinto River Waste Pits Superfund Site Pasadena, Texas. International Paper Company, Inc. & McGinnes Industrial Management Corporation, respondents.

USEPA et al., 2009. Public Announcement. Permit evaluation requirement process for all proposed and existing permits within the Area of Concern at the San Jacinto River Waste Pits Superfund Site. October 21, 2009. U.S. Environmental Protection

Agency, Region 6; U.S. Army Corps of Engineers, Galveston District; and Texas Commission on Environmental Quality.

USEPA, 2010. Region 3 Preliminary Remediation Goals for Fish. Available at http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/usersguide.htm.

USFWS, 2009. Amphibians and Reptiles of Trinity River National Wildlife Refuge. U.S. Fish and Wildlife Service. Accessed at: http://www.fws.gov/southwest/refuges/texas/trinityriver/Docs/TRNWRHerps2009.pdf Accessed on January 4, 2010.

USGS, 1997. Estimated Rate of recharge in Outcrops of the Chicot and Evangeline Aquifers near Houston, Texas. United Stated Department of Interior, YSGS Fact Sheey FS-1997-179-91, 1997.

USGS, 2002. Hydrogeology and Simulation of Ground-Water Flow and Land-Surface Subsidence in the Chicot and Evangeline Aquifers, Houston Area, Texas Water-Resources Investigations Report 02–4022 U.S. Department of the Interior U.S. Geological Survey.

Van den Berg, M., L. Birnbaum, A.T. Bosveld, B. Brumstrom, P. Cook, M. Feeley, J.P. Giesy, A. Hanberg, R. Hasegawa, S.W. Kennedy, T. Kubiak, J.C. Larsen, F.X. va Leeuwen, A.K. Liem, C. Nolt, R.E. Peterson, L. Poellinger, S. Safe, D. Schrenk, D. Tillitt, M. Tysklind, M. Younes, F. Waern, and T. Zacharewski, 1998. Toxic Equivalency Factors (TEFs) for PCBs, PCDDs, PCDFs for Humans and Wildlife. Environmental Health Perspectives 106:775-792.

Van den Berg, M., L.S. Birnbaum, M. Denison, et al., 2006. The 2005 World Health Organization Reevaluation of Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-Like Compounds. *Toxicol. Sci.* 93(2):223-241.

Van Siclen, D.C., 1991, Surficial geology of the Houston area: a offlapping series of Pleistocene (& Pliocene?) highest-sealevel fluviodeltaic sequences: Gulf Coast Association of Geological Societies Transactions, Vol. 41, p. 651-666.

Wenning R.J., M.A. Harris, M.J. Ungs, D.J. Paustenbach, and H. Bedbury, 1992. Chemometric comparisons of polychlorinated dibenzo-*p*-dioxin and dibenzofuran residues in surficial sediments from Newark Bay, New Jersey and other industrialized waterways. Archives in Environmental Contamination and Toxicology 22, 397-413.

Wenning, R.J., L. Martello, and T. Ianuzzi, 2004. Review of Approaches Used to Establish Sediment Benchmarks for PCDD/Fs. Organohalogen Compounds (66) 3449-3455.

Weston, 2006. Draft Field Activities Report for Sediment Sampling. San Jacinto River Bridge Dolphin Project IH-10 at the San Jacinto River. Prepared for the Texas Department of Transportation, Environmental Affairs Division, Austin, TX. Weston Solutions, Inc., Houston, Texas.

TABLES

Table 2-4
Data sets with Information on the Chemical Setting Evaluated for the San Jacinto River Waste Pits Superfund Site

Study	Sample Material	Common Name	Number of Locations	First Date	Last Date	Number of Samples	Analytes
ENSR and EHA (1995)	Edible	Blue crab	1	10/1/1993	10/1/1993	1	Dioxins and furans
ENSR and EHA (1995)	Fillet	Blue catfish	1	10/1/1993	10/1/1993	1	Dioxins and furans
ENSR and EHA (1995)	Sediment		1	8/19/1993	5/3/1994	2	Dioxins and furans
TCEQ and USEPA (2006)	Sediment		9	7/12/2005	7/13/2005	10	Dioxins and furans Metals PAH PCBs Pesticides Semivolatiles
URS (2010)	Sediment		4	8/20/2009	8/20/2009	5	Dioxins and furans
URS (2010)	Surface water		2	8/20/2009	8/20/2009	3	Dioxins and furans
University of Houston and Parsons (2008)	Sediment		1	5/2/2008	5/2/2008	1	PCBs
Koenig (2010, Pers. Comm.)	Sediment		1	5/6/2009	5/6/2009	1	PCBs
TDSHS (2007)	Edible	Blue crab	2	8/10/1999	4/7/2004	4	Dioxins and furans Herbicides Metals PAH PCBs Pesticides Semivolatiles Volatiles
TDSHS (2007)	Fillet	Blue catfish	2	1/13/1999	3/11/2004	3	Dioxins and furans Herbicides Metals PAH PCBs Pesticides Semivolatiles Volatiles
TDSHS (2007)	Fillet	Freshwater drum	1	1/13/1999	1/13/1999	1	Herbicides Metals PAH PCBs Pesticides Semivolatiles Volatiles

Table 2-4
Data sets with Information on the Chemical Setting Evaluated for the San Jacinto River Waste Pits Superfund Site

Study	Sample Material	Common Name	Number of Locations	First Date	Last Date	Number of Samples	Analytes
TDSHS (2007)	Fillet	hybrid striped bass	2	1/13/1999	3/11/2004	3	Dioxins and furans Herbicides Metals PAH PCBs Pesticides Semivolatiles Volatiles
TDSHS (2007)	Fillet	Red drum	1	3/11/2004	3/11/2004	2	Dioxins and furans Herbicides Metals PAH PCBs Pesticides Semivolatiles Volatiles
TDSHS (2007)	Fillet	Smallmouth buffalo	1	1/13/1999	1/13/1999	1	Herbicides Metals PAH PCBs Pesticides Semivolatiles Volatiles
TDSHS (2007)	Fillet	Southern flounder	1	1/13/1999	1/13/1999	1	Herbicides Metals PAH PCBs Pesticides Semivolatiles Volatiles
TDSHS (2007)	Fillet	Spotted seatrout	1	2/10/2004	3/11/2004	2	Dioxins and furans Herbicides Metals PAH PCBs Pesticides Semivolatiles Volatiles

Table 2-4
Data sets with Information on the Chemical Setting Evaluated for the San Jacinto River Waste Pits Superfund Site

Study	Sample Material	Common Name	Number of Locations	First Date	Last Date	Number of Samples	Analytes
University of Houston and Parsons (2006)	Edible	Blue catfish	1	11/20/2002	3/23/2004	2	Dioxins and furans PCBs Pesticides Physical/chemical parameters
University of Houston and Parsons (2006)	Edible	Blue crab	1	8/9/2002	10/27/2004	6	Dioxins and furans PCBs Pesticides Physical/chemical parameters
University of Houston and Parsons (2006)	Edible	Hardhead catfish	1	8/9/2002	10/28/2004	4	Dioxins and furans PCBs Physical/chemical parameters
University of Houston and Parsons (2006)	Sediment		24	8/8/2002	8/30/2005	45	Dioxins and furans Grain size PCBs Physical/chemical parameters
University of Houston and Parsons (2006)	Surface water		1	8/7/2002	11/3/2004	22	Dioxins and furans PCBs Physical/chemical parameters
Weston (2006)	Sediment		12	5/10/2006	6/2/2006	54	Dioxins and furans Grain size Metals PAH PCBs Physical/chemical parameters Semivolatiles

Table 2-5

Number of Surface Sediment and Core Sampling Locations by Study

Location[a]	Study	Number of Locations[b]	
		Surface	Core
Site	ENSR and EHA (1995)	1	0
Site	TCEQ and USEPA (2006)	9	0
Site	URS (2010)	4	0
Site	University of Houston and Parsons (2006)	24	1
Site	Weston (2006)	8	4
Nearby Area	ENSR and EHA (1995)	2	0
Nearby Area	Orion (2009)	15	0
Nearby Area	TCEQ and USEPA (2006)	5	0
Nearby Area	University of Houston and Parsons (2006)	4	0

Notes:

a - "Site" is within the preliminary Site perimeter established in the Unilateral Administrative Order; "Nearby Area" is a large area in the San Jacinto River, as shown in Figure 2-2.

b - The number of locations may differ from the number of samples if a location was sampled more than once (Table 2-1).

Table 2-6
Detection Frequencies and Summary Statistics for Analytes in Sediment Samples from the Site

Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
					Minimum	Maximum	Minimum	Mean	Maximum
Elements									
Aluminum	mg/kg	10	10	100%			6100	13000	22000
Antimony	mg/kg	10	1	10%	3.8	7.2	2.4	2.4	2.4
Arsenic	mg/kg	47	44	94%	1.0	1.4	0.26	3.5	8.6
Barium	mg/kg	47	47	100%			12	110	320
Beryllium	mg/kg	10	2	20%	0.32	#NAME?	0.89	1.1	1.3
Cadmium	mg/kg	47	14	30%	0.016	#NAME?	0.038	0.34	1.1
Calcium	mg/kg	10	10	100%			820	55000	190000
Chromium	mg/kg	47	47	100%			3.1	12	23
Cobalt	mg/kg	10	10	100%			3.1	5.7	13
Copper	mg/kg	10	9	90%	1.6	1.6	8.9	31	62
Iron	mg/kg	10	10	100%			3900	10000	20000
Lead	mg/kg	47	47	100%			3.2	14	59
Magnesium	mg/kg	10	10	100%			1300	3000	4800
Manganese	mg/kg	10	10	100%			58	370	790
Mercury	mg/kg	47	27	57%	0.00080	0.070	0.003	0.25	1.7
Nickel	mg/kg	10	10	100%			4.7	12	20
Potassium	mg/kg	10	8	80%	510	520	900	2100	3100
Selenium	mg/kg	47	36	77%	0.11	4.8	0.25	0.73	2.0
Silver	mg/kg	47	2	4%	0.01	1.4	0.21	0.25	0.29
Sodium	mg/kg	10	10	100%			1200	4100	6800
Thallium	mg/kg	10	1	10%	1.6	3.4	1.3	1.3	1.3
Vanadium	mg/kg	10	10	100%			12	23	49
Zinc	mg/kg	10	10	100%			14	110	240
Physical Properties									
Organic carbon	percent	50	50	100%			0.018	1.1	8.6
Clay	percent	48	48	100%			3	45	88
Gravel	percent	43	23	53%	0	0	0	2.8	13
Sand	percent	49	49	100%			0	23	90
Silt	percent	48	48	100%			6.7	32	63
Dioxins and Furans									
2,3,7,8-Tetrachlorodibenzo-*p* -dioxin	ng/kg	98	72	73%	0.0050	0.059	0.22	1500	23000
1,2,3,7,8-Pentachlorodibenzo-*p* -dioxin	ng/kg	98	79	81%	0.011	130	0.12	23	360
1,2,3,4,7,8-Hexachlorodibenzo-*p* -dioxin	ng/kg	98	60	61%	0.0075	70	0.053	1.1	6.2
1,2,3,6,7,8-Hexachlorodibenzo-*p* -dioxin	ng/kg	98	67	68%	0.0075	50	0.10	3.0	28
1,2,3,7,8,9-Hexachlorodibenzo-*p* -dioxin	ng/kg	98	69	70%	0.0075	170	0.15	2.2	10
1,2,3,4,6,7,8-Heptachlorodibenzo-*p* -dioxin	ng/kg	98	94	96%	0.069	220	0.083	72	1300
Octachlorodibenzo-*p* -dioxin	ng/kg	98	95	97%	170	170	0.49	1600	11000
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	98	71	72%	0.0055	0.42	2.9	4300	93000
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	98	63	64%	0.0055	120	0.10	270	3800
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	98	65	66%	0.0055	180	0.14	180	2300
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	98	65	66%	0.005	55	0.12	520	8700
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	98	64	65%	0.0055	95	0.11	140	2300
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	98	44	45%	0.0070	290	0.26	64	660

Table 2-6
Detection Frequencies and Summary Statistics for Analytes in Sediment Samples from the Site

Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
					Minimum	Maximum	Minimum	Mean	Maximum
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	98	56	57%	0.0060	230	0.090	27	350
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	98	75	77%	0.012	80	0.092	120	2400
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	98	63	64%	0.018	70	0.11	52	880
Octachlorodibenzofuran	ng/kg	98	91	93%	0.020	500	0.065	85	1100
Semivolatile Organic Compounds									
1,1'-Biphenyl	µg/kg	10	0	0%	200	460			
1,2,4-Trichlorobenzene	mg/kg	37	0	0%	0.017	0.049			
1,2-Dichlorobenzene	mg/kg	37	0	0%	0.017	0.049			
1,3-Dichlorobenzene	mg/kg	37	0	0%	0.017	0.049			
1,4-Dichlorobenzene	mg/kg	37	0	0%	0.017	0.049			
2,2'-oxybis(1-Chloropropane)	mg/kg	47	0	0%	0.017	0.46			
2,4,5-Trichlorophenol	mg/kg	47	0	0%	0.022	1.2			
2,4,6-Trichlorophenol	mg/kg	47	0	0%	0.022	0.46			
2,4-Dichlorophenol	mg/kg	47	0	0%	0.017	0.46			
2,4-Dimethylphenol	mg/kg	47	0	0%	0.017	0.46			
2,4-Dinitrophenol	mg/kg	47	0	0%	0.017	1.2			
2,4-Dinitrotoluene	mg/kg	47	0	0%	0.017	0.46			
2,6-Dinitrotoluene	mg/kg	47	0	0%	0.017	0.46			
2-Chloronaphthalene	mg/kg	47	0	0%	0.017	0.46			
2-Chlorophenol	mg/kg	47	0	0%	0.017	0.46			
2-Methylnaphthalene	mg/kg	47	0	0%	0.017	0.46			
2-Methylphenol	mg/kg	47	0	0%	0.017	0.46			
2-Nitroaniline	mg/kg	47	0	0%	0.017	1.2			
2-Nitrophenol	mg/kg	47	0	0%	0.017	0.46			
3,3'-Dichlorobenzidine	mg/kg	47	0	0%	0.017	0.46			
3,4-Methylphenol	mg/kg	37	0	0%	0.017	0.049			
3-Nitroaniline	mg/kg	47	0	0%	0.017	1.2			
4,6-Dinitro-2-methylphenol	mg/kg	47	0	0%	0.028	1.2			
4-Bromophenyl-phenylether	mg/kg	47	0	0%	0.017	0.46			
4-Chloro-3-methylphenol	mg/kg	47	0	0%	0.022	0.46			
4-Chloroaniline	mg/kg	47	0	0%	0.017	0.46			
4-Chlorophenyl-phenyl ether	mg/kg	47	0	0%	0.017	0.46			
4-Methylphenol	µg/kg	10	0	0%	200	460			
4-Nitroaniline	mg/kg	47	0	0%	0.017	1.2			
4-Nitrophenol	mg/kg	47	0	0%	0.055	1.2			
Acenaphthene	mg/kg	47	0	0%	0.017	0.46			
Acenaphthylene	mg/kg	47	0	0%	0.017	0.46			
Acetophenone	µg/kg	10	0	0%	200	460			
Anthracene	mg/kg	47	0	0%	0.017	0.46			
Benzaldehyde	µg/kg	10	0	0%	200	460			
Benzo[a]anthracene	mg/kg	47	0	0%	0.017	0.46			
Benzo[a]pyrene	mg/kg	47	0	0%	0.017	0.46			
Benzo[b]fluoranthene	mg/kg	47	0	0%	0.017	0.46			

Table 2-6
Detection Frequencies and Summary Statistics for Analytes in Sediment Samples from the Site

Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
					Minimum	Maximum	Minimum	Mean	Maximum
Benzo[g,h,i]perylene	mg/kg	47	0	0%	0.017	0.46			
Benzo[k]fluoranthene	mg/kg	47	0	0%	0.017	0.46			
Benzyl n-butyl phthalate	mg/kg	47	0	0%	0.017	0.46			
Bis(2-chloroethoxy)methane	mg/kg	47	0	0%	0.017	0.46			
Bis(2-chloroethyl)ether	mg/kg	47	0	0%	0.017	0.46			
Bis(2-ethylhexyl)phthalate	mg/kg	47	4	9%	0.017	0.46	0.11	0.56	1.8
Caprolactam	µg/kg	10	0	0%	200	460			
Chrysene	mg/kg	47	0	0%	0.017	0.46			
Dibenzo[a,h]anthracene	mg/kg	47	0	0%	0.017	0.46			
Dibenzofuran	mg/kg	47	0	0%	0.017	0.46			
Diethyl phthalate	mg/kg	47	0	0%	0.017	0.46			
Dimethyl phthalate	mg/kg	47	0	0%	0.017	0.46			
Di-n-butyl phthalate	mg/kg	47	1	2%	0.017	0.46	0.45	0.45	0.45
Di-n-octylphthalate	mg/kg	47	0	0%	0.017	0.46			
Fluoranthene	mg/kg	47	0	0%	0.017	0.46			
Fluorene	mg/kg	47	0	0%	0.017	0.46			
Hexachlorobenzene	mg/kg	47	0	0%	0.017	0.46			
Hexachlorobutadiene	mg/kg	47	0	0%	0.017	0.46			
Hexachlorocyclopentadiene	mg/kg	47	0	0%	0.017	0.46			
Hexachloroethane	mg/kg	47	0	0%	0.017	0.46			
Indeno[1,2,3-cd]pyrene	mg/kg	47	0	0%	0.017	0.46			
Isophorone	mg/kg	47	0	0%	0.017	0.46			
Naphthalene	mg/kg	47	0	0%	0.017	0.46			
Nitrobenzene	mg/kg	47	0	0%	0.017	0.46			
N-Nitrosodi-n-propylamine	mg/kg	47	0	0%	0.017	0.46			
N-Nitrosodiphenylamine	mg/kg	47	0	0%	0.017	0.46			
Pentachlorophenol	mg/kg	47	0	0%	0.028	1.2			
Phenanthrene	mg/kg	47	0	0%	0.017	0.46			
Phenol	mg/kg	47	0	0%	0.040	0.46			
Pyrene	mg/kg	47	0	0%	0.017	0.46			
Pesticides									
4,4'-DDD	µg/kg	10	0	0%	2.0	4.5			
4,4'-DDE	µg/kg	10	0	0%	2.0	4.5			
4,4'-DDT	µg/kg	10	0	0%	2.0	4.5			
Aldrin	µg/kg	10	0	0%	1.0	2.4			
Atrazine	µg/kg	10	0	0%	200	460			
alpha-Benzenehexachloride	µg/kg	10	0	0%	1.0	2.4			
beta-Benzenehexachloride	µg/kg	10	0	0%	1.0	2.4			
delta-Benzenehexachloride	µg/kg	10	0	0%	1.0	2.4			
gamma-Benzenehexachloride	µg/kg	10	0	0%	1.0	2.4			
Carbazole	mg/kg	47	0	0%	0.017	0.46			
cis-Chlordane	µg/kg	10	0	0%	1.0	2.4			
Dieldrin	µg/kg	10	0	0%	2.0	4.5			

Table 2-6
Detection Frequencies and Summary Statistics for Analytes in Sediment Samples from the Site

Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
					Minimum	Maximum	Minimum	Mean	Maximum
Endosulfan I	µg/kg	10	0	0%	1.0	2.4			
Endosulfan II	µg/kg	10	0	0%	2.0	4.5			
Endosulfan sulfate	µg/kg	10	0	0%	2.0	4.5			
Endrin	µg/kg	10	0	0%	2.0	4.5			
Endrin aldehyde	µg/kg	10	0	0%	2.0	4.5			
Endrin ketone	µg/kg	10	0	0%	2.0	4.5			
Heptachlor	µg/kg	10	0	0%	1.0	2.4			
Heptachlor epoxide	µg/kg	10	0	0%	1.0	2.4			
Methoxychlor	µg/kg	10	0	0%	10	24			
Toxaphene	µg/kg	10	0	0%	100	240			
trans-Chlordane	µg/kg	10	0	0%	1.0	2.4			
Polychlorinated Biphenyls									
Aroclor 1016	mg/kg	47	0	0%	0.0017	0.046			
Aroclor 1221	mg/kg	47	0	0%	0.0017	0.090			
Aroclor 1232	mg/kg	47	0	0%	0.0017	0.046			
Aroclor 1242	mg/kg	47	0	0%	0.0017	0.046			
Aroclor 1248	mg/kg	47	0	0%	0.0017	0.046			
Aroclor 1254	mg/kg	47	0	0%	0.0017	0.046			
Aroclor 1260	mg/kg	47	0	0%	0.0012	0.046			

Notes:

All concentrations are on a dry-weight basis.

Table 2-7

Detection Frequencies and Summary Statistics for Analytes in Sediment Samples Within the Nearby Area But Outside the Preliminary Site Perimeter

Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
					Minimum	Maximum	Minimum	Mean	Maximum
Elements									
Aluminum	mg/kg	2	2	100%			2200	2500	2800
Antimony	mg/kg	2	0	0%	3.7	3.8			
Arsenic	mg/kg	2	0	0%	0.60	0.65			
Barium	mg/kg	2	0	0%	12	13			
Beryllium	mg/kg	2	0	0%	0.31	0.32			
Cadmium	mg/kg	2	0	0%	0.31	0.32			
Calcium	mg/kg	2	1	50%	100	100	620	620	620
Chromium	mg/kg	2	2	100%			3.2	3.6	3.9
Cobalt	mg/kg	2	2	100%			1.1	1.3	1.5
Copper	mg/kg	2	2	100%			1.4	1.9	2.4
Iron	mg/kg	2	2	100%			1800	2200	2600
Lead	mg/kg	2	2	100%			2.5	2.7	2.9
Magnesium	mg/kg	2	1	50%	320	320	730	730	730
Manganese	mg/kg	2	2	100%			12	22	33
Mercury	mg/kg	2	0	0%	0.060	0.060			
Nickel	mg/kg	2	2	100%			1.7	2.0	2.3
Potassium	mg/kg	2	0	0%	310	320			
Selenium	mg/kg	2	0	0%	2.2	2.2			
Silver	mg/kg	2	0	0%	0.60	0.65			
Sodium	mg/kg	2	2	100%			720	780	840
Thallium	mg/kg	2	0	0%	1.6	1.6			
Vanadium	mg/kg	2	2	100%			4.3	4.8	5.3
Zinc	mg/kg	2	2	100%			6.0	7.5	8.9
Physical Properties									
Organic carbon	percent	7	7	100%			0.26	0.90	1.4
Clay	percent	7	7	100%			8.6	19	42
Gravel	percent	3	3	100%			0	0.033	0.10
Sand	percent	7	7	100%			10	46	72
Silt	percent	7	7	100%			19	35	64
Dioxins and Furans									
2,3,7,8-Tetrachlorodibenzo-*p* -dioxin	pg/g	23	22	96%	0.12	0.12	0.47	17	33
1,2,3,7,8-Pentachlorodibenzo-*p* -dioxin	pg/g	23	19	83%	0.058	2.0	0.20	1.0	1.5
1,2,3,4,7,8-Hexachlorodibenzo-*p* -dioxin	pg/g	23	18	78%	0.30	2.1	0.30	1.5	2.3
1,2,3,6,7,8-Hexachlorodibenzo-*p* -dioxin	pg/g	23	21	91%	0.60	1.6	0.46	3.6	5.7
1,2,3,7,8,9-Hexachlorodibenzo-*p* -dioxin	pg/g	23	20	87%	0.29	1.5	0.58	4.5	7.8
1,2,3,4,6,7,8-Heptachlorodibenzo-*p* -dioxin	pg/g	23	23	100%			11	120	190
Octachlorodibenzo-*p* -dioxin	pg/g	23	23	100%			390	3600	7300
2,3,7,8-Tetrachlorodibenzofuran	pg/g	23	22	96%	0.13	0.13	1.1	36	64
1,2,3,7,8-Pentachlorodibenzofuran	pg/g	23	17	74%	0.23	1.4	0.24	2.0	2.8
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	23	19	83%	0.14	1.2	0.2	1.9	2.8
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/g	23	18	78%	0.26	1.3	0.11	3.3	4.9
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/g	23	19	83%	0.14	1.2	0.16	1.6	2.9

Table 2-7

Detection Frequencies and Summary Statistics for Analytes in Sediment Samples Within the Nearby Area But Outside the Preliminary Site Perimeter

Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
					Minimum	Maximum	Minimum	Mean	Maximum
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/g	23	15	65%	0.065	1.2	0.12	0.64	0.89
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/g	23	17	74%	0.025	1.4	0.56	1.4	1.9
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/g	23	21	91%	0.24	1.2	1.0	18	30
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/g	23	17	74%	0.055	2.1	0.12	2.0	3.7
Octachlorodibenzofuran	pg/g	23	23	100%			3.3	230	610
Semivolatile Organic Compounds									
1,1'-Biphenyl	µg/kg	2	0	0%	220	220			
2-Methylnaphthalene	µg/kg	2	0	0%	220	220			
2-Nitroaniline	µg/kg	2	0	0%	550	550			
3-Nitroaniline	µg/kg	2	0	0%	550	550			
4-Nitroaniline	µg/kg	2	0	0%	550	550			
Acenaphthene	µg/kg	2	0	0%	220	220			
Acenaphthylene	µg/kg	2	0	0%	220	220			
Anthracene	µg/kg	2	0	0%	220	220			
Benzo[a]anthracene	µg/kg	2	0	0%	220	220			
Benzo[a]pyrene	µg/kg	2	0	0%	220	220			
Benzo[b]fluoranthene	µg/kg	2	0	0%	220	220			
Benzo[g,h,i]perylene	µg/kg	2	0	0%	220	220			
Benzo[k]fluoranthene	µg/kg	2	0	0%	220	220			
Chrysene	µg/kg	2	0	0%	220	220			
Dibenzo[a,h]anthracene	µg/kg	2	0	0%	220	220			
Dibenzofuran	µg/kg	2	0	0%	220	220			
Fluoranthene	µg/kg	2	0	0%	220	220			
Fluorene	µg/kg	2	0	0%	220	220			
Indeno[1,2,3-cd]pyrene	µg/kg	2	0	0%	220	220			
Naphthalene	µg/kg	2	0	0%	220	220			
Phenanthrene	µg/kg	2	0	0%	220	220			
Pyrene	µg/kg	2	0	0%	220	220			
2,2'-Oxybis(1-chloropropane)	µg/kg	2	0	0%	220	220			
2,4,5-Trichlorophenol	µg/kg	2	0	0%	550	550			
2,4,6-Trichlorophenol	µg/kg	2	0	0%	220	220			
2,4-Dichlorophenol	µg/kg	2	0	0%	220	220			
2,4-Dimethylphenol	µg/kg	2	0	0%	220	220			
2,4-Dinitrophenol	µg/kg	2	0	0%	550	550			
2,4-Dinitrotoluene	µg/kg	2	0	0%	220	220			
2,6-Dinitrotoluene	µg/kg	2	0	0%	220	220			
2-Chloronaphthalene	µg/kg	2	0	0%	220	220			
2-Chlorophenol	µg/kg	2	0	0%	220	220			
2-Methylphenol	µg/kg	2	0	0%	220	220			
2-Nitrophenol	µg/kg	2	0	0%	220	220			
3,3'-Dichlorobenzidine	µg/kg	2	0	0%	220	220			
4,6-Dinitro-2-methylphenol	µg/kg	2	0	0%	550	550			
4-Bromophenyl-phenylether	µg/kg	2	0	0%	220	220			

Table 2-7

Detection Frequencies and Summary Statistics for Analytes in Sediment Samples Within the Nearby Area But Outside the Preliminary Site Perimeter

Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
					Minimum	Maximum	Minimum	Mean	Maximum
4-Chloro-3-methylphenol	µg/kg	2	0	0%	220	220			
4-Chloroaniline	µg/kg	2	0	0%	220	220			
4-Chlorophenyl-phenyl ether	µg/kg	2	0	0%	220	220			
4-Methylphenol	µg/kg	2	0	0%	220	220			
4-Nitrophenol	µg/kg	2	0	0%	550	550			
Acetophenone	µg/kg	2	0	0%	220	220			
Benzaldehyde	µg/kg	2	0	0%	220	220			
Benzyl n-butyl phthalate	µg/kg	2	0	0%	220	220			
Bis(2-chloroethoxy)methane	µg/kg	2	0	0%	220	220			
Bis(2-ethylhexyl)phthalate	µg/kg	2	0	0%	220	220			
Caprolactam	µg/kg	2	0	0%	220	220			
Diethyl phthalate	µg/kg	2	0	0%	220	220			
Dimethyl phthalate	µg/kg	2	0	0%	220	220			
Di-n-butyl phthalate	µg/kg	2	0	0%	220	220			
Di-n-octylphthalate	µg/kg	2	0	0%	220	220			
Hexachlorobenzene	µg/kg	2	0	0%	220	220			
Hexachlorobutadiene	µg/kg	2	0	0%	220	220			
Hexachlorocyclopentadiene	µg/kg	2	0	0%	220	220			
Hexachloroethane	µg/kg	2	0	0%	220	220			
Isophorone	µg/kg	2	0	0%	220	220			
Nitrobenzene	µg/kg	2	0	0%	220	220			
N-Nitrosodi-n-propylamine	µg/kg	2	0	0%	220	220			
N-Nitrosodiphenylamine	µg/kg	2	0	0%	220	220			
Pentachlorophenol	µg/kg	2	0	0%	550	550			
Phenol	µg/kg	2	0	0%	220	220			
Bis(2-chloroethyl)ether	µg/kg	2	0	0%	220	220			
Pesticides									
4,4'-DDD	µg/kg	2	2	100%			7.7	16	25
4,4'-DDE	µg/kg	2	0	0%	2.2	2.2			
4,4'-DDT	µg/kg	2	2	100%			14	36	57
Aldrin	µg/kg	2	1	50%	1.1	1.1	0.70	0.70	0.70
alpha-Benzenehexachloride	µg/kg	2	0	0%	1.1	1.1			
Atrazine	µg/kg	2	0	0%	220	220			
beta-Benzenehexachloride	µg/kg	2	0	0%	1.1	1.1			
Carbazole	µg/kg	2	0	0%	220	220			
cis-Chlordane	µg/kg	2	0	0%	1.1	1.1			
delta-Benzenehexachloride	µg/kg	2	0	0%	1.1	1.1			
Dieldrin	µg/kg	2	0	0%	2.2	2.2			
Endosulfan I	µg/kg	2	0	0%	1.1	1.1			
Endosulfan II	µg/kg	2	0	0%	2.2	2.2			
Endosulfan sulfate	µg/kg	2	0	0%	2.2	2.2			
Endrin	µg/kg	2	0	0%	2.2	2.2			
Endrin aldehyde	µg/kg	2	0	0%	2.2	2.2			

Table 2-7

Detection Frequencies and Summary Statistics for Analytes in Sediment Samples Within the Nearby Area But Outside the Preliminary Site Perimeter

Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
					Minimum	Maximum	Minimum	Mean	Maximum
Endrin ketone	µg/kg	2	0	0%	2.2	2.2			
gamma-Benzenehexachloride	µg/kg	2	0	0%	1.1	1.1			
Heptachlor	µg/kg	2	0	0%	1.1	1.1			
Heptachlor epoxide	µg/kg	2	0	0%	1.1	1.1			
Methoxychlor	µg/kg	2	0	0%	11	11			
Toxaphene	µg/kg	2	0	0%	110	110			
trans-Chlordane	µg/kg	2	1	50%	1.1	1.1	1.2	1.2	1.2
Polychlorinated Biphenyls									
Aroclor 1016	µg/kg	2	0	0%	22	22			
Aroclor 1221	µg/kg	2	0	0%	43	44			
Aroclor 1232	µg/kg	2	0	0%	22	22			
Aroclor 1242	µg/kg	2	0	0%	22	22			
Aroclor 1248	µg/kg	2	0	0%	22	22			
Aroclor 1254	µg/kg	2	0	0%	22	22			
Aroclor 1260	µg/kg	2	0	0%	22	22			

Notes:

All concentrations are on a dry-weight basis.

Table 2-8
Detection Frequencies and Summary Statistics for Dioxins and Furans in Surface Water Samples from the Site

Analyte	Measurement basis	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits (pg/L)		Detected Data (pg/L)		
					Minimum	Maximum	Minimum	Mean	Maximum
2,3,7,8-Tetrachlorodibenzo-*p* -dioxin	Total	3	3	100%			1.9	5.5	7.5
1,2,3,7,8-Pentachlorodibenzo-*p* -dioxin	Total	3	0	0%	0.65	0.70			
1,2,3,4,7,8-Hexachlorodibenzo-*p* -dioxin	Total	3	0	0%	0.60	0.70			
1,2,3,6,7,8-Hexachlorodibenzo-*p* -dioxin	Total	3	0	0%	0.70	0.80			
1,2,3,7,8,9-Hexachlorodibenzo-*p* -dioxin	Total	3	0	0%	0.55	0.85			
1,2,3,4,6,7,8-Heptachlorodibenzo-*p* -dioxin	Total	3	0	0%	2.6	3.4			
Octachlorodibenzo-*p* -dioxin	Total	3	0	0%	70	80			
2,3,7,8-Tetrachlorodibenzofuran	Total	3	3	100%			9.1	22	30
1,2,3,7,8-Pentachlorodibenzofuran	Total	3	2	67%	0.65	0.65	1.9	2.4	2.9
2,3,4,7,8-Pentachlorodibenzofuran	Total	3	2	67%	0.46	0.46	1.9	1.9	1.9
1,2,3,4,7,8-Hexachlorodibenzofuran	Total	3	3	100%			1.2	6.3	12
1,2,3,6,7,8-Hexachlorodibenzofuran	Total	3	2	67%	0.55	0.55	1.8	2.5	3.1
1,2,3,7,8,9-Hexachlorodibenzofuran	Total	3	0	0%	0.55	0.70			
2,3,4,6,7,8-Hexachlorodibenzofuran	Total	3	0	0%	0.46	0.65			
1,2,3,4,6,7,8-Heptachlorodibenzofuran	Total	3	2	67%	0.80	0.80	3.4	4.3	5.1
1,2,3,4,7,8,9-Heptachlorodibenzofuran	Total	3	0	0%	1.3	1.5			
Octachlorodibenzofuran	Total	3	2	67%	4.4	4.4	8.9	11	13
2,3,7,8-Tetrachlorodibenzo-*p* -dioxin	Dissolved	9	7	78%	10	12	27	84	130
1,2,3,7,8-Pentachlorodibenzo-*p* -dioxin	Dissolved	9	1	11%	1.7	3.8	5.1	5.1	5.1
1,2,3,4,7,8-Hexachlorodibenzo-*p* -dioxin	Dissolved	9	6	67%	2.3	7.0	2.9	6.1	9.5
1,2,3,6,7,8-Hexachlorodibenzo-*p* -dioxin	Dissolved	9	6	67%	3.0	7.0	5.8	11	14
1,2,3,7,8,9-Hexachlorodibenzo-*p* -dioxin	Dissolved	9	6	67%	2.9	7.0	8.7	15	20
1,2,3,4,6,7,8-Heptachlorodibenzo-*p* -dioxin	Dissolved	9	8	89%	60	60	91	300	490
Octachlorodibenzo-*p* -dioxin	Dissolved	9	9	100%			2500	9600	19000
2,3,7,8-Tetrachlorodibenzofuran	Dissolved	9	9	100%			74	260	480
1,2,3,7,8-Pentachlorodibenzofuran	Dissolved	9	5	56%	1.2	10	6.4	9.3	13
2,3,4,7,8-Pentachlorodibenzofuran	Dissolved	9	5	56%	2.8	9.0	5.7	8.1	9.5
1,2,3,4,7,8-Hexachlorodibenzofuran	Dissolved	9	5	56%	2.4	38	12	17	24
1,2,3,6,7,8-Hexachlorodibenzofuran	Dissolved	9	4	44%	1.6	8.5	4.3	5.7	6.4
1,2,3,7,8,9-Hexachlorodibenzofuran	Dissolved	9	0	0%	1.0	4.5			
2,3,4,6,7,8-Hexachlorodibenzofuran	Dissolved	9	4	44%	1.0	4.1	3.1	3.9	5.2
1,2,3,4,6,7,8-Heptachlorodibenzofuran	Dissolved	9	4	44%	7.0	28	28	38	55
1,2,3,4,7,8,9-Heptachlorodibenzofuran	Dissolved	9	4	44%	1.4	9.5	4.3	6.5	9.1
Octachlorodibenzofuran	Dissolved	9	9	100%			81	210	610

Notes:

All data were collected within the preliminary site perimeter (TCEQ 2009).

Table 2-9
TCDD and TCDF Concentrations in Surface Water Samples from the Site

Location	Sample Date	Measurement Basis	2,3,7,8-TCDD (pg/L)		2,3,7,8-TCDF (pg/L)	
11193	8/7/2002	Dissolved	12	*U*	110	
11193	11/20/2002	Dissolved	46		200	
11193	6/4/2003	Dissolved	120		410	
11193	3/23/2004	Dissolved	96		320	*J*
11193	3/23/2004	Dissolved	90		300	*J*
11193	8/3/2004	Dissolved	82		370	
11193	8/3/2004	Dissolved	130		480	
11193	11/3/2004	Dissolved	27		78	
11193	11/3/2004	Dissolved	10	*UJ*	74	
TCEQ2009_01	8/20/2009	Total	7.0	*J*	27	
TCEQ2009_01	8/20/2009	Total	7.5	*J*	30	
TCEQ2009_03	8/20/2009	Total	1.9	*J*	9.1	*J*

Notes:

J = estimated

U = undetected

TCDD = tetrachlorodibenzo-*p* -dioxin

TCDF = tetrachlorodibenzofuran

Table 2-10
Dissolved TCDD and TCDF Concentrations in Upstream Surface Water Samples

Location ID	Sample Date	2,3,7,8-TCDD (pg/L, dissolved)		2,3,7,8-TCDF (pg/L, dissolved)	
11200	9/2/2002	1.4	*U*	9.2	*J*
16622	9/2/2002	1.4	*U*	11	*J*
11200	11/21/2002	1.9	*U*	8	*J*
16622	6/3/2003	2.7	*U*	22	
11197	3/24/2004	3.8	*U*	29	
11197	10/29/2004	6.0	*UJ*	38	

Notes:

Data are from the Total Maximum Daily Load program (University of Houston and Parsons 2006).

J = estimated
U = undetected
TCDD = tetrachlorodibenzo-*p* -dioxin
TCDF = tetrachlorodibenzofuran

Table 2-11
Ambient Air Sampling Event

Event	Number of Locations	Sampling Dates	Type of Samples Collected	Blank
September/02	3	09/01/02-09/27/02	T (4)	T(1)
October /02	5	10/12/02-11/01/02	T(5), P(2), G(2)	T(1)
November /02	4	11/09/02-11/29/02	T(4),P(1), G(1)	T(1)
December/02	4	11/30/02-12/20/02	T(5)	P(1), G(1)
January/03	4	01/11/03-01/30/02	T(4), P(2), G(2)	T(1)
February/03	4	02/01/03-02/27/03	T(4), P(2), G(2)	T(1)
March/03	5	03/08/03-04/03/03	T (5), P(2), G(2)	T(1)
April/03	5	04/05/03-05/01/03	T(5), P(2), G(2)	T(1)
May/03	5	05/03/03-05/28/03	T(5), P(2), G(2)	T(1)
June/03	5	05/31/03-06/26/03	T(5), P(2), G(2)	T(1)
July/03	5	06/30/03-07/28/03	T(5), P(2), G(2)	T(1)
August/03	5	08/02/03-08/28/03	T(5), P(2), G(2)	T(1)
December/03-January/04	2	12/13/03-01/09/04	T(2), P(2), G(2), DD(2)	T(1), DD(1)
January/04-February/04	2	01/17/04-02/20/04	T(2), P(2), G(2), DD(1)	T(1), DD(1)
February/04-March/04	2	02/27/04-03/26/04	P(2), G(2), DD(2)	T(1)
March/04-April/04	2	03/26/04-04/23/04	P(2), G(2), DD(2), WD(1)	
September/04-October/04	1	09/07/04-11/02/04	P(1), G(1), DD(1), PSD(6)	
November /04-December/04	1	11/03/04-12/28/04	P(1), G(1), DD(1), PSD(6)	
January/05-February/05	1	12/28/04-202/22/05	P(1), G(1), DD(1), WD(1), BD(1), PSD(6)	T(1), PSD(3)
June/05-May/06	1	06/08/05-05/09/06	P(1), G(1), DD(1), WD(1), BD(1)	T(1)
Numbers in parenthesis correspond to the number of samples collected.				
T - Total ambient air				
P - Particle phase				
G - Gas phase				
DD - Dry deposition				
WD - Wet deposition				
BD - Bulk deposition				
PSD - Particle size distribution				

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
Blue Catfish / Edible / Physical and Chemical										
	Lipid	percent	2	2	100%			0.80	1.6	2.4
Blue Catfish / Edible / Dioxins and Furans										
	2,3,7,8-Tetrachlorodibenzo-*p*-dioxin	ng/kg	2	2	100%			4.3	4.5	4.6
	1,2,3,7,8-Pentachlorodibenzo-*p*-dioxin	ng/kg	2	2	100%			0.27	0.28	0.29
	1,2,3,4,7,8-Hexachlorodibenzo-*p*-dioxin	ng/kg	2	0	0%	0.070	0.090			
	1,2,3,6,7,8-Hexachlorodibenzo-*p*-dioxin	ng/kg	2	2	100%			0.40	0.42	0.43
	1,2,3,7,8,9-Hexachlorodibenzo-*p*-dioxin	ng/kg	2	2	100%			0.23	0.30	0.37
	1,2,3,4,6,7,8-Heptachlorodibenzo-*p*-dioxin	ng/kg	2	1	50%	0.41	0.41	1.5	1.5	1.5
	Octachlorodibenzo-*p*-dioxin	ng/kg	2	2	100%			3.6	5.3	7.0
	Tetrachlorodibenzo-*p*-dioxin (Total)	ng/kg	2	2	100%			4.3	4.5	4.6
	Pentachlorodibenzo-*p*-dioxin (Total)	ng/kg	2	2	100%			0.27	0.28	0.29
	Hexachlorodibenzo-*p*-dioxin (Total)	ng/kg	2	2	100%			0.63	0.71	0.79
	Heptachlorodibenzo-*p*-dioxin (Total)	ng/kg	2	2	100%			0.62	1.4	2.2
	2,3,7,8-Tetrachlorodibenzofuran	ng/kg	2	1	50%	0.095	0.095	0.29	0.29	0.29
	2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	2	2	100%			0.37	0.39	0.41
	1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	2	2	100%			0.13	0.39	0.64
	1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	2	1	50%	0.090	0.090	0.12	0.12	0.12
	1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	2	1	50%	0.085	0.085	0.10	0.10	0.10
	1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	2	2	100%			0.088	0.26	0.44
	2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	2	1	50%	0.13	0.13	0.11	0.11	0.11
	1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	2	0	0%	0.18	0.38			
	1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	2	0	0%	0.090	0.20			
	Octachlorodibenzofuran	ng/kg	2	2	100%			0.91	1.2	1.4
	Tetrachlorodibenzofuran (Total)	ng/kg	2	2	100%			0.24	0.27	0.29
	Pentachlorodibenzofuran (Total)	ng/kg	2	2	100%			1.1	2.8	4.5
	Hexachlorodibenzofuran (Total)	ng/kg	2	2	100%			0.33	1.1	1.9
	Heptachlorodibenzofuran (Total)	ng/kg	2	1	50%	0.43	0.43	0.41	0.41	0.41
Blue Catfish / Edible / Pesticides										
	Dieldrin	mg/kg	1	0	0%	0.0030	0.0030			
	Heptachlor epoxide	mg/kg	1	0	0%	0.0015	0.0015			
	sum of p,p'-DDD and o,p'-DDD	mg/kg	1	0	0%	0.0030	0.0030			
	sum of p,p'-DDE and o,p'-DDE	mg/kg	1	1	100%			0.0070	0.0070	0.0070
Blue Catfish / Edible / Polychlorinated Biphenyls										
	Aroclor 1016	mg/kg	1	0	0%	0.019	0.019			
	Aroclor 1221	mg/kg	1	0	0%	0.0075	0.0075			
	Aroclor 1232	mg/kg	1	0	0%	0.019	0.019			
	Aroclor 1242	mg/kg	1	0	0%	0.019	0.019			
	Aroclor 1248	mg/kg	1	0	0%	0.011	0.011			
	Aroclor 1254	mg/kg	1	0	0%	0.030	0.030			
	Aroclor 1260	mg/kg	1	0	0%	0.016	0.016			
	Total PCBs	mg/kg	1	0	0%	0.030	0.030			
Blue Catfish / Fillet / Metals										
	Arsenic	mg/kg	2	0	0%	0.014	0.031			
	Cadmium	mg/kg	2	0	0%	0.0070	0.0076			
	Copper	mg/kg	2	2	100%			0.19	0.20	0.21
	Lead	mg/kg	2	1	50%	0.018	0.018	0.073	0.073	0.073
	Mercury	mg/kg	2	2	100%			0.076	0.10	0.13
	Selenium	mg/kg	2	2	100%			0.23	0.24	0.25
	Zinc	mg/kg	2	2	100%			3.9	4.0	4.2
Blue Catfish / Fillet / Dioxins and Furans										
	2,3,7,8-Tetrachlorodibenzo-*p*-dioxin	pg/g	2	2	100%			2.8	5.4	8.1

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
	1,2,3,7,8-Pentachlorodibenzo-*p* -dioxin	pg/g	2	0	0%	0.041	0.21			
	1,2,3,4,7,8-Hexachlorodibenzo-*p* -dioxin	pg/g	2	0	0%	0.025	0.028			
	1,2,3,6,7,8-Hexachlorodibenzo-*p* -dioxin	pg/g	2	2	100%			0.39	0.81	1.2
	1,2,3,7,8,9-Hexachlorodibenzo-*p* -dioxin	pg/g	2	1	50%	0.060	0.060	0.43	0.43	0.43
	1,2,3,4,6,7,8-Heptachlorodibenzo-*p* -dioxin	pg/g	2	2	100%			0.98	1.3	1.6
	Octachlorodibenzo-*p* -dioxin	pg/g	2	2	100%			1.3	2.2	3.0
	2,3,7,8-Tetrachlorodibenzofuran	pg/g	2	2	100%			0.67	1.1	1.5
	1,2,3,7,8-Pentachlorodibenzofuran	pg/g	2	1	50%	0.027	0.027	0.17	0.17	0.17
	2,3,4,7,8-Pentachlorodibenzofuran	pg/g	2	2	100%			0.22	0.43	0.64
	1,2,3,4,7,8-Hexachlorodibenzofuran	pg/g	2	0	0%	0.026	0.041			
	1,2,3,6,7,8-Hexachlorodibenzofuran	pg/g	2	0	0%	0.023	0.040			
	1,2,3,7,8,9-Hexachlorodibenzofuran	pg/g	2	0	0%	0.033	0.042			
	2,3,4,6,7,8-Hexachlorodibenzofuran	pg/g	2	0	0%	0.025	0.042			
	1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/g	2	0	0%	0.036	0.055			
	1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/g	2	0	0%	0.048	0.055			
	Octachlorodibenzofuran	pg/g	2	0	0%	0.028	0.036			
Blue Catfish / Fillet / Semivolatile and Volatile Organic Compounds										
	1,1,1,2-Tetrachloroethane	µg/kg	1	0	0%	10	10			
	1,1,1-Trichloroethane	µg/kg	1	0	0%	10	10			
	1,1,2,2-Tetrachloroethane	µg/kg	1	0	0%	10	10			
	1,1,2-Trichloroethane	µg/kg	1	0	0%	10	10			
	1,1-Dichloroethane	µg/kg	1	0	0%	10	10			
	1,1-Dichloroethene	µg/kg	1	0	0%	10	10			
	1,1-Dichloropropene	µg/kg	1	0	0%	10	10			
	1,2,3-Trichlorobenzene	µg/kg	1	0	0%	10	10			
	1,2,3-Trichloropropane	µg/kg	1	0	0%	10	10			
	1,2,4,5-Tetrachlorobenzene	mg/kg	1	0	0%	0.50	0.50			
	1,2,4-Trichlorobenzene	mg/kg	1	0	0%	0.010	0.010			
	1,2,4-Trimethylbenzene	µg/kg	1	0	0%	10	10			
	1,2-Dibromo-3-chloropropane	µg/kg	1	0	0%	10	10			
	1,2-Dibromoethane	µg/kg	1	0	0%	10	10			
	1,2-Dichlorobenzene	mg/kg	1	0	0%	0.010	0.010			
	1,2-Dichloroethane	µg/kg	1	0	0%	10	10			
	1,2-Dichloropropane	µg/kg	1	0	0%	10	10			
	1,3,5-Trinitrobenzene	µg/kg	1	0	0%	10	10			
	1,3-Dichlorobenzene	mg/kg	1	0	0%	0.010	0.010			
	1,3-Dichloropropane	µg/kg	1	0	0%	10	10			
	1,4-Dichlorobenzene	mg/kg	1	0	0%	0.010	0.010			
	2,2-Dichloropropane	µg/kg	1	0	0%	10	10			
	2,4,5-Trichlorophenol	mg/kg	1	0	0%	0.50	0.50			
	2,4,6-Trichlorophenol	mg/kg	1	0	0%	0.50	0.50			
	2,4-Dichlorophenol	mg/kg	1	0	0%	0.50	0.50			
	2,4-Dimethylphenol	mg/kg	1	0	0%	0.50	0.50			
	2,4-Dinitrophenol	mg/kg	1	0	0%	1.0	1.0			
	2,4-Dinitrotoluene	mg/kg	1	0	0%	1.0	1.0			
	2,6-Dinitrotoluene	mg/kg	1	0	0%	0.50	0.50			
	2-Butanone	µg/kg	1	0	0%	50	50			
	2-Chloronaphthalene	mg/kg	1	0	0%	0.50	0.50			
	2-Chlorophenol	mg/kg	1	0	0%	0.50	0.50			
	2-Chlorotoluene	µg/kg	1	0	0%	10	10			
	2-Hexanone	µg/kg	1	0	0%	10	10			
	2-Methylnaphthalene	mg/kg	1	0	0%	0.50	0.50			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
	2-Methylphenol	mg/kg	1	0	0%	0.50	0.50			
	2-Nitroaniline	mg/kg	1	0	0%	0.50	0.50			
	2-Nitrophenol	mg/kg	1	0	0%	0.50	0.50			
	3,3'-Dichlorobenzidine	mg/kg	1	0	0%	2.0	2.0			
	3,4-Methylphenol	mg/kg	1	0	0%	0.50	0.50			
	3-Nitroaniline	mg/kg	1	0	0%	1.0	1.0			
	4,6-Dinitro-2-methylphenol	mg/kg	1	0	0%	1.0	1.0			
	4-Bromophenyl-phenylether	mg/kg	1	0	0%	0.50	0.50			
	4-Chloro-3-methylphenol	mg/kg	1	0	0%	0.50	0.50			
	4-Chloroaniline	mg/kg	1	0	0%	0.20	0.20			
	4-Chlorophenyl-phenyl ether	mg/kg	1	0	0%	0.50	0.50			
	4-Chlorotoluene	µg/kg	1	0	0%	10	10			
	4-Isopropyl toluene	µg/kg	1	0	0%	10	10			
	4-Methyl-2-pentanone	µg/kg	1	0	0%	10	10			
	4-Nitroaniline	mg/kg	1	0	0%	1.0	1.0			
	4-Nitrophenol	mg/kg	1	0	0%	2.0	2.0			
	Acenaphthene	mg/kg	1	0	0%	0.20	0.20			
	Acenaphthylene	mg/kg	1	0	0%	0.20	0.20			
	Acetone	µg/kg	1	1	100%			360	360	360
	Acrylonitrile	µg/kg	1	0	0%	10	10			
	Aniline	mg/kg	1	0	0%	2.0	2.0			
	Anthracene	mg/kg	1	0	0%	0.20	0.20			
	Benzene	µg/kg	1	0	0%	10	10			
	Benzidine	mg/kg	1	0	0%	0	0			
	Benzo[a]anthracene	mg/kg	1	0	0%	0.20	0.20			
	Benzo[a]pyrene	mg/kg	1	0	0%	0.20	0.20			
	Benzo[b]fluoranthene	mg/kg	1	0	0%	0.20	0.20			
	Benzo[g,h,i]perylene	mg/kg	1	0	0%	0.20	0.20			
	Benzo[k]fluoranthene	mg/kg	1	0	0%	0.20	0.20			
	Benzoic acid	mg/kg	1	0	0%	0.50	0.50			
	Benzyl alcohol	mg/kg	1	0	0%	0.50	0.50			
	Benzyl n-butyl phthalate	mg/kg	1	0	0%	0.50	0.50			
	Bis(2-chloroethoxy)methane	mg/kg	1	0	0%	0.50	0.50			
	Bis(2-chloroethyl)ether	mg/kg	1	0	0%	1.0	1.0			
	Bis(2-chloroisopropyl) ether	mg/kg	1	0	0%	0.50	0.50			
	Bis(2-ethylhexyl) adipate	mg/kg	1	0	0%	0.50	0.50			
	Bis(2-ethylhexyl)phthalate	mg/kg	1	0	0%	0.50	0.50			
	Bromobenzene	µg/kg	1	0	0%	10	10			
	Bromochloromethane	µg/kg	1	0	0%	10	10			
	Bromodichloromethane	µg/kg	1	0	0%	10	10			
	Bromoform	µg/kg	1	0	0%	10	10			
	Bromomethane	µg/kg	1	0	0%	25	25			
	Carbon disulfide	µg/kg	1	0	0%	25	25			
	Carbon Tetrachloride	µg/kg	1	0	0%	10	10			
	Chlorobenzene	µg/kg	1	0	0%	10	10			
	Chloroethane	µg/kg	1	0	0%	25	25			
	Chloroform	µg/kg	1	0	0%	10	10			
	Chloromethane	µg/kg	1	0	0%	25	25			
	Chrysene	mg/kg	1	0	0%	0.20	0.20			
	cis-1,2-Dichloroethene	µg/kg	1	0	0%	10	10			
	cis-1,3-Dichloropropene	µg/kg	1	0	0%	50	50			
	Dibenzo[a,h]anthracene	mg/kg	1	0	0%	0.20	0.20			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
	Dibenzofuran	mg/kg	1	0	0%	0.50	0.50			
	Dibromochloromethane	µg/kg	1	0	0%	10	10			
	Dibromomethane	µg/kg	1	0	0%	10	10			
	Dichlorodifluoromethane	µg/kg	1	0	0%	25	25			
	Diethyl phthalate	mg/kg	1	0	0%	0.50	0.50			
	Dimethyl phthalate	mg/kg	1	0	0%	0.50	0.50			
	Di-n-butyl phthalate	mg/kg	1	0	0%	0.50	0.50			
	Di-n-octylphthalate	mg/kg	1	0	0%	0.50	0.50			
	Diphenylhydrazine	mg/kg	1	0	0%	0.50	0.50			
	Ethyl methacrylate	µg/kg	1	0	0%	10	10			
	Ethylbenzene	µg/kg	1	0	0%	10	10			
	Fluoranthene	mg/kg	1	0	0%	0.20	0.20			
	Fluorene	mg/kg	1	0	0%	0.20	0.20			
	Hexachlorobenzene	mg/kg	2	0	0%	0.0010	0.0010			
	Hexachlorobutadiene	mg/kg	1	0	0%	0.025	0.025			
	Hexachlorocyclopentadiene	mg/kg	1	0	0%	2.0	2.0			
	Hexachloroethane	mg/kg	1	0	0%	0.50	0.50			
	Hexachlorophene	mg/kg	1	0	0%	0	0			
	Indeno[1,2,3-cd]pyrene	mg/kg	1	0	0%	0.20	0.20			
	Iodomethane	µg/kg	1	0	0%	25	25			
	Isophorone	mg/kg	1	0	0%	0.50	0.50			
	Isopropylbenzene	µg/kg	1	0	0%	10	10			
	m,p-Xylene	µg/kg	1	0	0%	20	20			
	Methyl methacrylate	µg/kg	1	0	0%	10	10			
	Methyl tert-butyl ether	µg/kg	1	0	0%	10	10			
	Methylene Chloride	µg/kg	1	0	0%	25	25			
	Naphthalene	mg/kg	1	0	0%	0.010	0.010			
	n-Butylbenzene	µg/kg	1	0	0%	10	10			
	Nitrobenzene	mg/kg	1	0	0%	0.50	0.50			
	N-nitroso diethylamine	mg/kg	1	0	0%	0.50	0.50			
	N-nitroso-dibutylamine	mg/kg	1	0	0%	0.50	0.50			
	N-Nitrosodimethylamine	mg/kg	1	0	0%	0.50	0.50			
	N-Nitrosodi-n-propylamine	mg/kg	1	0	0%	0.50	0.50			
	N-Nitrosodiphenylamine	mg/kg	1	0	0%	0.50	0.50			
	n-Propylbenzene	µg/kg	1	0	0%	10	10			
	o-Xylene	µg/kg	1	0	0%	10	10			
	Pentachlorophenol	mg/kg	1	0	0%	1.0	1.0			
	Phenanthrene	mg/kg	1	0	0%	0.20	0.20			
	Phenol	mg/kg	1	0	0%	0.50	0.50			
	Pyrene	mg/kg	1	0	0%	0.20	0.20			
	Pyridine	mg/kg	1	0	0%	0.50	0.50			
	sec-Butylbenzene	µg/kg	1	0	0%	10	10			
	Styrene	µg/kg	1	0	0%	10	10			
	tert-Butylbenzene	µg/kg	1	0	0%	10	10			
	Tetrachloroethene	µg/kg	1	0	0%	10	10			
	Tetrahydrofuran	µg/kg	1	0	0%	25	25			
	Toluene	µg/kg	1	0	0%	10	10			
	trans-1,2-Dichloroethene	µg/kg	1	0	0%	10	10			
	trans-1,3-Dichloropropene	µg/kg	1	0	0%	50	50			
	Trichloroethene	µg/kg	1	0	0%	10	10			
	Trichlorofluoromethane	µg/kg	1	0	0%	25	25			
	Vinyl Chloride	µg/kg	1	0	0%	25	25			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
Blue Catfish / Fillet / Pesticides										
	4,4'-DDD	mg/kg	2	1	50%	0.0050	0.0050	0.012	0.012	0.012
	4,4'-DDE	mg/kg	2	1	50%	0.0025	0.0025	0.0055	0.0055	0.0055
	4,4'-DDT	mg/kg	2	0	0%	0.0050	0.0050			
	Aldrin	mg/kg	2	0	0%	0.0010	0.0010			
	alpha-Benzenehexachloride	mg/kg	2	0	0%	0.0010	0.0010			
	beta-Benzenehexachloride	mg/kg	2	0	0%	0.0010	0.0010			
	Chlordane	µg/kg	2	2	100%			36	36	36
	Chlorpyrifos	µg/kg	2	0	0%	5.0	5.0			
	delta-Benzenehexachloride	mg/kg	2	0	0%	0.0010	0.0010			
	Diazinon	µg/kg	2	0	0%	5.0	5.0			
	Dieldrin	mg/kg	2	0	0%	0.0030	0.0030			
	Endosulfan I	mg/kg	2	0	0%	0.0050	0.0050			
	Endosulfan II	mg/kg	2	0	0%	0.0050	0.0050			
	Endosulfan sulfate	mg/kg	2	0	0%	0.0050	0.0050			
	Endrin	mg/kg	2	0	0%	0.0030	0.0030			
	Endrin aldehyde	mg/kg	1	0	0%	0	0			
	Endrin ketone	mg/kg	1	0	0%	0.50	0.50			
	gamma-Benzenehexachloride	mg/kg	2	0	0%	0.0010	0.0010			
	Heptachlor	mg/kg	2	0	0%	0.0010	0.0010			
	Heptachlor epoxide	mg/kg	2	0	0%	0.0020	0.0020			
	Malathion	µg/kg	2	0	0%	10	10			
	Methoxychlor	µg/kg	2	0	0%	15	15			
	Methyl parathion	µg/kg	2	0	0%	5.0	5.0			
	Mirex	µg/kg	2	0	0%	4.0	4.0			
	Parathion	µg/kg	2	0	0%	5.0	5.0			
	Toxaphene	µg/kg	2	0	0%	50	50			
Blue Catfish / Fillet / Herbicides										
	Alachlor	µg/kg	2	0	0%	4.0	4.0			
	Dimethyl tetrachloroterephthalate	µg/kg	2	0	0%	1.5	1.5			
Blue Catfish / Fillet / Polychlorinated Biphenyls										
	Aroclor 1016	µg/kg	2	0	0%	20	20			
	Aroclor 1221	µg/kg	2	0	0%	20	20			
	Aroclor 1232	µg/kg	2	0	0%	20	20			
	Aroclor 1242	µg/kg	2	0	0%	20	20			
	Aroclor 1248	µg/kg	2	0	0%	20	20			
	Aroclor 1254	µg/kg	2	0	0%	20	20			
	Aroclor 1260	µg/kg	2	1	50%	20	20	52	52	52
Blue Crab / Edible / Metals										
	Arsenic	mg/kg	2	0	0%	0.012	0.014			
	Cadmium	mg/kg	2	1	50%	0.0060	0.0060	0.025	0.025	0.025
	Copper	mg/kg	2	2	100%			7.7	8.1	8.5
	Lead	mg/kg	2	0	0%	0.015	0.023			
	Mercury	mg/kg	2	2	100%			0.078	0.078	0.078
	Selenium	mg/kg	2	2	100%			0.90	0.92	0.94
	Zinc	mg/kg	2	2	100%			30	30	31
Blue Crab / Edible / Physical and Chemical										
	Lipid	percent	6	6	100%			0.70	0.95	1.1
Blue Crab / Edible / Dioxins and Furans										
	2,3,7,8-Tetrachlorodibenzo-*p*-dioxin	ng/kg	8	7	88%	0.80	0.80	2.4	4.7	11
	1,2,3,7,8-Pentachlorodibenzo-*p*-dioxin	ng/kg	8	3	38%	0.025	0.17	0.12	0.15	0.18
	2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	8	4	50%	0.085	0.12	0.25	0.44	0.56

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
	1,2,3,4,7,8-Hexachlorodibenzo-*p* -dioxin	ng/kg	8	1	13%	0.027	0.13	0.21	0.21	0.21
	1,2,3,6,7,8-Hexachlorodibenzo-*p* -dioxin	ng/kg	8	3	38%	0.030	0.14	0.21	0.23	0.24
	1,2,3,7,8,9-Hexachlorodibenzo-*p* -dioxin	ng/kg	8	3	38%	0.028	0.13	0.18	0.20	0.23
	1,2,3,4,6,7,8-Heptachlorodibenzo-*p* -dioxin	ng/kg	8	7	88%	0.14	0.14	0.44	0.77	1.4
	Octachlorodibenzo-*p* -dioxin	ng/kg	8	8	100%			1.6	5.3	15
	Tetrachlorodibenzo-*p* -dioxin (Total)	ng/kg	6	5	83%	0.80	0.80	3.6	6.7	12
	Pentachlorodibenzo-*p* -dioxin (Total)	ng/kg	6	4	67%	0.080	0.17	0.29	0.65	0.99
	Hexachlorodibenzo-*p* -dioxin (Total)	ng/kg	6	6	100%			0.37	1.8	3.2
	Heptachlorodibenzo-*p* -dioxin (Total)	ng/kg	6	6	100%			1.3	1.8	2.3
	2,3,7,8-Tetrachlorodibenzofuran	ng/kg	8	8	100%			3.3	10	29
	1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	8	3	38%	0.029	0.12	0.18	0.37	0.49
	1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	8	2	25%	0.024	0.090	0.14	0.15	0.16
	1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	8	1	13%	0.022	0.29	0.11	0.11	0.11
	1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	8	1	13%	0.031	0.17	0.21	0.21	0.21
	2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	8	2	25%	0.024	0.12	0.13	0.19	0.24
	1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	8	3	38%	0.060	0.13	0.25	0.34	0.50
	1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	8	0	0%	0.032	0.15			
	Octachlorodibenzofuran	ng/kg	8	5	63%	0.032	0.15	0.51	1.1	2.0
	Tetrachlorodibenzofuran (Total)	ng/kg	6	6	100%			4.1	18	38
	Pentachlorodibenzofuran (Total)	ng/kg	6	6	100%			0.54	2.3	5.0
	Hexachlorodibenzofuran (Total)	ng/kg	6	5	83%	0.45	0.45	0.33	0.71	1.2
	Heptachlorodibenzofuran (Total)	ng/kg	6	4	67%	0.075	0.095	0.32	0.65	1.1
Blue Crab / Edible / Semivolatile and Volatile Organic Compounds										
	1,1,1,2-Tetrachloroethane	µg/kg	1	0	0%	10	10			
	1,1,1-Trichloroethane	µg/kg	1	0	0%	10	10			
	1,1,2,2-Tetrachloroethane	µg/kg	1	0	0%	10	10			
	1,1,2-Trichloroethane	µg/kg	1	0	0%	10	10			
	1,1-Dichloroethane	µg/kg	1	0	0%	10	10			
	1,1-Dichloroethene	µg/kg	1	0	0%	10	10			
	1,1-Dichloropropene	µg/kg	1	0	0%	10	10			
	1,2,3-Trichlorobenzene	µg/kg	1	0	0%	10	10			
	1,2,3-Trichloropropane	µg/kg	1	0	0%	10	10			
	1,2,4,5-Tetrachlorobenzene	mg/kg	1	0	0%	0.50	0.50			
	1,2,4-Trichlorobenzene	mg/kg	1	0	0%	0.010	0.010			
	1,2,4-Trimethylbenzene	µg/kg	1	0	0%	10	10			
	1,2-Dibromo-3-chloropropane	µg/kg	1	0	0%	10	10			
	1,2-Dibromoethane	µg/kg	1	0	0%	10	10			
	1,2-Dichlorobenzene	mg/kg	1	0	0%	0.010	0.010			
	1,2-Dichloroethane	µg/kg	1	0	0%	10	10			
	1,2-Dichloropropane	µg/kg	1	0	0%	10	10			
	1,3,5-Trinitrobenzene	µg/kg	1	0	0%	10	10			
	1,3-Dichlorobenzene	mg/kg	1	0	0%	0.010	0.010			
	1,3-Dichloropropane	µg/kg	1	0	0%	10	10			
	1,4-Dichlorobenzene	mg/kg	1	0	0%	0.010	0.010			
	2,2-Dichloropropane	µg/kg	1	0	0%	10	10			
	2,4,5-Trichlorophenol	mg/kg	1	0	0%	0.50	0.50			
	2,4,6-Trichlorophenol	mg/kg	1	0	0%	0.50	0.50			
	2,4-Dichlorophenol	mg/kg	1	0	0%	0.50	0.50			
	2,4-Dimethylphenol	mg/kg	1	0	0%	0.50	0.50			
	2,4-Dinitrophenol	mg/kg	1	0	0%	1.0	1.0			
	2,4-Dinitrotoluene	mg/kg	1	0	0%	1.0	1.0			
	2,6-Dinitrotoluene	mg/kg	1	0	0%	0.50	0.50			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
	2-Butanone	µg/kg	1	0	0%	50	50			
	2-Chloronaphthalene	mg/kg	1	0	0%	0.50	0.50			
	2-Chlorophenol	mg/kg	1	0	0%	0.50	0.50			
	2-Chlorotoluene	µg/kg	1	0	0%	10	10			
	2-Hexanone	µg/kg	1	0	0%	10	10			
	2-Methylnaphthalene	mg/kg	1	0	0%	0.50	0.50			
	2-Methylphenol	mg/kg	1	0	0%	0.50	0.50			
	2-Nitroaniline	mg/kg	1	0	0%	0.50	0.50			
	2-Nitrophenol	mg/kg	1	0	0%	0.50	0.50			
	3,3'-Dichlorobenzidine	mg/kg	1	0	0%	2.0	2.0			
	3,4-Methylphenol	mg/kg	1	0	0%	0.50	0.50			
	3-Nitroaniline	mg/kg	1	0	0%	1.0	1.0			
	4,6-Dinitro-2-methylphenol	mg/kg	1	0	0%	1.0	1.0			
	4-Bromophenyl-phenylether	mg/kg	1	0	0%	0.50	0.50			
	4-Chloro-3-methylphenol	mg/kg	1	0	0%	0.50	0.50			
	4-Chloroaniline	mg/kg	1	0	0%	0.20	0.20			
	4-Chlorophenyl-phenyl ether	mg/kg	1	0	0%	0.50	0.50			
	4-Chlorotoluene	µg/kg	1	0	0%	10	10			
	4-Isopropyl toluene	µg/kg	1	0	0%	10	10			
	4-Methyl-2-pentanone	µg/kg	1	0	0%	10	10			
	4-Nitroaniline	mg/kg	1	0	0%	1.0	1.0			
	4-Nitrophenol	mg/kg	1	0	0%	2.0	2.0			
	Acenaphthene	mg/kg	1	0	0%	0.20	0.20			
	Acenaphthylene	mg/kg	1	0	0%	0.20	0.20			
	Acetone	µg/kg	1	0	0%	100	100			
	Acrylonitrile	µg/kg	1	0	0%	10	10			
	Aniline	mg/kg	1	0	0%	2.0	2.0			
	Anthracene	mg/kg	1	0	0%	0.20	0.20			
	Benzene	µg/kg	1	0	0%	10	10			
	Benzidine	mg/kg	1	0	0%	0	0			
	Benzo[a]anthracene	mg/kg	1	0	0%	0.20	0.20			
	Benzo[a]pyrene	mg/kg	1	0	0%	0.20	0.20			
	Benzo[b]fluoranthene	mg/kg	1	0	0%	0.20	0.20			
	Benzo[g,h,i]perylene	mg/kg	1	0	0%	0.20	0.20			
	Benzo[k]fluoranthene	mg/kg	1	0	0%	0.20	0.20			
	Benzoic acid	mg/kg	1	0	0%	0.50	0.50			
	Benzyl alcohol	mg/kg	1	0	0%	0.50	0.50			
	Benzyl n-butyl phthalate	mg/kg	1	0	0%	0.50	0.50			
	Bis(2-chloroethoxy)methane	mg/kg	1	0	0%	0.50	0.50			
	Bis(2-chloroethyl)ether	mg/kg	1	0	0%	1.0	1.0			
	Bis(2-chloroisopropyl) ether	mg/kg	1	0	0%	0.50	0.50			
	Bis(2-ethylhexyl) adipate	mg/kg	1	0	0%	0.50	0.50			
	Bis(2-ethylhexyl)phthalate	mg/kg	1	0	0%	0.50	0.50			
	Bromobenzene	µg/kg	1	0	0%	10	10			
	Bromochloromethane	µg/kg	1	0	0%	10	10			
	Bromodichloromethane	µg/kg	1	0	0%	10	10			
	Bromoform	µg/kg	1	0	0%	10	10			
	Bromomethane	µg/kg	1	0	0%	25	25			
	Carbon disulfide	µg/kg	1	1	100%			65	65	65
	Carbon Tetrachloride	µg/kg	1	0	0%	10	10			
	Chlorobenzene	µg/kg	1	0	0%	10	10			
	Chloroethane	µg/kg	1	0	0%	25	25			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
	Chloroform	µg/kg	1	0	0%	10	10			
	Chloromethane	µg/kg	1	0	0%	25	25			
	Chrysene	mg/kg	1	0	0%	0.20	0.20			
	cis-1,2-Dichloroethene	µg/kg	1	0	0%	10	10			
	cis-1,3-Dichloropropene	µg/kg	1	0	0%	50	50			
	Dibenzo[a,h]anthracene	mg/kg	1	0	0%	0.20	0.20			
	Dibenzofuran	mg/kg	1	0	0%	0.50	0.50			
	Dibromochloromethane	µg/kg	1	0	0%	10	10			
	Dibromomethane	µg/kg	1	0	0%	10	10			
	Dichlorodifluoromethane	µg/kg	1	0	0%	25	25			
	Diethyl phthalate	mg/kg	1	0	0%	0.50	0.50			
	Dimethyl phthalate	mg/kg	1	0	0%	0.50	0.50			
	Di-n-butyl phthalate	mg/kg	1	0	0%	0.50	0.50			
	Di-n-octylphthalate	mg/kg	1	0	0%	0.50	0.50			
	Diphenylhydrazine	mg/kg	1	0	0%	0.50	0.50			
	Ethyl methacrylate	µg/kg	1	0	0%	10	10			
	Ethylbenzene	µg/kg	1	0	0%	10	10			
	Fluoranthene	mg/kg	1	0	0%	0.20	0.20			
	Fluorene	mg/kg	1	0	0%	0.20	0.20			
	Hexachlorobenzene	mg/kg	2	0	0%	0.0010	0.0010			
	Hexachlorobutadiene	mg/kg	1	0	0%	0.025	0.025			
	Hexachlorocyclopentadiene	mg/kg	1	0	0%	2.0	2.0			
	Hexachloroethane	mg/kg	1	0	0%	0.50	0.50			
	Hexachlorophene	mg/kg	1	0	0%	0	0			
	Indeno[1,2,3-cd]pyrene	mg/kg	1	0	0%	0.20	0.20			
	Iodomethane	µg/kg	1	0	0%	25	25			
	Isophorone	mg/kg	1	0	0%	0.50	0.50			
	Isopropylbenzene	µg/kg	1	0	0%	10	10			
	m,p-Xylene	µg/kg	1	0	0%	20	20			
	Methyl methacrylate	µg/kg	1	0	0%	10	10			
	Methyl tert-butyl ether	µg/kg	1	0	0%	10	10			
	Methylene Chloride	µg/kg	1	0	0%	25	25			
	Naphthalene	mg/kg	1	0	0%	0.010	0.010			
	n-Butylbenzene	µg/kg	1	0	0%	10	10			
	Nitrobenzene	mg/kg	1	0	0%	0.50	0.50			
	N-nitroso diethylamine	mg/kg	1	0	0%	0.50	0.50			
	N-nitroso-dibutylamine	mg/kg	1	0	0%	0.50	0.50			
	N-Nitrosodimethylamine	mg/kg	1	0	0%	0.50	0.50			
	N-Nitrosodi-n-propylamine	mg/kg	1	0	0%	0.50	0.50			
	N-Nitrosodiphenylamine	mg/kg	1	0	0%	0.50	0.50			
	n-Propylbenzene	µg/kg	1	0	0%	10	10			
	o-Xylene	µg/kg	1	0	0%	10	10			
	Pentachlorophenol	mg/kg	1	0	0%	1.0	1.0			
	Phenanthrene	mg/kg	1	0	0%	0.20	0.20			
	Phenol	mg/kg	1	0	0%	0.50	0.50			
	Pyrene	mg/kg	1	0	0%	0.20	0.20			
	Pyridine	mg/kg	1	0	0%	0.50	0.50			
	sec-Butylbenzene	µg/kg	1	0	0%	10	10			
	Styrene	µg/kg	1	0	0%	10	10			
	tert-Butylbenzene	µg/kg	1	0	0%	10	10			
	Tetrachloroethene	µg/kg	1	0	0%	10	10			
	Tetrahydrofuran	µg/kg	1	0	0%	25	25			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
	Toluene	µg/kg	1	0	0%	10	10			
	trans-1,2-Dichloroethene	µg/kg	1	0	0%	10	10			
	trans-1,3-Dichloropropene	µg/kg	1	0	0%	50	50			
	Trichloroethene	µg/kg	1	0	0%	10	10			
	Trichlorofluoromethane	µg/kg	1	0	0%	25	25			
	Vinyl Chloride	µg/kg	1	0	0%	25	25			
Blue Crab / Edible / Pesticides										
	4,4'-DDD	mg/kg	2	0	0%	0.0050	0.0050			
	4,4'-DDE	mg/kg	2	0	0%	0.0025	0.0025			
	4,4'-DDT	mg/kg	2	0	0%	0.0050	0.0050			
	Aldrin	mg/kg	2	0	0%	0.0010	0.0010			
	alpha-Benzenehexachloride	mg/kg	2	0	0%	0.0010	0.0010			
	beta-Benzenehexachloride	mg/kg	2	0	0%	0.0010	0.0010			
	Chlordane	µg/kg	2	2	100%			13	17	21
	Chlorpyrifos	µg/kg	2	0	0%	5.0	5.0			
	delta-Benzenehexachloride	mg/kg	2	0	0%	0.0010	0.0010			
	Diazinon	µg/kg	2	0	0%	5.0	5.0			
	Dieldrin	mg/kg	3	0	0%	0.0030	0.0030			
	Endosulfan I	mg/kg	2	0	0%	0.0050	0.0050			
	Endosulfan II	mg/kg	2	0	0%	0.0050	0.0050			
	Endosulfan sulfate	mg/kg	2	0	0%	0.0050	0.0050			
	Endrin	mg/kg	2	0	0%	0.0030	0.0030			
	Endrin aldehyde	mg/kg	1	0	0%	0	0			
	Endrin ketone	mg/kg	1	0	0%	0.50	0.50			
	gamma-Benzenehexachloride	mg/kg	2	0	0%	0.0010	0.0010			
	Heptachlor	mg/kg	2	0	0%	0.0010	0.0010			
	Heptachlor epoxide	mg/kg	3	0	0%	0.0015	0.0020			
	Malathion	µg/kg	2	0	0%	10	10			
	Methoxychlor	µg/kg	2	0	0%	15	15			
	Methyl parathion	µg/kg	2	0	0%	5.0	5.0			
	Mirex	µg/kg	2	0	0%	4.0	4.0			
	Parathion	µg/kg	2	0	0%	5.0	5.0			
	sum of p,p'-DDD and o,p'-DDD	mg/kg	1	0	0%	0.0030	0.0030			
	sum of p,p'-DDE and o,p'-DDE	mg/kg	1	0	0%	0.0020	0.0020			
	sum of p,p'-DDT and o,p'-DDT	mg/kg	1	0	0%	0.0045	0.0045			
	Toxaphene	µg/kg	2	0	0%	50	50			
Blue Crab / Edible / Herbicides										
	Alachlor	µg/kg	2	0	0%	4.0	4.0			
	Dimethyl tetrachloroterephthalate	µg/kg	2	0	0%	1.5	1.5			
Blue Crab / Edible / Polychlorinated Biphenyls										
	Aroclor 1016	mg/kg	4	0	0%	0.019	0.020			
	Aroclor 1221	mg/kg	4	0	0%	0.0075	0.020			
	Aroclor 1232	mg/kg	4	0	0%	0.019	0.020			
	Aroclor 1242	mg/kg	4	0	0%	0.019	0.020			
	Aroclor 1248	mg/kg	4	0	0%	0.011	0.020			
	Aroclor 1254	mg/kg	4	0	0%	0.020	0.030			
	Aroclor 1260	mg/kg	4	0	0%	0.016	0.020			
	Total PCBs	mg/kg	2	0	0%	0.030	0.030			
Hardhead Catfish / Edible / Physical and Chemical										
	Lipid	percent	4	4	100%			0.40	2.4	3.5
Hardhead Catfish / Edible / Dioxins and Furans										
	2,3,7,8-Tetrachlorodibenzo-*p*-dioxin	ng/kg	4	4	100%			5.1	11	14

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
	1,2,3,7,8-Pentachlorodibenzo-*p* -dioxin	ng/kg	4	4	100%			0.35	0.43	0.50
	1,2,3,4,7,8-Hexachlorodibenzo-*p* -dioxin	ng/kg	4	4	100%			0.21	0.31	0.41
	1,2,3,6,7,8-Hexachlorodibenzo-*p* -dioxin	ng/kg	4	1	25%	0.26	0.48	0.86	0.86	0.86
	1,2,3,7,8,9-Hexachlorodibenzo-*p* -dioxin	ng/kg	4	3	75%	0.17	0.17	0.29	0.33	0.38
	1,2,3,4,6,7,8-Heptachlorodibenzo-*p* -dioxin	ng/kg	4	4	100%			0.73	1.1	1.4
	Octachlorodibenzo-*p* -dioxin	ng/kg	4	4	100%			2.4	3.0	3.6
	Tetrachlorodibenzo-*p* -dioxin (Total)	ng/kg	4	4	100%			5.1	11	14
	Pentachlorodibenzo-*p* -dioxin (Total)	ng/kg	4	4	100%			0.35	0.43	0.50
	Hexachlorodibenzo-*p* -dioxin (Total)	ng/kg	4	4	100%			0.31	0.80	1.7
	Heptachlorodibenzo-*p* -dioxin (Total)	ng/kg	4	3	75%	0.80	0.80	0.73	1.0	1.4
	2,3,7,8-Tetrachlorodibenzofuran	ng/kg	4	4	100%			0.18	0.76	1.1
	1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	4	2	50%	0.055	0.18	0.19	0.23	0.26
	2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	4	4	100%			0.55	0.66	0.75
	1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	4	0	0%	0.060	0.15			
	1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	4	2	50%	0.055	2.9	0.19	0.21	0.22
	1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	4	1	25%	0.085	0.21	0.13	0.13	0.13
	2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	4	1	25%	0.090	0.11	0.27	0.27	0.27
	1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	4	0	0%	0.13	0.20			
	1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	4	0	0%	0.080	0.29			
	Octachlorodibenzofuran	ng/kg	4	4	100%			0.50	0.85	1.3
	Tetrachlorodibenzofuran (Total)	ng/kg	4	4	100%			0.18	0.76	1.1
	Pentachlorodibenzofuran (Total)	ng/kg	4	4	100%			0.83	5.4	18
	Hexachlorodibenzofuran (Total)	ng/kg	4	3	75%	3.4	3.4	0.24	0.35	0.45
	Heptachlorodibenzofuran (Total)	ng/kg	4	1	25%	0.18	1.8	0.17	0.17	0.17
Hardhead Catfish / Edible / Polychlorinated Biphenyls										
	Aroclor 1016	mg/kg	1	0	0%	0.019	0.019			
	Aroclor 1221	mg/kg	1	0	0%	0.0075	0.0075			
	Aroclor 1232	mg/kg	1	0	0%	0.019	0.019			
	Aroclor 1242	mg/kg	1	0	0%	0.019	0.019			
	Aroclor 1248	mg/kg	1	0	0%	0.011	0.011			
	Aroclor 1254	mg/kg	1	0	0%	0.030	0.030			
	Aroclor 1260	mg/kg	1	0	0%	0.016	0.016			
	Total PCBs	mg/kg	1	0	0%	0.030	0.030			
Hybrid Striped Bass / Fillet / Metals										
	Arsenic	mg/kg	1	0	0%	0.025	0.025			
	Cadmium	mg/kg	1	0	0%	0.0072	0.0072			
	Copper	mg/kg	1	1	100%			0.21	0.21	0.21
	Lead	mg/kg	1	0	0%	0.017	0.017			
	Mercury	mg/kg	1	1	100%			0.43	0.43	0.43
	Selenium	mg/kg	1	1	100%			0.55	0.55	0.55
	Zinc	mg/kg	1	1	100%			2.7	2.7	2.7
Hybrid Striped Bass / Fillet / Dioxins and Furans										
	2,3,7,8-Tetrachlorodibenzo-*p* -dioxin	pg/g	1	1	100%			0.59	0.59	0.59
	1,2,3,7,8-Pentachlorodibenzo-*p* -dioxin	pg/g	1	0	0%	0.30	0.30			
	1,2,3,4,7,8-Hexachlorodibenzo-*p* -dioxin	pg/g	1	0	0%	0.15	0.15			
	1,2,3,6,7,8-Hexachlorodibenzo-*p* -dioxin	pg/g	1	1	100%			1.2	1.2	1.2
	1,2,3,7,8,9-Hexachlorodibenzo-*p* -dioxin	pg/g	1	1	100%			0.31	0.31	0.31
	1,2,3,4,6,7,8-Heptachlorodibenzo-*p* -dioxin	pg/g	1	1	100%			1.1	1.1	1.1
	Octachlorodibenzo-*p* -dioxin	pg/g	1	1	100%			4.2	4.2	4.2
	2,3,7,8-Tetrachlorodibenzofuran	pg/g	1	1	100%			3.5	3.5	3.5
	1,2,3,7,8-Pentachlorodibenzofuran	pg/g	1	0	0%	0.16	0.16			
	2,3,4,7,8-Pentachlorodibenzofuran	pg/g	1	0	0%	0.22	0.22			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
	1,2,3,4,7,8-Hexachlorodibenzofuran	pg/g	1	0	0%	0.055	0.055			
	1,2,3,6,7,8-Hexachlorodibenzofuran	pg/g	1	0	0%	0.048	0.048			
	1,2,3,7,8,9-Hexachlorodibenzofuran	pg/g	1	0	0%	0.065	0.065			
	2,3,4,6,7,8-Hexachlorodibenzofuran	pg/g	1	0	0%	0.055	0.055			
	1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/g	1	0	0%	0.042	0.042			
	1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/g	1	0	0%	0.032	0.032			
	Octachlorodibenzofuran	pg/g	1	0	0%	0.032	0.032			
Hybrid Striped Bass / Fillet / Semivolatile and Volatile Organic Compounds										
	1,1,1,2-Tetrachloroethane	µg/kg	1	0	0%	10	10			
	1,1,1-Trichloroethane	µg/kg	1	0	0%	10	10			
	1,1,2,2-Tetrachloroethane	µg/kg	1	0	0%	10	10			
	1,1,2-Trichloroethane	µg/kg	1	0	0%	10	10			
	1,1-Dichloroethane	µg/kg	1	0	0%	10	10			
	1,1-Dichloroethene	µg/kg	1	0	0%	10	10			
	1,1-Dichloropropene	µg/kg	1	0	0%	10	10			
	1,2,3-Trichlorobenzene	µg/kg	1	0	0%	10	10			
	1,2,3-Trichloropropane	µg/kg	1	0	0%	10	10			
	1,2,4,5-Tetrachlorobenzene	mg/kg	1	0	0%	0.50	0.50			
	1,2,4-Trichlorobenzene	mg/kg	1	0	0%	0.010	0.010			
	1,2,4-Trimethylbenzene	µg/kg	1	0	0%	10	10			
	1,2-Dibromo-3-chloropropane	µg/kg	1	0	0%	10	10			
	1,2-Dibromoethane	µg/kg	1	0	0%	10	10			
	1,2-Dichlorobenzene	mg/kg	1	0	0%	0.010	0.010			
	1,2-Dichloroethane	µg/kg	1	0	0%	10	10			
	1,2-Dichloropropane	µg/kg	1	0	0%	10	10			
	1,3,5-Trinitrobenzene	µg/kg	1	0	0%	10	10			
	1,3-Dichlorobenzene	mg/kg	1	0	0%	0.010	0.010			
	1,3-Dichloropropane	µg/kg	1	0	0%	10	10			
	1,4-Dichlorobenzene	mg/kg	1	0	0%	0.010	0.010			
	2,2-Dichloropropane	µg/kg	1	0	0%	10	10			
	2,4,5-Trichlorophenol	mg/kg	1	0	0%	0.50	0.50			
	2,4,6-Trichlorophenol	mg/kg	1	0	0%	0.50	0.50			
	2,4-Dichlorophenol	mg/kg	1	0	0%	0.50	0.50			
	2,4-Dimethylphenol	mg/kg	1	0	0%	0.50	0.50			
	2,4-Dinitrophenol	mg/kg	1	0	0%	1.0	1.0			
	2,4-Dinitrotoluene	mg/kg	1	0	0%	1.0	1.0			
	2,6-Dinitrotoluene	mg/kg	1	0	0%	0.50	0.50			
	2-Butanone	µg/kg	1	0	0%	50	50			
	2-Chloronaphthalene	mg/kg	1	0	0%	0.50	0.50			
	2-Chlorophenol	mg/kg	1	0	0%	0.50	0.50			
	2-Chlorotoluene	µg/kg	1	0	0%	10	10			
	2-Hexanone	µg/kg	1	0	0%	10	10			
	2-Methylnaphthalene	mg/kg	1	0	0%	0.50	0.50			
	2-Methylphenol	mg/kg	1	0	0%	0.50	0.50			
	2-Nitroaniline	mg/kg	1	0	0%	0.50	0.50			
	2-Nitrophenol	mg/kg	1	0	0%	0.50	0.50			
	3,3'-Dichlorobenzidine	mg/kg	1	0	0%	2.0	2.0			
	3,4-Methylphenol	mg/kg	1	0	0%	0.50	0.50			
	3-Nitroaniline	mg/kg	1	0	0%	1.0	1.0			
	4,6-Dinitro-2-methylphenol	mg/kg	1	0	0%	1.0	1.0			
	4-Bromophenyl-phenylether	mg/kg	1	0	0%	0.50	0.50			
	4-Chloro-3-methylphenol	mg/kg	1	0	0%	0.50	0.50			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
	4-Chloroaniline	mg/kg	1	0	0%	0.20	0.20			
	4-Chlorophenyl-phenyl ether	mg/kg	1	0	0%	0.50	0.50			
	4-Chlorotoluene	µg/kg	1	0	0%	10	10			
	4-Isopropyl toluene	µg/kg	1	0	0%	10	10			
	4-Methyl-2-pentanone	µg/kg	1	0	0%	10	10			
	4-Nitroaniline	mg/kg	1	0	0%	1.0	1.0			
	4-Nitrophenol	mg/kg	1	0	0%	2.0	2.0			
	Acenaphthene	mg/kg	1	0	0%	0.20	0.20			
	Acenaphthylene	mg/kg	1	0	0%	0.20	0.20			
	Acetone	µg/kg	1	0	0%	100	100			
	Acrylonitrile	µg/kg	1	0	0%	10	10			
	Aniline	mg/kg	1	0	0%	2.0	2.0			
	Anthracene	mg/kg	1	0	0%	0.20	0.20			
	Benzene	µg/kg	1	0	0%	10	10			
	Benzidine	mg/kg	1	0	0%	0	0			
	Benzo[a]anthracene	mg/kg	1	0	0%	0.20	0.20			
	Benzo[a]pyrene	mg/kg	1	0	0%	0.20	0.20			
	Benzo[b]fluoranthene	mg/kg	1	0	0%	0.20	0.20			
	Benzo[g,h,i]perylene	mg/kg	1	0	0%	0.20	0.20			
	Benzo[k]fluoranthene	mg/kg	1	0	0%	0.20	0.20			
	Benzoic acid	mg/kg	1	0	0%	0.50	0.50			
	Benzyl alcohol	mg/kg	1	0	0%	0.50	0.50			
	Benzyl n-butyl phthalate	mg/kg	1	0	0%	0.50	0.50			
	Bis(2-chloroethoxy)methane	mg/kg	1	0	0%	0.50	0.50			
	Bis(2-chloroethyl)ether	mg/kg	1	0	0%	1.0	1.0			
	Bis(2-chloroisopropyl) ether	mg/kg	1	0	0%	0.50	0.50			
	Bis(2-ethylhexyl) adipate	mg/kg	1	0	0%	0.50	0.50			
	Bis(2-ethylhexyl)phthalate	mg/kg	1	0	0%	0.50	0.50			
	Bromobenzene	µg/kg	1	0	0%	10	10			
	Bromochloromethane	µg/kg	1	0	0%	10	10			
	Bromodichloromethane	µg/kg	1	0	0%	10	10			
	Bromoform	µg/kg	1	0	0%	10	10			
	Bromomethane	µg/kg	1	0	0%	25	25			
	Carbon disulfide	µg/kg	1	0	0%	25	25			
	Carbon Tetrachloride	µg/kg	1	0	0%	10	10			
	Chlorobenzene	µg/kg	1	0	0%	10	10			
	Chloroethane	µg/kg	1	0	0%	25	25			
	Chloroform	µg/kg	1	0	0%	10	10			
	Chloromethane	µg/kg	1	0	0%	25	25			
	Chrysene	mg/kg	1	0	0%	0.20	0.20			
	cis-1,2-Dichloroethene	µg/kg	1	0	0%	10	10			
	cis-1,3-Dichloropropene	µg/kg	1	0	0%	50	50			
	Dibenzo[a,h]anthracene	mg/kg	1	0	0%	0.20	0.20			
	Dibenzofuran	mg/kg	1	0	0%	0.50	0.50			
	Dibromochloromethane	µg/kg	1	0	0%	10	10			
	Dibromomethane	µg/kg	1	0	0%	10	10			
	Dichlorodifluoromethane	µg/kg	1	0	0%	25	25			
	Diethyl phthalate	mg/kg	1	0	0%	0.50	0.50			
	Dimethyl phthalate	mg/kg	1	0	0%	0.50	0.50			
	Di-n-butyl phthalate	mg/kg	1	0	0%	0.50	0.50			
	Di-n-octylphthalate	mg/kg	1	0	0%	0.50	0.50			
	Diphenylhydrazine	mg/kg	1	0	0%	0.50	0.50			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
	Ethyl methacrylate	µg/kg	1	0	0%	10	10			
	Ethylbenzene	µg/kg	1	0	0%	10	10			
	Fluoranthene	mg/kg	1	0	0%	0.20	0.20			
	Fluorene	mg/kg	1	0	0%	0.20	0.20			
	Hexachlorobenzene	mg/kg	1	0	0%	0.0010	0.0010			
	Hexachlorobutadiene	mg/kg	1	0	0%	0.025	0.025			
	Hexachlorocyclopentadiene	mg/kg	1	0	0%	2.0	2.0			
	Hexachloroethane	mg/kg	1	0	0%	0.50	0.50			
	Hexachlorophene	mg/kg	1	0	0%	0	0			
	Indeno[1,2,3-cd]pyrene	mg/kg	1	0	0%	0.20	0.20			
	Iodomethane	µg/kg	1	0	0%	25	25			
	Isophorone	mg/kg	1	0	0%	0.50	0.50			
	Isopropylbenzene	µg/kg	1	0	0%	10	10			
	m,p-Xylene	µg/kg	1	0	0%	20	20			
	Methyl methacrylate	µg/kg	1	0	0%	10	10			
	Methyl tert-butyl ether	µg/kg	1	0	0%	10	10			
	Methylene Chloride	µg/kg	1	0	0%	25	25			
	Naphthalene	mg/kg	1	0	0%	0.010	0.010			
	n-Butylbenzene	µg/kg	1	0	0%	10	10			
	Nitrobenzene	mg/kg	1	0	0%	0.50	0.50			
	N-nitroso diethylamine	mg/kg	1	0	0%	0.50	0.50			
	N-nitroso-dibutylamine	mg/kg	1	0	0%	0.50	0.50			
	N-Nitrosodimethylamine	mg/kg	1	0	0%	0.50	0.50			
	N-Nitrosodi-n-propylamine	mg/kg	1	0	0%	0.50	0.50			
	N-Nitrosodiphenylamine	mg/kg	1	0	0%	0.50	0.50			
	n-Propylbenzene	µg/kg	1	0	0%	10	10			
	o-Xylene	µg/kg	1	0	0%	10	10			
	Pentachlorophenol	mg/kg	1	0	0%	1.0	1.0			
	Phenanthrene	mg/kg	1	0	0%	0.20	0.20			
	Phenol	mg/kg	1	0	0%	0.50	0.50			
	Pyrene	mg/kg	1	0	0%	0.20	0.20			
	Pyridine	mg/kg	1	0	0%	0.50	0.50			
	sec-Butylbenzene	µg/kg	1	0	0%	10	10			
	Styrene	µg/kg	1	0	0%	10	10			
	tert-Butylbenzene	µg/kg	1	0	0%	10	10			
	Tetrachloroethene	µg/kg	1	0	0%	10	10			
	Tetrahydrofuran	µg/kg	1	0	0%	25	25			
	Toluene	µg/kg	1	0	0%	10	10			
	trans-1,2-Dichloroethene	µg/kg	1	0	0%	10	10			
	trans-1,3-Dichloropropene	µg/kg	1	0	0%	50	50			
	Trichloroethene	µg/kg	1	0	0%	10	10			
	Trichlorofluoromethane	µg/kg	1	0	0%	25	25			
	Vinyl Chloride	µg/kg	1	0	0%	25	25			
Hybrid Striped Bass / Fillet / Pesticides										
	4,4'-DDD	mg/kg	1	0	0%	0.0050	0.0050			
	4,4'-DDE	mg/kg	1	1	100%			0.0053	0.0053	0.0053
	4,4'-DDT	mg/kg	1	0	0%	0.0050	0.0050			
	Aldrin	mg/kg	1	0	0%	0.0010	0.0010			
	alpha-Benzenehexachloride	mg/kg	1	0	0%	0.0010	0.0010			
	beta-Benzenehexachloride	mg/kg	1	0	0%	0.0010	0.0010			
	Chlordane	µg/kg	1	1	100%			76	76	76
	Chlorpyrifos	µg/kg	1	0	0%	5.0	5.0			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
	delta-Benzenehexachloride	mg/kg	1	0	0%	0.0010	0.0010			
	Diazinon	µg/kg	1	0	0%	5.0	5.0			
	Dieldrin	mg/kg	1	0	0%	0.0030	0.0030			
	Endosulfan I	mg/kg	1	0	0%	0.0050	0.0050			
	Endosulfan II	mg/kg	1	0	0%	0.0050	0.0050			
	Endosulfan sulfate	mg/kg	1	0	0%	0.0050	0.0050			
	Endrin	mg/kg	1	0	0%	0.0030	0.0030			
	Endrin aldehyde	mg/kg	1	0	0%	0	0			
	Endrin ketone	mg/kg	1	0	0%	0.50	0.50			
	gamma-Benzenehexachloride	mg/kg	1	0	0%	0.0010	0.0010			
	Heptachlor	mg/kg	1	0	0%	0.0010	0.0010			
	Heptachlor epoxide	mg/kg	1	0	0%	0.0020	0.0020			
	Malathion	µg/kg	1	0	0%	10	10			
	Methoxychlor	µg/kg	1	0	0%	15	15			
	Methyl parathion	µg/kg	1	0	0%	5.0	5.0			
	Mirex	µg/kg	1	0	0%	4.0	4.0			
	Parathion	µg/kg	1	0	0%	5.0	5.0			
	Toxaphene	µg/kg	1	0	0%	50	50			
Hybrid Striped Bass / Fillet / Herbicides										
	Alachlor	µg/kg	1	0	0%	4.0	4.0			
	Dimethyl tetrachloroterephthalate	µg/kg	1	0	0%	1.5	1.5			
Hybrid Striped Bass / Fillet / Polychorinated Biphenyls										
	Aroclor 1016	µg/kg	1	0	0%	20	20			
	Aroclor 1221	µg/kg	1	0	0%	20	20			
	Aroclor 1232	µg/kg	1	0	0%	20	20			
	Aroclor 1242	µg/kg	1	0	0%	20	20			
	Aroclor 1248	µg/kg	1	0	0%	20	20			
	Aroclor 1254	µg/kg	1	0	0%	20	20			
	Aroclor 1260	µg/kg	1	0	0%	20	20			
Red Drum / Fillet / Metals										
	Arsenic	mg/kg	2	0	0%	0.014	0.028			
	Cadmium	mg/kg	2	0	0%	0.0068	0.0071			
	Copper	mg/kg	2	2	100%			0.16	0.16	0.17
	Lead	mg/kg	2	0	0%	0.016	0.034			
	Mercury	mg/kg	2	2	100%			0.10	0.15	0.20
	Selenium	mg/kg	2	2	100%			0.65	0.85	1.1
	Zinc	mg/kg	2	2	100%			2.4	2.4	2.5
Red Drum / Fillet / Dioxins and Furans										
	2,3,7,8-Tetrachlorodibenzo-*p*-dioxin	pg/g	2	0	0%	0.026	0.026			
	1,2,3,7,8-Pentachlorodibenzo-*p*-dioxin	pg/g	2	0	0%	0.032	0.034			
	1,2,3,4,7,8-Hexachlorodibenzo-*p*-dioxin	pg/g	2	0	0%	0.029	27			
	1,2,3,6,7,8-Hexachlorodibenzo-*p*-dioxin	pg/g	2	0	0%	0.028	0.060			
	1,2,3,7,8,9-Hexachlorodibenzo-*p*-dioxin	pg/g	2	0	0%	0.028	0.031			
	1,2,3,4,6,7,8-Heptachlorodibenzo-*p*-dioxin	pg/g	2	0	0%	0.030	0.049			
	Octachlorodibenzo-*p*-dioxin	pg/g	2	1	50%	0.027	0.027	1.2	1.2	1.2
	2,3,7,8-Tetrachlorodibenzofuran	pg/g	2	0	0%	0.049	0.13			
	1,2,3,7,8-Pentachlorodibenzofuran	pg/g	2	0	0%	0.028	0.028			
	2,3,4,7,8-Pentachlorodibenzofuran	pg/g	2	0	0%	0.026	0.026			
	1,2,3,4,7,8-Hexachlorodibenzofuran	pg/g	2	0	0%	0.027	0.028			
	1,2,3,6,7,8-Hexachlorodibenzofuran	pg/g	2	0	0%	0.024	0.026			
	1,2,3,7,8,9-Hexachlorodibenzofuran	pg/g	2	0	0%	0.033	0.034			
	2,3,4,6,7,8-Hexachlorodibenzofuran	pg/g	2	0	0%	0.026	0.030			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
	1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/g	2	0	0%	0.021	0.038			
	1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/g	2	0	0%	0.033	0.035			
	Octachlorodibenzofuran	pg/g	2	0	0%	0.030	0.042			
Red Drum / Fillet / Semivolatile and Volatile Organic Compounds										
	1,1,1,2-Tetrachloroethane	µg/kg	2	0	0%	10	10			
	1,1,1-Trichloroethane	µg/kg	2	0	0%	10	10			
	1,1,2,2-Tetrachloroethane	µg/kg	2	0	0%	10	10			
	1,1,2-Trichloroethane	µg/kg	2	0	0%	10	10			
	1,1-Dichloroethane	µg/kg	2	0	0%	10	10			
	1,1-Dichloroethene	µg/kg	2	0	0%	10	10			
	1,1-Dichloropropene	µg/kg	2	0	0%	10	10			
	1,2,3-Trichlorobenzene	µg/kg	2	0	0%	10	10			
	1,2,3-Trichloropropane	µg/kg	2	0	0%	10	10			
	1,2,4,5-Tetrachlorobenzene	mg/kg	2	0	0%	0.50	0.50			
	1,2,4-Trichlorobenzene	mg/kg	2	0	0%	0.010	0.010			
	1,2,4-Trimethylbenzene	µg/kg	2	0	0%	10	10			
	1,2-Dibromo-3-chloropropane	µg/kg	2	0	0%	10	10			
	1,2-Dibromoethane	µg/kg	2	0	0%	10	10			
	1,2-Dichlorobenzene	mg/kg	2	0	0%	0.010	0.010			
	1,2-Dichloroethane	µg/kg	2	0	0%	10	10			
	1,2-Dichloropropane	µg/kg	2	0	0%	10	10			
	1,3,5-Trinitrobenzene	µg/kg	2	0	0%	10	10			
	1,3-Dichlorobenzene	mg/kg	2	0	0%	0.010	0.010			
	1,3-Dichloropropane	µg/kg	2	0	0%	10	10			
	1,4-Dichlorobenzene	mg/kg	2	0	0%	0.010	0.010			
	2,2-Dichloropropane	µg/kg	2	0	0%	10	10			
	2,4,5-Trichlorophenol	mg/kg	2	0	0%	0.50	0.50			
	2,4,6-Trichlorophenol	mg/kg	2	0	0%	0.50	0.50			
	2,4-Dichlorophenol	mg/kg	2	0	0%	0.50	0.50			
	2,4-Dimethylphenol	mg/kg	2	0	0%	0.50	0.50			
	2,4-Dinitrophenol	mg/kg	2	0	0%	1.0	1.0			
	2,4-Dinitrotoluene	mg/kg	2	0	0%	1.0	1.0			
	2,6-Dinitrotoluene	mg/kg	2	0	0%	0.50	0.50			
	2-Butanone	µg/kg	2	0	0%	50	50			
	2-Chloronaphthalene	mg/kg	2	0	0%	0.50	0.50			
	2-Chlorophenol	mg/kg	2	0	0%	0.50	0.50			
	2-Chlorotoluene	µg/kg	2	0	0%	10	10			
	2-Hexanone	µg/kg	2	0	0%	10	10			
	2-Methylnaphthalene	mg/kg	2	0	0%	0.50	0.50			
	2-Methylphenol	mg/kg	2	0	0%	0.50	0.50			
	2-Nitroaniline	mg/kg	2	0	0%	0.50	0.50			
	2-Nitrophenol	mg/kg	2	0	0%	0.50	0.50			
	3,3'-Dichlorobenzidine	mg/kg	2	0	0%	2.0	2.0			
	3,4-Methylphenol	mg/kg	2	0	0%	0.50	0.50			
	3-Nitroaniline	mg/kg	2	0	0%	1.0	1.0			
	4,6-Dinitro-2-methylphenol	mg/kg	2	0	0%	1.0	1.0			
	4-Bromophenyl-phenylether	mg/kg	2	0	0%	0.50	0.50			
	4-Chloro-3-methylphenol	mg/kg	2	0	0%	0.50	0.50			
	4-Chloroaniline	mg/kg	2	0	0%	0.20	0.20			
	4-Chlorophenyl-phenyl ether	mg/kg	2	0	0%	0.50	0.50			
	4-Chlorotoluene	µg/kg	2	0	0%	10	10			
	4-Isopropyl toluene	µg/kg	2	0	0%	10	10			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
	4-Methyl-2-pentanone	µg/kg	2	0	0%	10	10			
	4-Nitroaniline	mg/kg	2	0	0%	1.0	1.0			
	4-Nitrophenol	mg/kg	2	0	0%	2.0	2.0			
	Acenaphthene	mg/kg	2	0	0%	0.20	0.20			
	Acenaphthylene	mg/kg	2	0	0%	0.20	0.20			
	Acetone	µg/kg	2	0	0%	100	100			
	Acrylonitrile	µg/kg	2	0	0%	10	10			
	Aniline	mg/kg	2	0	0%	2.0	2.0			
	Anthracene	mg/kg	2	0	0%	0.20	0.20			
	Benzene	µg/kg	2	0	0%	10	10			
	Benzidine	mg/kg	2	0	0%	0	0			
	Benzo[a]anthracene	mg/kg	2	0	0%	0.20	0.20			
	Benzo[a]pyrene	mg/kg	2	0	0%	0.20	0.20			
	Benzo[b]fluoranthene	mg/kg	2	0	0%	0.20	0.20			
	Benzo[g,h,i]perylene	mg/kg	2	0	0%	0.20	0.20			
	Benzo[k]fluoranthene	mg/kg	2	0	0%	0.20	0.20			
	Benzoic acid	mg/kg	2	0	0%	0.50	0.50			
	Benzyl alcohol	mg/kg	2	0	0%	0.50	0.50			
	Benzyl n-butyl phthalate	mg/kg	2	0	0%	0.50	0.50			
	Bis(2-chloroethoxy)methane	mg/kg	2	0	0%	0.50	0.50			
	Bis(2-chloroethyl)ether	mg/kg	2	0	0%	1.0	1.0			
	Bis(2-chloroisopropyl) ether	mg/kg	2	0	0%	0.50	0.50			
	Bis(2-ethylhexyl) adipate	mg/kg	2	0	0%	0.50	0.50			
	Bis(2-ethylhexyl)phthalate	mg/kg	2	0	0%	0.50	0.50			
	Bromobenzene	µg/kg	2	0	0%	10	10			
	Bromochloromethane	µg/kg	2	0	0%	10	10			
	Bromodichloromethane	µg/kg	2	0	0%	10	10			
	Bromoform	µg/kg	2	0	0%	10	10			
	Bromomethane	µg/kg	2	0	0%	25	25			
	Carbon disulfide	µg/kg	2	0	0%	25	25			
	Carbon Tetrachloride	µg/kg	2	0	0%	10	10			
	Chlorobenzene	µg/kg	2	0	0%	10	10			
	Chloroethane	µg/kg	2	0	0%	25	25			
	Chloroform	µg/kg	2	0	0%	10	10			
	Chloromethane	µg/kg	2	0	0%	25	25			
	Chrysene	mg/kg	2	0	0%	0.20	0.20			
	cis-1,2-Dichloroethene	µg/kg	2	0	0%	10	10			
	cis-1,3-Dichloropropene	µg/kg	2	0	0%	50	50			
	Dibenzo[a,h]anthracene	mg/kg	2	0	0%	0.20	0.20			
	Dibenzofuran	mg/kg	2	0	0%	0.50	0.50			
	Dibromochloromethane	µg/kg	2	0	0%	10	10			
	Dibromomethane	µg/kg	2	0	0%	10	10			
	Dichlorodifluoromethane	µg/kg	2	0	0%	25	25			
	Diethyl phthalate	mg/kg	2	0	0%	0.50	0.50			
	Dimethyl phthalate	mg/kg	2	0	0%	0.50	0.50			
	Di-n-butyl phthalate	mg/kg	2	0	0%	0.50	0.50			
	Di-n-octylphthalate	mg/kg	2	0	0%	0.50	0.50			
	Diphenylhydrazine	mg/kg	2	0	0%	0.50	0.50			
	Ethyl methacrylate	µg/kg	2	0	0%	10	10			
	Ethylbenzene	µg/kg	2	0	0%	10	10			
	Fluoranthene	mg/kg	2	0	0%	0.20	0.20			
	Fluorene	mg/kg	2	0	0%	0.20	0.20			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
	Hexachlorobenzene	mg/kg	2	0	0%	0.0010	0.0010			
	Hexachlorobutadiene	mg/kg	2	0	0%	0.025	0.025			
	Hexachlorocyclopentadiene	mg/kg	2	0	0%	2.0	2.0			
	Hexachloroethane	mg/kg	2	0	0%	0.50	0.50			
	Hexachlorophene	mg/kg	2	0	0%	0	0			
	Indeno[1,2,3-cd]pyrene	mg/kg	2	0	0%	0.20	0.20			
	Iodomethane	µg/kg	2	0	0%	25	25			
	Isophorone	mg/kg	2	0	0%	0.50	0.50			
	Isopropylbenzene	µg/kg	2	0	0%	10	10			
	m,p-Xylene	µg/kg	2	0	0%	20	20			
	Methyl methacrylate	µg/kg	2	0	0%	10	10			
	Methyl tert-butyl ether	µg/kg	2	0	0%	10	10			
	Methylene Chloride	µg/kg	2	0	0%	25	25			
	Naphthalene	mg/kg	2	0	0%	0.010	0.010			
	n-Butylbenzene	µg/kg	2	0	0%	10	10			
	Nitrobenzene	mg/kg	2	0	0%	0.50	0.50			
	N-nitroso diethylamine	mg/kg	2	0	0%	0.50	0.50			
	N-nitroso-dibutylamine	mg/kg	2	0	0%	0.50	0.50			
	N-Nitrosodimethylamine	mg/kg	2	0	0%	0.50	0.50			
	N-Nitrosodi-n-propylamine	mg/kg	2	0	0%	0.50	0.50			
	N-Nitrosodiphenylamine	mg/kg	2	0	0%	0.50	0.50			
	n-Propylbenzene	µg/kg	2	0	0%	10	10			
	o-Xylene	µg/kg	2	0	0%	10	10			
	Pentachlorophenol	mg/kg	2	0	0%	1.0	1.0			
	Phenanthrene	mg/kg	2	0	0%	0.20	0.20			
	Phenol	mg/kg	2	0	0%	0.50	0.50			
	Pyrene	mg/kg	2	0	0%	0.20	0.20			
	Pyridine	mg/kg	2	0	0%	0.50	0.50			
	sec-Butylbenzene	µg/kg	2	0	0%	10	10			
	Styrene	µg/kg	2	0	0%	10	10			
	tert-Butylbenzene	µg/kg	2	0	0%	10	10			
	Tetrachloroethene	µg/kg	2	0	0%	10	10			
	Tetrahydrofuran	µg/kg	2	0	0%	25	25			
	Toluene	µg/kg	2	0	0%	10	10			
	trans-1,2-Dichloroethene	µg/kg	2	0	0%	10	10			
	trans-1,3-Dichloropropene	µg/kg	2	0	0%	50	50			
	Trichloroethene	µg/kg	2	0	0%	10	10			
	Trichlorofluoromethane	µg/kg	2	0	0%	25	25			
	Vinyl Chloride	µg/kg	2	0	0%	25	25			
Red Drum / Fillet / Pesticides										
	4,4'-DDD	mg/kg	2	0	0%	0.0050	0.0050			
	4,4'-DDE	mg/kg	2	0	0%	0.0025	0.0025			
	4,4'-DDT	mg/kg	2	0	0%	0.0050	0.0050			
	Aldrin	mg/kg	2	0	0%	0.0010	0.0010			
	alpha-Benzenehexachloride	mg/kg	2	0	0%	0.0010	0.0010			
	beta-Benzenehexachloride	mg/kg	2	0	0%	0.0010	0.0010			
	Chlordane	µg/kg	2	0	0%	5.0	5.0			
	Chlorpyrifos	µg/kg	2	0	0%	5.0	5.0			
	delta-Benzenehexachloride	mg/kg	2	0	0%	0.0010	0.0010			
	Diazinon	µg/kg	2	0	0%	5.0	5.0			
	Dieldrin	mg/kg	2	0	0%	0.0030	0.0030			
	Endosulfan I	mg/kg	2	0	0%	0.0050	0.0050			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
	Endosulfan II	mg/kg	2	0	0%	0.0050	0.0050			
	Endosulfan sulfate	mg/kg	2	0	0%	0.0050	0.0050			
	Endrin	mg/kg	2	0	0%	0.0030	0.0030			
	Endrin aldehyde	mg/kg	2	0	0%	0	0			
	Endrin ketone	mg/kg	2	0	0%	0.50	0.50			
	gamma-Benzenehexachloride	mg/kg	2	0	0%	0.0010	0.0010			
	Heptachlor	mg/kg	2	0	0%	0.0010	0.0010			
	Heptachlor epoxide	mg/kg	2	0	0%	0.0020	0.0020			
	Malathion	µg/kg	2	0	0%	10	10			
	Methoxychlor	µg/kg	2	0	0%	15	15			
	Methyl parathion	µg/kg	2	0	0%	5.0	5.0			
	Mirex	µg/kg	2	0	0%	4.0	4.0			
	Parathion	µg/kg	2	0	0%	5.0	5.0			
	Toxaphene	µg/kg	2	0	0%	50	50			
Red Drum / Fillet / Herbicides										
	Alachlor	µg/kg	2	0	0%	4.0	4.0			
	Dimethyl tetrachloroterephthalate	µg/kg	2	0	0%	1.5	1.5			
Red Drum / Fillet / Polychlorinated Biphenyls										
	Aroclor 1016	µg/kg	2	0	0%	20	20			
	Aroclor 1221	µg/kg	2	0	0%	20	20			
	Aroclor 1232	µg/kg	2	0	0%	20	20			
	Aroclor 1242	µg/kg	2	0	0%	20	20			
	Aroclor 1248	µg/kg	2	0	0%	20	20			
	Aroclor 1254	µg/kg	2	0	0%	20	20			
	Aroclor 1260	µg/kg	2	0	0%	20	20			
Spotted Seatrout / Fillet / Metals										
	Arsenic	mg/kg	2	0	0%	0.013	0.030			
	Cadmium	mg/kg	2	0	0%	0.0067	0.0070			
	Copper	mg/kg	2	0	0%	0.069	0.071			
	Lead	mg/kg	2	0	0%	0.017	0.13			
	Mercury	mg/kg	2	2	100%			0.20	0.21	0.22
	Selenium	mg/kg	2	2	100%			1.4	1.4	1.4
	Zinc	mg/kg	2	2	100%			2.1	2.2	2.3
Spotted Seatrout / Fillet / Dioxins and Furans										
	2,3,7,8-Tetrachlorodibenzo-*p*-dioxin	pg/g	2	1	50%	0.026	0.026	0.17	0.17	0.17
	1,2,3,7,8-Pentachlorodibenzo-*p*-dioxin	pg/g	2	0	0%	0.026	0.036			
	1,2,3,4,7,8-Hexachlorodibenzo-*p*-dioxin	pg/g	2	0	0%	0.024	0.029			
	1,2,3,6,7,8-Hexachlorodibenzo-*p*-dioxin	pg/g	2	0	0%	0.033	0.080			
	1,2,3,7,8,9-Hexachlorodibenzo-*p*-dioxin	pg/g	2	0	0%	0.025	0.030			
	1,2,3,4,6,7,8-Heptachlorodibenzo-*p*-dioxin	pg/g	2	0	0%	0.070	0.080			
	Octachlorodibenzo-*p*-dioxin	pg/g	2	1	50%	0.58	0.58	0.70	0.70	0.70
	2,3,7,8-Tetrachlorodibenzofuran	pg/g	2	1	50%	0.27	0.27	1.1	1.1	1.1
	1,2,3,7,8-Pentachlorodibenzofuran	pg/g	2	1	50%	0.065	0.065	0.23	0.23	0.23
	2,3,4,7,8-Pentachlorodibenzofuran	pg/g	2	0	0%	0.026	0.026			
	1,2,3,4,7,8-Hexachlorodibenzofuran	pg/g	2	0	0%	0.028	0.034			
	1,2,3,6,7,8-Hexachlorodibenzofuran	pg/g	2	0	0%	0.028	0.030			
	1,2,3,7,8,9-Hexachlorodibenzofuran	pg/g	2	0	0%	0.028	0.029			
	2,3,4,6,7,8-Hexachlorodibenzofuran	pg/g	2	0	0%	0.028	0.029			
	1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/g	2	0	0%	0.021	0.032			
	1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/g	2	0	0%	0.037	0.055			
	Octachlorodibenzofuran	pg/g	2	0	0%	0.029	0.035			
Spotted Seatrout / Fillet / Semivolatile and Volatile Organic Compounds										

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
	1,1,1,2-Tetrachloroethane	µg/kg	1	0	0%	10	10			
	1,1,1-Trichloroethane	µg/kg	1	0	0%	10	10			
	1,1,2,2-Tetrachloroethane	µg/kg	1	0	0%	10	10			
	1,1,2-Trichloroethane	µg/kg	1	0	0%	10	10			
	1,1-Dichloroethane	µg/kg	1	0	0%	10	10			
	1,1-Dichloroethene	µg/kg	1	0	0%	10	10			
	1,1-Dichloropropene	µg/kg	1	0	0%	10	10			
	1,2,3-Trichlorobenzene	µg/kg	1	0	0%	10	10			
	1,2,3-Trichloropropane	µg/kg	1	0	0%	10	10			
	1,2,4,5-Tetrachlorobenzene	mg/kg	1	0	0%	0.50	0.50			
	1,2,4-Trichlorobenzene	mg/kg	1	0	0%	0.010	0.010			
	1,2,4-Trimethylbenzene	µg/kg	1	0	0%	10	10			
	1,2-Dibromo-3-chloropropane	µg/kg	1	0	0%	10	10			
	1,2-Dibromoethane	µg/kg	1	0	0%	10	10			
	1,2-Dichlorobenzene	mg/kg	1	0	0%	0.010	0.010			
	1,2-Dichloroethane	µg/kg	1	0	0%	10	10			
	1,2-Dichloropropane	µg/kg	1	0	0%	10	10			
	1,3,5-Trinitrobenzene	µg/kg	1	0	0%	10	10			
	1,3-Dichlorobenzene	mg/kg	1	0	0%	0.010	0.010			
	1,3-Dichloropropane	µg/kg	1	0	0%	10	10			
	1,4-Dichlorobenzene	mg/kg	1	0	0%	0.010	0.010			
	2,2-Dichloropropane	µg/kg	1	0	0%	10	10			
	2,4,5-Trichlorophenol	mg/kg	1	0	0%	0.50	0.50			
	2,4,6-Trichlorophenol	mg/kg	1	0	0%	0.50	0.50			
	2,4-Dichlorophenol	mg/kg	1	0	0%	0.50	0.50			
	2,4-Dimethylphenol	mg/kg	1	0	0%	0.50	0.50			
	2,4-Dinitrophenol	mg/kg	1	0	0%	1.0	1.0			
	2,4-Dinitrotoluene	mg/kg	1	0	0%	1.0	1.0			
	2,6-Dinitrotoluene	mg/kg	1	0	0%	0.50	0.50			
	2-Butanone	µg/kg	1	0	0%	50	50			
	2-Chloronaphthalene	mg/kg	1	0	0%	0.50	0.50			
	2-Chlorophenol	mg/kg	1	0	0%	0.50	0.50			
	2-Chlorotoluene	µg/kg	1	0	0%	10	10			
	2-Hexanone	µg/kg	1	0	0%	10	10			
	2-Methylnaphthalene	mg/kg	1	0	0%	0.50	0.50			
	2-Methylphenol	mg/kg	1	0	0%	0.50	0.50			
	2-Nitroaniline	mg/kg	1	0	0%	0.50	0.50			
	2-Nitrophenol	mg/kg	1	0	0%	0.50	0.50			
	3,3'-Dichlorobenzidine	mg/kg	1	0	0%	2.0	2.0			
	3,4-Methylphenol	mg/kg	1	0	0%	0.50	0.50			
	3-Nitroaniline	mg/kg	1	0	0%	1.0	1.0			
	4,6-Dinitro-2-methylphenol	mg/kg	1	0	0%	1.0	1.0			
	4-Bromophenyl-phenylether	mg/kg	1	0	0%	0.50	0.50			
	4-Chloro-3-methylphenol	mg/kg	1	0	0%	0.50	0.50			
	4-Chloroaniline	mg/kg	1	0	0%	0.20	0.20			
	4-Chlorophenyl-phenyl ether	mg/kg	1	0	0%	0.50	0.50			
	4-Chlorotoluene	µg/kg	1	0	0%	10	10			
	4-Isopropyl toluene	µg/kg	1	0	0%	10	10			
	4-Methyl-2-pentanone	µg/kg	1	0	0%	10	10			
	4-Nitroaniline	mg/kg	1	0	0%	1.0	1.0			
	4-Nitrophenol	mg/kg	1	0	0%	2.0	2.0			
	Acenaphthene	mg/kg	1	0	0%	0.20	0.20			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
	Acenaphthylene	mg/kg	1	0	0%	0.20	0.20			
	Acetone	µg/kg	1	0	0%	100	100			
	Acrylonitrile	µg/kg	1	0	0%	10	10			
	Aniline	mg/kg	1	0	0%	2.0	2.0			
	Anthracene	mg/kg	1	0	0%	0.20	0.20			
	Benzene	µg/kg	1	0	0%	10	10			
	Benzidine	mg/kg	1	0	0%	0	0			
	Benzo[a]anthracene	mg/kg	1	0	0%	0.20	0.20			
	Benzo[a]pyrene	mg/kg	1	0	0%	0.20	0.20			
	Benzo[b]fluoranthene	mg/kg	1	0	0%	0.20	0.20			
	Benzo[g,h,i]perylene	mg/kg	1	0	0%	0.20	0.20			
	Benzo[k]fluoranthene	mg/kg	1	0	0%	0.20	0.20			
	Benzoic acid	mg/kg	1	0	0%	0.50	0.50			
	Benzyl alcohol	mg/kg	1	0	0%	0.50	0.50			
	Benzyl n-butyl phthalate	mg/kg	1	0	0%	0.50	0.50			
	Bis(2-chloroethoxy)methane	mg/kg	1	0	0%	0.50	0.50			
	Bis(2-chloroethyl)ether	mg/kg	1	0	0%	1.0	1.0			
	Bis(2-chloroisopropyl) ether	mg/kg	1	0	0%	0.50	0.50			
	Bis(2-ethylhexyl) adipate	mg/kg	1	0	0%	0.50	0.50			
	Bis(2-ethylhexyl)phthalate	mg/kg	1	0	0%	0.50	0.50			
	Bromobenzene	µg/kg	1	0	0%	10	10			
	Bromochloromethane	µg/kg	1	0	0%	10	10			
	Bromodichloromethane	µg/kg	1	0	0%	10	10			
	Bromoform	µg/kg	1	0	0%	10	10			
	Bromomethane	µg/kg	1	0	0%	25	25			
	Carbon disulfide	µg/kg	1	0	0%	25	25			
	Carbon Tetrachloride	µg/kg	1	0	0%	10	10			
	Chlorobenzene	µg/kg	1	0	0%	10	10			
	Chloroethane	µg/kg	1	0	0%	25	25			
	Chloroform	µg/kg	1	0	0%	10	10			
	Chloromethane	µg/kg	1	0	0%	25	25			
	Chrysene	mg/kg	1	0	0%	0.20	0.20			
	cis-1,2-Dichloroethene	µg/kg	1	0	0%	10	10			
	cis-1,3-Dichloropropene	µg/kg	1	0	0%	50	50			
	Dibenzo[a,h]anthracene	mg/kg	1	0	0%	0.20	0.20			
	Dibenzofuran	mg/kg	1	0	0%	0.50	0.50			
	Dibromochloromethane	µg/kg	1	0	0%	10	10			
	Dibromomethane	µg/kg	1	0	0%	10	10			
	Dichlorodifluoromethane	µg/kg	1	0	0%	25	25			
	Diethyl phthalate	mg/kg	1	0	0%	0.50	0.50			
	Dimethyl phthalate	mg/kg	1	0	0%	0.50	0.50			
	Di-n-butyl phthalate	mg/kg	1	0	0%	0.50	0.50			
	Di-n-octylphthalate	mg/kg	1	0	0%	0.50	0.50			
	Diphenylhydrazine	mg/kg	1	0	0%	0.50	0.50			
	Ethyl methacrylate	µg/kg	1	0	0%	10	10			
	Ethylbenzene	µg/kg	1	0	0%	10	10			
	Fluoranthene	mg/kg	1	0	0%	0.20	0.20			
	Fluorene	mg/kg	1	0	0%	0.20	0.20			
	Hexachlorobenzene	mg/kg	2	2	100%			0.0022	0.0027	0.0031
	Hexachlorobutadiene	mg/kg	1	0	0%	0.025	0.025			
	Hexachlorocyclopentadiene	mg/kg	1	0	0%	2.0	2.0			
	Hexachloroethane	mg/kg	1	0	0%	0.50	0.50			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
	Hexachlorophene	mg/kg	1	0	0%	0	0			
	Indeno[1,2,3-cd]pyrene	mg/kg	1	0	0%	0.20	0.20			
	Iodomethane	µg/kg	1	0	0%	25	25			
	Isophorone	mg/kg	1	0	0%	0.50	0.50			
	Isopropylbenzene	µg/kg	1	0	0%	10	10			
	m,p-Xylene	µg/kg	1	0	0%	20	20			
	Methyl methacrylate	µg/kg	1	0	0%	10	10			
	Methyl tert-butyl ether	µg/kg	1	0	0%	10	10			
	Methylene Chloride	µg/kg	1	0	0%	25	25			
	Naphthalene	mg/kg	1	0	0%	0.010	0.010			
	n-Butylbenzene	µg/kg	1	0	0%	10	10			
	Nitrobenzene	mg/kg	1	0	0%	0.50	0.50			
	N-nitroso diethylamine	mg/kg	1	0	0%	0.50	0.50			
	N-nitroso-dibutylamine	mg/kg	1	0	0%	0.50	0.50			
	N-Nitrosodimethylamine	mg/kg	1	0	0%	0.50	0.50			
	N-Nitrosodi-n-propylamine	mg/kg	1	0	0%	0.50	0.50			
	N-Nitrosodiphenylamine	mg/kg	1	0	0%	0.50	0.50			
	n-Propylbenzene	µg/kg	1	0	0%	10	10			
	o-Xylene	µg/kg	1	0	0%	10	10			
	Pentachlorophenol	mg/kg	1	0	0%	1.0	1.0			
	Phenanthrene	mg/kg	1	0	0%	0.20	0.20			
	Phenol	mg/kg	1	0	0%	0.50	0.50			
	Pyrene	mg/kg	1	0	0%	0.20	0.20			
	Pyridine	mg/kg	1	0	0%	0.50	0.50			
	sec-Butylbenzene	µg/kg	1	0	0%	10	10			
	Styrene	µg/kg	1	0	0%	10	10			
	tert-Butylbenzene	µg/kg	1	0	0%	10	10			
	Tetrachloroethene	µg/kg	1	0	0%	10	10			
	Tetrahydrofuran	µg/kg	1	0	0%	25	25			
	Toluene	µg/kg	1	0	0%	10	10			
	trans-1,2-Dichloroethene	µg/kg	1	0	0%	10	10			
	trans-1,3-Dichloropropene	µg/kg	1	0	0%	50	50			
	Trichloroethene	µg/kg	1	0	0%	10	10			
	Trichlorofluoromethane	µg/kg	1	0	0%	25	25			
	Vinyl Chloride	µg/kg	1	0	0%	25	25			
Spotted Seatrout / Fillet / Pesticides										
	4,4'-DDD	mg/kg	2	0	0%	0.0050	0.0050			
	4,4'-DDE	mg/kg	2	1	50%	0.0025	0.0025	0.0057	0.0057	0.0057
	4,4'-DDT	mg/kg	2	0	0%	0.0050	0.0050			
	Aldrin	mg/kg	2	0	0%	0.0010	0.0010			
	alpha-Benzenehexachloride	mg/kg	2	0	0%	0.0010	0.0010			
	beta-Benzenehexachloride	mg/kg	2	0	0%	0.0010	0.0010			
	Chlordane	µg/kg	2	2	100%			48	48	48
	Chlorpyrifos	µg/kg	2	0	0%	5.0	5.0			
	delta-Benzenehexachloride	mg/kg	2	0	0%	0.0010	0.0010			
	Diazinon	µg/kg	2	0	0%	5.0	5.0			
	Dieldrin	mg/kg	2	0	0%	0.0030	0.0030			
	Endosulfan I	mg/kg	2	0	0%	0.0050	0.0050			
	Endosulfan II	mg/kg	2	0	0%	0.0050	0.0050			
	Endosulfan sulfate	mg/kg	2	0	0%	0.0050	0.0050			
	Endrin	mg/kg	2	0	0%	0.0030	0.0030			
	Endrin aldehyde	mg/kg	1	0	0%	0	0			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
	Endrin ketone	mg/kg	1	0	0%	0.50	0.50			
	gamma-Benzenehexachloride	mg/kg	2	0	0%	0.0010	0.0010			
	Heptachlor	mg/kg	2	0	0%	0.0010	0.0010			
	Heptachlor epoxide	mg/kg	2	2	100%			0.0040	0.0044	0.0048
	Malathion	µg/kg	2	0	0%	10	10			
	Methoxychlor	µg/kg	2	0	0%	15	15			
	Methyl parathion	µg/kg	2	0	0%	5.0	5.0			
	Mirex	µg/kg	2	0	0%	4.0	4.0			
	Parathion	µg/kg	2	0	0%	5.0	5.0			
	Toxaphene	µg/kg	2	0	0%	50	50			
Spotted Seatrout / Fillet / Herbicides										
	Alachlor	µg/kg	2	0	0%	4.0	4.0			
	Dimethyl tetrachloroterephthalate	µg/kg	2	0	0%	1.5	1.5			
Spotted Seatrout / Fillet / Polychlorinated Biphenyls										
	Aroclor 1016	µg/kg	2	0	0%	20	20			
	Aroclor 1221	µg/kg	2	0	0%	20	20			
	Aroclor 1232	µg/kg	2	0	0%	20	20			
	Aroclor 1242	µg/kg	2	0	0%	20	20			
	Aroclor 1248	µg/kg	2	0	0%	20	20			
	Aroclor 1254	µg/kg	2	0	0%	20	20			
	Aroclor 1260	µg/kg	2	2	100%			63	68	72

Notes:
All concentrations are on a wet weight basis.

Table 2-13
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from Upstream of the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
Blue Catfish / Edible / Physical and Chemical										
	Lipid	percent	4	3	75%	0.050	0.050	0.40	0.60	0.70
Blue Catfish / Edible / Dioxins and Furans										
	2,3,7,8-Tetrachlorodibenzo-*p* -dioxin	ng/kg	4	4	100%			0.62	2.0	3.5
	1,2,3,7,8-Pentachlorodibenzo-*p* -dioxin	ng/kg	4	2	50%	0.15	0.27	0.17	0.19	0.21
	1,2,3,4,7,8-Hexachlorodibenzo-*p* -dioxin	ng/kg	4	1	25%	0.050	0.15	0.17	0.17	0.17
	1,2,3,6,7,8-Hexachlorodibenzo-*p* -dioxin	ng/kg	4	4	100%			0.21	0.43	0.64
	1,2,3,7,8,9-Hexachlorodibenzo-*p* -dioxin	ng/kg	4	1	25%	0.065	0.16	0.20	0.20	0.20
	1,2,3,4,6,7,8-Heptachlorodibenzo-*p* -dioxin	ng/kg	4	4	100%			0.23	0.90	1.3
	Octachlorodibenzo-*p* -dioxin	ng/kg	4	4	100%			1.6	4.3	6.3
	Tetrachlorodibenzo-*p* -dioxin (Total)	ng/kg	4	4	100%			0.62	2.0	3.5
	Pentachlorodibenzo-*p* -dioxin (Total)	ng/kg	4	3	75%	0.27	0.27	0.17	0.36	0.69
	Hexachlorodibenzo-*p* -dioxin (Total)	ng/kg	4	4	100%			0.21	0.51	0.94
	Heptachlorodibenzo-*p* -dioxin (Total)	ng/kg	4	4	100%			0.23	1.2	1.8
	2,3,7,8-Tetrachlorodibenzofuran	ng/kg	4	2	50%	0.060	0.22	0.27	0.35	0.42
	1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	4	1	25%	0.044	0.16	0.11	0.11	0.11
	2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	4	1	25%	0.11	0.24	0.27	0.27	0.27
	1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	4	2	50%	0.070	0.19	0.067	0.080	0.092
	1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	4	0	0%	0.075	0.16			
	1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	4	1	25%	0.032	0.075	0.71	0.71	0.71
	2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	4	2	50%	0.075	0.24	0.083	0.092	0.10
	1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	4	1	25%	0.12	0.47	0.28	0.28	0.28
	1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	4	0	0%	0.060	0.55			
	Octachlorodibenzofuran	ng/kg	4	4	100%			0.82	1.6	2.8
	Tetrachlorodibenzofuran (Total)	ng/kg	4	2	50%	0.060	22	0.27	0.35	0.42
	Pentachlorodibenzofuran (Total)	ng/kg	4	2	50%	0.28	0.28	0.61	1.3	2.0
	Hexachlorodibenzofuran (Total)	ng/kg	4	4	100%			0.21	0.89	2.2
	Heptachlorodibenzofuran (Total)	ng/kg	4	3	75%	0.55	0.55	0.29	0.55	1.0
Blue Catfish / Edible / Polychlorinated Biphenyls										
	Aroclor 1016	mg/kg	1	0	0%	0.019	0.019			
	Aroclor 1221	mg/kg	1	0	0%	0.0075	0.0075			
	Aroclor 1232	mg/kg	1	0	0%	0.019	0.019			
	Aroclor 1242	mg/kg	1	0	0%	0.019	0.019			
	Aroclor 1248	mg/kg	1	0	0%	0.011	0.011			
	Aroclor 1254	mg/kg	1	0	0%	0.030	0.030			
	Aroclor 1260	mg/kg	1	1	100%			0.48	0.48	0.48
	Total PCBs	mg/kg	1	1	100%			0.48	0.48	0.48
Blue Crab / Edible / Physical and Chemical										
	Lipid	percent	4	4	100%			0.70	0.95	1.2
Blue Crab / Edible / Dioxins and Furans										
	2,3,7,8-Tetrachlorodibenzo-*p* -dioxin	ng/kg	4	3	75%	0.14	0.14	0.87	2.8	6.2
	1,2,3,7,8-Pentachlorodibenzo-*p* -dioxin	ng/kg	4	3	75%	0.23	0.23	0.16	0.17	0.18
	1,2,3,4,7,8-Hexachlorodibenzo-*p* -dioxin	ng/kg	4	2	50%	0.060	0.085	0.15	0.17	0.18
	1,2,3,6,7,8-Hexachlorodibenzo-*p* -dioxin	ng/kg	4	3	75%	0.11	0.11	0.30	0.40	0.60
	1,2,3,7,8,9-Hexachlorodibenzo-*p* -dioxin	ng/kg	4	2	50%	0.095	0.11	0.24	0.25	0.26
	1,2,3,4,6,7,8-Heptachlorodibenzo-*p* -dioxin	ng/kg	4	4	100%			0.29	0.78	1.1
	Octachlorodibenzo-*p* -dioxin	ng/kg	4	4	100%			1.7	4.7	9.5
	Tetrachlorodibenzo-*p* -dioxin (Total)	ng/kg	4	3	75%	0.14	0.14	1.1	3.5	6.7
	Pentachlorodibenzo-*p* -dioxin (Total)	ng/kg	4	4	100%			0.16	0.65	0.93
	Hexachlorodibenzo-*p* -dioxin (Total)	ng/kg	4	3	75%	0.095	0.095	0.86	2.7	3.8

Table 2-13
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from Upstream of the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
	Heptachlorodibenzo-*p* -dioxin (Total)	ng/kg	4	4	100%			0.56	1.8	2.7
	2,3,7,8-Tetrachlorodibenzofuran	ng/kg	4	3	75%	0.11	0.11	1.6	6.4	14
	1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	4	2	50%	0.065	0.11	0.16	0.21	0.26
	2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	4	3	75%	0.11	0.11	0.23	0.30	0.40
	1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	4	1	25%	0.055	0.095	0.19	0.19	0.19
	1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	4	1	25%	0.049	0.11	0.15	0.15	0.15
	1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	4	0	0%	0.046	0.10			
	2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	4	0	0%	0.048	0.11			
	1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	4	0	0%	0.10	0.19			
	1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	4	1	25%	0.055	0.20	0.28	0.28	0.28
	Octachlorodibenzofuran	ng/kg	4	4	100%			0.38	0.83	2.1
	Tetrachlorodibenzofuran (Total)	ng/kg	4	3	75%	0.34	0.34	2.7	10	20
	Pentachlorodibenzofuran (Total)	ng/kg	4	3	75%	0.55	0.55	0.79	2.1	3.2
	Hexachlorodibenzofuran (Total)	ng/kg	4	4	100%			0.35	1.7	5.2
	Heptachlorodibenzofuran (Total)	ng/kg	4	2	50%	0.11	0.19	0.26	0.53	0.79
Blue Crab / Edible / Polychlorinated Biphenyls										
	Aroclor 1016	mg/kg	1	0	0%	0.019	0.019			
	Aroclor 1221	mg/kg	1	0	0%	0.0075	0.0075			
	Aroclor 1232	mg/kg	1	0	0%	0.019	0.019			
	Aroclor 1242	mg/kg	1	0	0%	0.019	0.019			
	Aroclor 1248	mg/kg	1	0	0%	0.011	0.011			
	Aroclor 1254	mg/kg	1	0	0%	0.030	0.030			
	Aroclor 1260	mg/kg	1	0	0%	0.016	0.016			
	Total PCBs	mg/kg	1	0	0%	0.030	0.030			
Hardhead Catfish / Edible / Physical and Chemical										
	Lipid	percent	1	1	100%			4.0	4.0	4.0
Hardhead Catfish / Edible / Dioxins and Furans										
	2,3,7,8-Tetrachlorodibenzo-*p* -dioxin	ng/kg	1	1	100%			14	14	14
	1,2,3,7,8-Pentachlorodibenzo-*p* -dioxin	ng/kg	1	1	100%			0.50	0.50	0.50
	1,2,3,4,7,8-Hexachlorodibenzo-*p* -dioxin	ng/kg	1	1	100%			0.45	0.45	0.45
	1,2,3,6,7,8-Hexachlorodibenzo-*p* -dioxin	ng/kg	1	1	100%			1.3	1.3	1.3
	1,2,3,7,8,9-Hexachlorodibenzo-*p* -dioxin	ng/kg	1	1	100%			0.43	0.43	0.43
	1,2,3,4,6,7,8-Heptachlorodibenzo-*p* -dioxin	ng/kg	1	1	100%			1.7	1.7	1.7
	Octachlorodibenzo-*p* -dioxin	ng/kg	1	1	100%			3.8	3.8	3.8
	Tetrachlorodibenzo-*p* -dioxin (Total)	ng/kg	1	1	100%			14	14	14
	Pentachlorodibenzo-*p* -dioxin (Total)	ng/kg	1	1	100%			0.50	0.50	0.50
	Hexachlorodibenzo-*p* -dioxin (Total)	ng/kg	1	1	100%			2.2	2.2	2.2
	Heptachlorodibenzo-*p* -dioxin (Total)	ng/kg	1	1	100%			1.7	1.7	1.7
	2,3,7,8-Tetrachlorodibenzofuran	ng/kg	1	1	100%			0.76	0.76	0.76
	1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	1	1	100%			0.19	0.19	0.19
	2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	1	1	100%			0.82	0.82	0.82
	1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	1	0	0%	0.18	0.18			
	1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	1	1	100%			0.18	0.18	0.18
	1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	1	0	0%	0.060	0.060			
	2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	1	1	100%			0.22	0.22	0.22
	1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	1	0	0%	0.16	0.16			
	1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	1	0	0%	0.085	0.085			
	Octachlorodibenzofuran	ng/kg	1	0	0%	0.22	0.22			
	Tetrachlorodibenzofuran (Total)	ng/kg	1	1	100%			0.76	0.76	0.76

Table 2-13

Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from Upstream of the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
	Pentachlorodibenzofuran (Total)	ng/kg	1	1	100%			1.2	1.2	1.2
	Hexachlorodibenzofuran (Total)	ng/kg	1	1	100%			0.56	0.56	0.56
	Heptachlorodibenzofuran (Total)	ng/kg	1	0	0%	0.21	0.21			

Table 2-14
Chronological Summary of TDSHS Fish Consumption Advisories Relevant to the Site

Advisory Activity		Date		Description of Activity
Advisory ADV-3 issued (TDH 1990)		9/19/1990		ADV-3 covered the Houston Ship Channel and all contiguous waters, and Upper Galveston Bay north of a line drawn from Red Bluff Point to Five Mile Cut Marker to Houston Point. ADV-3 was based on health concerns regarding dioxin in catfish and blue crabs.
Advisory ADV-3 re-evaluated based on new monitoring data		--		Re-evaluated ADV-3 based on results from the 1994 Near Coastal Water Grant study by TDSHS. Based on re-evaluation, the TDSHS continued ADV-3, unchanged from the original 1990 consumption advisory issued for these areas.
Advisory ADV-3 re-evaluated based on new monitoring data		--		Re-evaluated ADV-3 based on new results from 24 seafood samples collected by TDSHS in April 1996 from Houston Ship Channel and Upper Galveston Bay. Based on re-evaluation, the TDSHS continued ADV-3, unchanged from the original 1990 consumption advisory issued for these areas.
Report Issued: *Health Consultation For Consumption of Seafood From Houston Ship Channel and Upper Galveston Bay* (TDH 1997)		5/12/1997		Summarized re-evaluation of ADV-3 based on 1996 TDSHS monitoring data. Major recommendations included: 1) The Houston Ship Channel advisory of 1990 should continue to limit consumption of catfish and crabs. 2) If the restricted status of oysters in the Houston Ship Channel advisory area should change in the future, inclusion of oysters in the consumption advisory should be considered due to dioxin contamination of these oysters. 3) Other species of fish should remain excluded from the consumption advisory since they do not pose a significant health risk.
Report Issued: *Health Consultation Houston Ship Channel and Tabbs Bay. Harris County, Texas* (TDH 2001a)		8/1/2001		Summarized re-evaluation of ADV-3 based on 1999 TDSHS monitoring data. Major recommendations relevant to Site waters included: 1) That TDSHS continue the existing advisory (ADV-3) on consumption of blue crabs and catfish from the Houston Ship Channel and contiguous waters, including Tabbs Bay. 2) That TDSHS issue a second advisory (ADV-20) for the Houston Ship Channel and the San Jacinto River to include all species of finfish due to the presence of pesticides and PCBs in concentrations exceeding health-based assessment comparison values (HAC values).
Advisory ADV-20 issued (TDH 2001b)		10/9/2001		ADV-20 issued based on samples of fish taken from the Houston Ship Channel upstream of the Lynchburg Ferry crossing and from the San Jacinto River downstream of the U.S. Highway 90 bridge, which indicated the presence of organochlorine pesticides and polychlorinated biphenyls at concentrations that may pose a threat to human health if consumed. ADV-20 expanded advisory coverage of same waters covered by ADV-3.
Report Issued: *Characterization of Potential Health Risks Associated with Consumption of Fish or Blue Crabs from the Houston Ship Channel, the San Jacinto River (Tidal Portions), Tabbs Bay, and Upper Galveston Bay. Harris and Chambers Counties, Texas* (TDSHS 2005a)		1/10/2005		Summarized re-evaluation of ADV-3 based on 2004 TDSHS monitoring data, collected in collaboration with the TCEQ. Major recommendations relevant to Site waters included: 1) That TDSHS continue the existing advisory (ADV-3) on consumption of blue crabs and catfish from the Houston Ship Channel and contiguous waters, including Upper Galveston Bay and Tabbs Bay. 2) TDSHS continue the advisory (ADV-20) for the Houston Ship Channel and the San Jacinto River that includes all species of fish due to the presence of elevated concentrations of pesticides and PCBs. 3) That TDSHS modify consumption advice for the Houston Ship Channel – including the tidal portion of the San Jacinto River, Tabbs Bay, and all contiguous waters – and Upper Galveston Bay to inform people that health risks may be associated with consumption of spotted seatrout containing polychlorinated biphenyls, chlorinated pesticides, or dioxin (ADV-28).
Advisory ADV-28 issued (TDSHS 2005b)		1/27/2005		Issued based on monitoring data for spotted seatrout collected from Upper Galveston Bay, Tabbs Bay, and the tidal portion of the San Jacinto River, which indicated the presence of PCBs at concentrations that may pose a threat to human health if consumed.

Table 3-1
Summary of Data Quality and Usability Assessment Checks

	Checks to be Performed	Stage 1	Stage 2A	Stage 2B	Stage 3	Stage 4
1	Analytical laboratory identified, sample documentation (COCs) included	X	X	X	X	X
2	Requested analytical methods performed, analysis dates present	X	X	X	X	X
3	Requested target analyte results reported with lab data qualifiers and qualifier definitions	X	X	X	X	X
4	Requested target analyte result units reported	X	X	X	X	X
5	Requested RLs met	X	X	X	X	X
6	Sampling dates & times, date & time of lab receipt, and sample conditions documented	X	X	X	X	X
7	Rad-chem ONLY - Sample-specific critical values and minimum detectable values reported	X	X	X	X	X
8	Rad-chem ONLY - Chemical yield and reference date & time reported	X	X	X	X	X
9	Sample results evaluated using Stage 1 criteria	X	X	X	X	X
10	Requested methods performed (handling, prep, cleanup, and analytical)		X	X	X	X
11	Dates for preparation, cleanup, & other sample handling steps present		X	X	X	X
12	Sample-related QC data and QC acceptance criteria present		X	X	X	X
13	Requested spike analytes/compounds added as appropriate (e.g. surrogates, LCS, etc.)		X	X	X	X
14	Holding times met		X	X	X	X
15	QC sample frequency met (e.g., one LCS per 20 samples in a prep batch)		X	X	X	X
16	Sample results evaluated using Stage 2A criteria		X	X	X	X
17	Initial calibration data (e.g., ICAL, ICV, ICBs) present			X	X	X
18	Appropriate number and concentration of ICAL standards present			X	X	X
19	Continuing calibration data (e.g., CCV, CCBs) present			X	X	X
20	Samples bracketed by CCV/CCB, as needed			X	X	X
21	Instrument performance checks present (e.g. tune, DDT breakdown, etc)			X	X	X
22	Appropriate frequency of instrument QC samples			X	X	X
23	Sample results evaluated using Stage 2B criteria			X	X	X
24	Instrument response data (e.g., GC peak areas, ICP corrected intensities), MS/MSDs, LCS, MBs, calibration data and instrument QC checks (e.g. tunes, DDT/Endrin breakdowns, interelement correction factors, and Florisil cartridge checks) reported				X	X
25	Reported target analyte instrument responses associated with appropriate internal standard analyte(s)				X	X
26	Appropriate ICAL curve used				X	X
27	Compare instrument response to minimum response requirements for each analyte				X	X
28	Recalculation of each CCV (and CCB) response from peak data, as appropriate				X	X
29	Compliance check of recalculated CCV (and CCB)				X	X
30	Recalculation of % ratios for each tune from the instrument response, as appropriate				X	X
31	Compliance check of recaculated % ratio				X	X
32	Recalculation of instrument performance checks (e.g., DDT/Endrin breakdown for pesticide analysis, instrument blanks, interference checks)				X	X
33	Recalculation and compliance check of retention time windows				X	X
34	Recalculation of reported target analyte results				X	X
35	Recalculation of each (or selected) reported spike recovery				X	X
36	Sample results evaluated using Stage 3 criteria				X	X
37	All required instrument outputs for evaluating sample & instrument performance are present					X
38	Sample results evaluated by checking against instrument output					X
39	Each instrument's output evaluated for confirmation of non-detected or TIC analytes					X

Notes:

CCB = continuing calibration blank
CCV = continuing calibration verification
COC = chain-of-custody
ICAL = initial calibration standards
ICB = initial calibration blank
ICV = initial calibration verification
LCS = laboratory control standard
MB = method blank
MS/MSD = matrix spike/matrix spike duplicate
QC = quality control
RL = reporting limit
TIC = tentatively identified compound

Table 3-2
Data Quality Assessment Summary - Historical Data

Data Study Reference[a]	Matrix	Data Quality Assessment Category
ENSR and EHA 1995	Sediment	Cat 2
ENSR and EHA 1995	Surface Water[b]	Cat 2
ENSR and EHA 1995	Tissue	Cat 2
Orion 2009	Sediment	Cat 2
TCEQ and USEPA 2006	Sediment	Cat 1
Texas Department of State Health Services	Tissue	Cat 2
University of Houston and Parsons 2006	Sediment	Cat 2
University of Houston and Parsons 2006	Air	Cat 2
University of Houston and Parsons 2006	Tissue	Cat 2
University of Houston and Parsons 2006	Surface Water	Cat 2
URS 2010	Sediment	Cat 1
URS 2010	Surface Water	Cat 1
Weston 2006	Sediment	Cat 2

Notes:

Cat 1 = Data are of known quality and are considered acceptable for use in decision making

Cat 2 = Data are of unknown quality, suspect quality, or insufficient information is available to assess data quality for decision making purposes

[a]This data represents the data available at the time this Work Plan was being produced. Any additional data incorporated into the project database will undergo the same data quality assessment process.

[b]While surface water data quality from ENSR and EHA 1995 was assessed, these data were not included in the data used to evaluate the chemical setting for the Site (Table 2-4), because this surface water data set was not considered representative of baseline conditions.

Table 4-1
Toxicity Equivalency Factors for Dioxins and Furans

Compound	Mammalian TEFs[a]	Avian TEFs[b]	Fish TEFs[b]
Chlorinated Dibenzo-*p* -Dioxins			
2,3,7,8-TCDD	1	1	1
1,2,3,7,8-PeCDD	1	1	1
1,2,3,4,7,8-HxCDD	0.1	0.05	0.5
1,2,3,6,7,8-HxCDD	0.1	0.01	0.01
1,2,3,7,8,9-HxCDD	0.1	0.1	0.01
1,2,3,4,6,7,8-HpCDD	0.01	<0.001	0.001
OCDD	0.0003	0.0001	<0.0001
Chlorinated Dibenzofurans			
2,3,7,8-TCDF	0.1	1	0.05
1,2,3,7,8-PeCDF	0.03	0.1	0.05
2,3,4,7,8-PeCDF	0.3	1	0.5
1,2,3,4,7,8-HxCDF	0.1	0.1	0.1
1,2,3,6,7,8-HxCDF	0.1	0.1	0.1
1,2,3,7,8,9-HxCDF	0.1	0.1	0.1
2,3,4,6,7,8-HxCDF	0.1	0.1	0.1
1,2,3,4,6,7,8-HpCDF	0.01	0.01	0.01
1,2,3,4,7,8,9-HpCDF	0.01	0.01	0.01
OCDF	0.0003	0.0001	<0.0001

Notes:

TEF = toxicity equivalency factor

Table 6-1
Summary of Ecological Receptor Surrogates

Receptor Group	Receptor Surrogate	Feeding Guild	Potentially Present	Representative of One or More Feeding Guilds	High Site Fidelity/Residential	Sensitive or Potentially Highly Exposed	Life History Information Is Readily Available	Additional Considerations
Benthic macroinvertebrates								
	Molluscs	Filter feeders	X	X	X	X [a]	X	Close association with sediment
Fish								
	Gulf killifish	Omnivore	X	X	X		X	Common prey for other fish and bird species
	Black drum	Benthic invertivore	X	X	X		X	Popular sport fish; limited range, limited interbay movement
	Southern flounder	Benthic piscivore	X	X	X [b]	X	X	Supports commercial and recreational fisheries
Reptiles								
	Alligator snapping turtle	Omnivore	X	X	X	X	X [c]	Sensitive species (state threatened)
Birds								
	Neotropic cormorant	Piscivore (diving)	X	X			X	
	Great blue heron	Piscivore (wading)	X	X			X	
	Spotted sandpiper	Invertivore (probing)	X	X		X	X	As a sediment-probing invertivore, expected to be closely associated with sediment exposure pathway
	Killdeer	Invertivore (terrestrial)	X	X	X		X	Feeds on invertebrate fauna closely associated with soils
Mammals								
	Marsh Rice Rat	Omnivore	X	X	X		X	Semi-aquatic, diet consists of aquatic and emergent plants, and invertebrates
	Raccoon	Omnivore	X	X			X	Representative of both aquatic and terrestrial omnivorous feeding guilds

Notes

a - Sensitive reproductive endpoint, see Appendix B, Attachment B2.

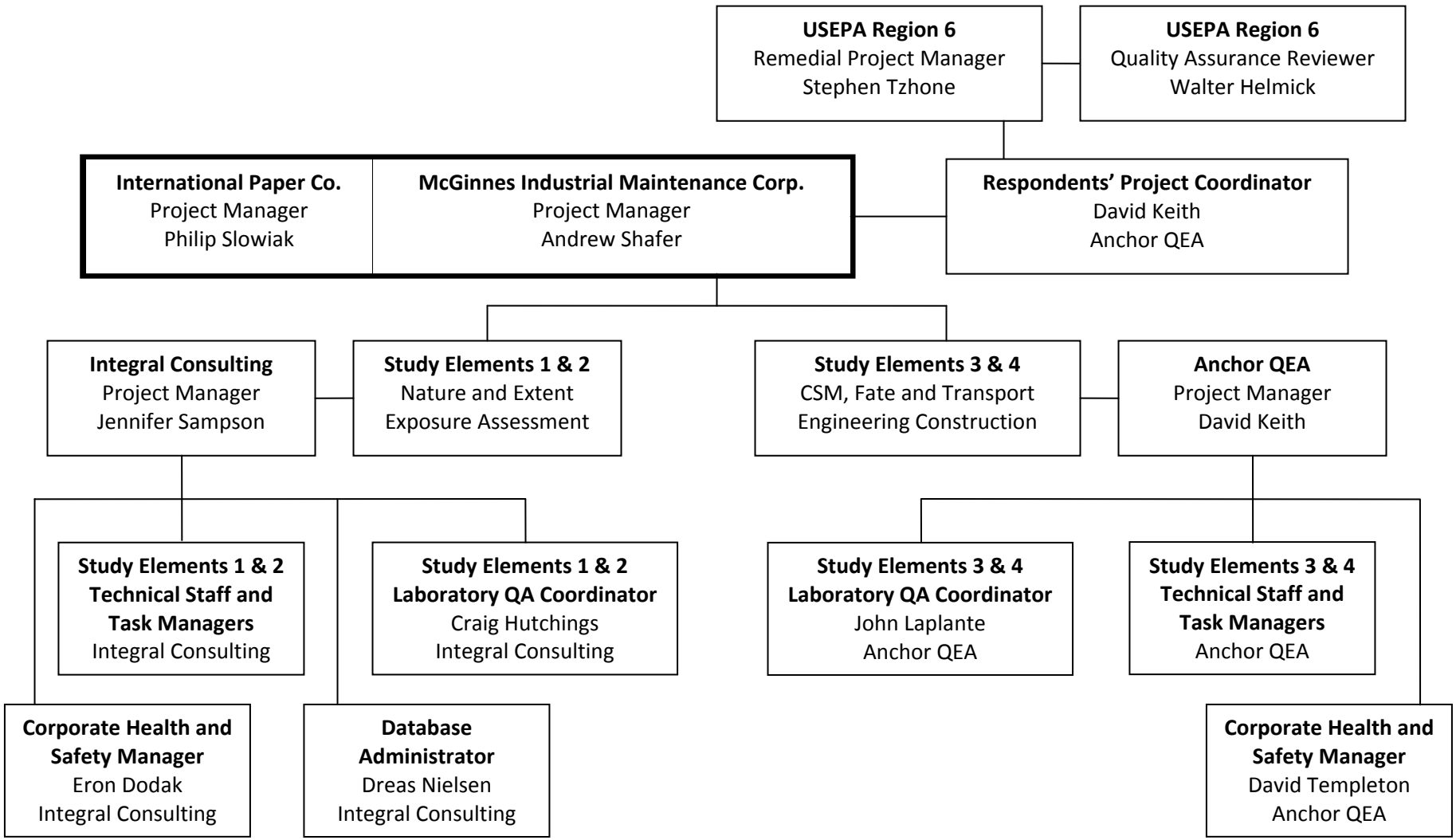
b - Site fidelity is probably high except in winter, when this species moves into more saline waters to spawn.

c - Life history information is readily available for another turtle in the snapping turtle family, the common snapping turtle (*Chelydra serpentina*).

Table 6-2
Summary of Receptor Surrogates, Assessment Endpoints, and Risk Questions for the BERA

Receptor Class	Assessment Endpoint	Risk Questions
Benthic macroinvertebrates	Functional benthic macroinvertebrate community	Are the concentrations of chemicals of potential concern (COPCs) in whole sediment from benthic habitats of the Site greater than threshold concentrations relating to the survival, growth, or reproduction of benthic invertebrates, or the productivity or viability of invertebrate populations or communities?
Bivalve molluscs	Stable or increasing populations of bivalves within the Site	Are concentrations of organic primary COPCs in tissue of field collected clams equal to or greater than concentrations considered threshold levels of reproductive effects in molluscs?
Fish	Stable or increasing populations of fish in the following feeding guilds:	Are the concentrations of COPCs in waters of the Site greater than threshold concentrations relating to the survival, growth, or reproduction of fish?
	- Benthic omnivore - Benthic invertivore - Benthic piscivore	Are the concentrations of inorganic COPCs (metals) in the diet of fish greater than threshold effect levels for survival, growth, or reproduction of fish?
		Are concentrations of organic COPCs in fish tissue from the Site greater than the concentrations of COPCs associated with effects on the survival, growth or reproduction of fish?
Reptiles	Stable or increasing populations of omnivorous reptiles	Is the total daily ingested dose (mg/kg bw-day) of COPCs greater than doses known to cause effects on the survival, growth and reproduction of reptiles?
Birds	Stable or increasing populations of birds (that may be exposed to COPCs from the Site) in the following feeding guilds:	Is the total daily ingested dose (mg/kg bw-day) of COPCs greater than doses known to cause effects on the survival, growth, and reproduction of birds? Is the estimated concentration of dioxins and furans, expressed as TEQs, in bird eggs greater than threshold concentrations for reproductive effects in birds?
	- Invertivore (aquatic and terrestrial)	
	- Omnivorous wading bird	
	- Piscivorous diving bird	
Mammals	Stable or increasing populations of omnivorous mammals	Is the total daily ingested dose (mg/kg bw-day) of COPCs greater than doses known to cause effects on the survival, growth and reproduction of mammals?

FIGURES



DRAFT

Figure 1-1
Project Organization Chart
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC

P:\Projects\C643_SJWaste_IPC\Production_MXDs\RI_FS_Workplan\Figure_2_1_Overview.mxd - 6/28/2010 @ 1:14:46 PM

ANCHOR QEA

integral consulting inc.

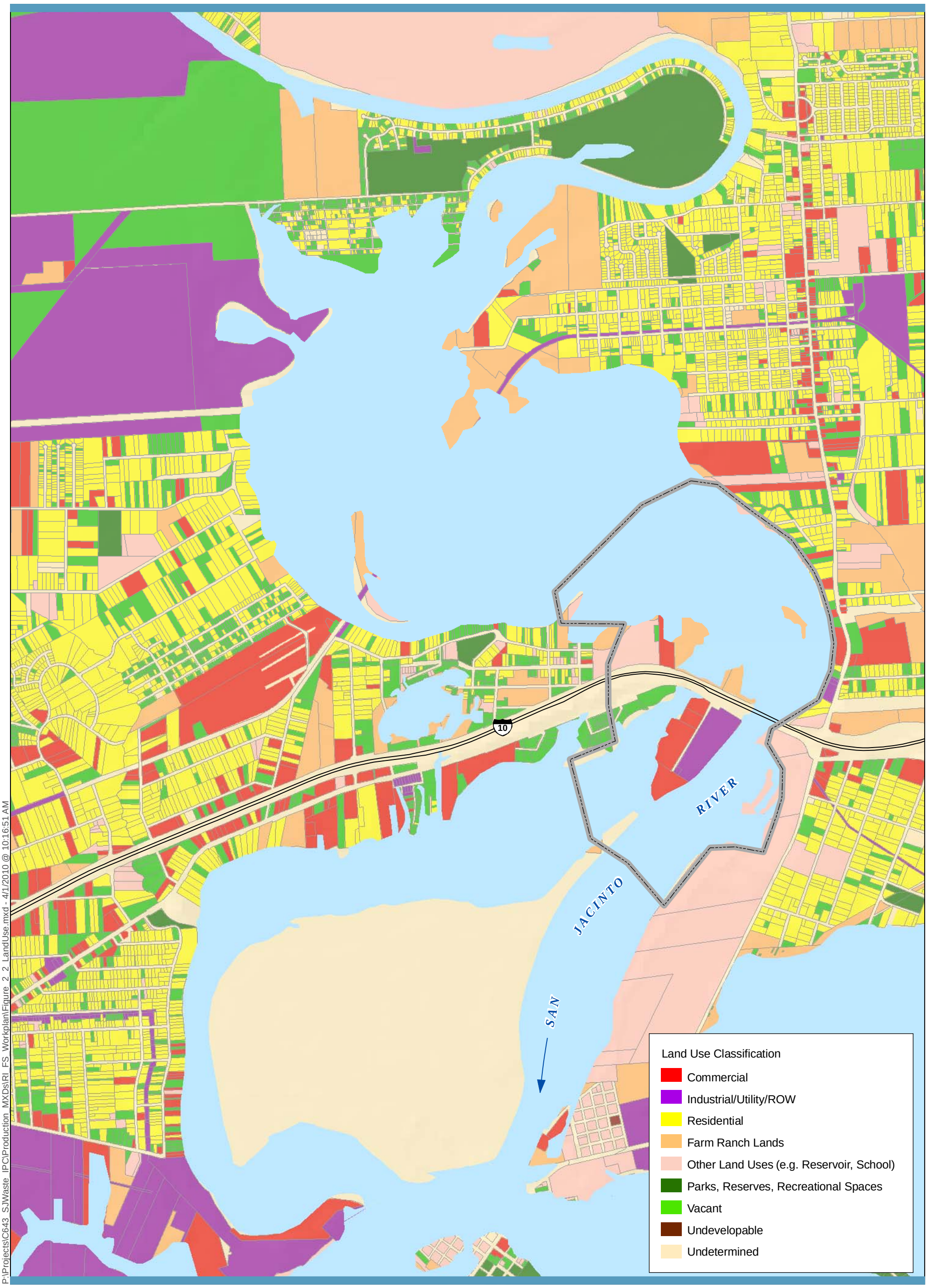
Preliminary Site Perimeter
Property West of the Impoundments
Original (1966) Perimeter of the Impoundments

0 800
Scale in Feet

FEATURE SOURCES:
Aerial Imagery: 0.5-meter January 2009 DOQQs - Texas Strategic Mapping Program (StratMap), TNIS

Figure 2-1
Overview of Current Site
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC

DRAFT
DO NOT QUOTE OR CITE



P:\Projects\C643_SJWaste_IPC\Production_MXDs\RI_FS_Workplan\Figure_2_2_LandUse.mxd - 4/1/2010 @ 10:16:51 AM

ANCHOR QEA integral consulting inc.

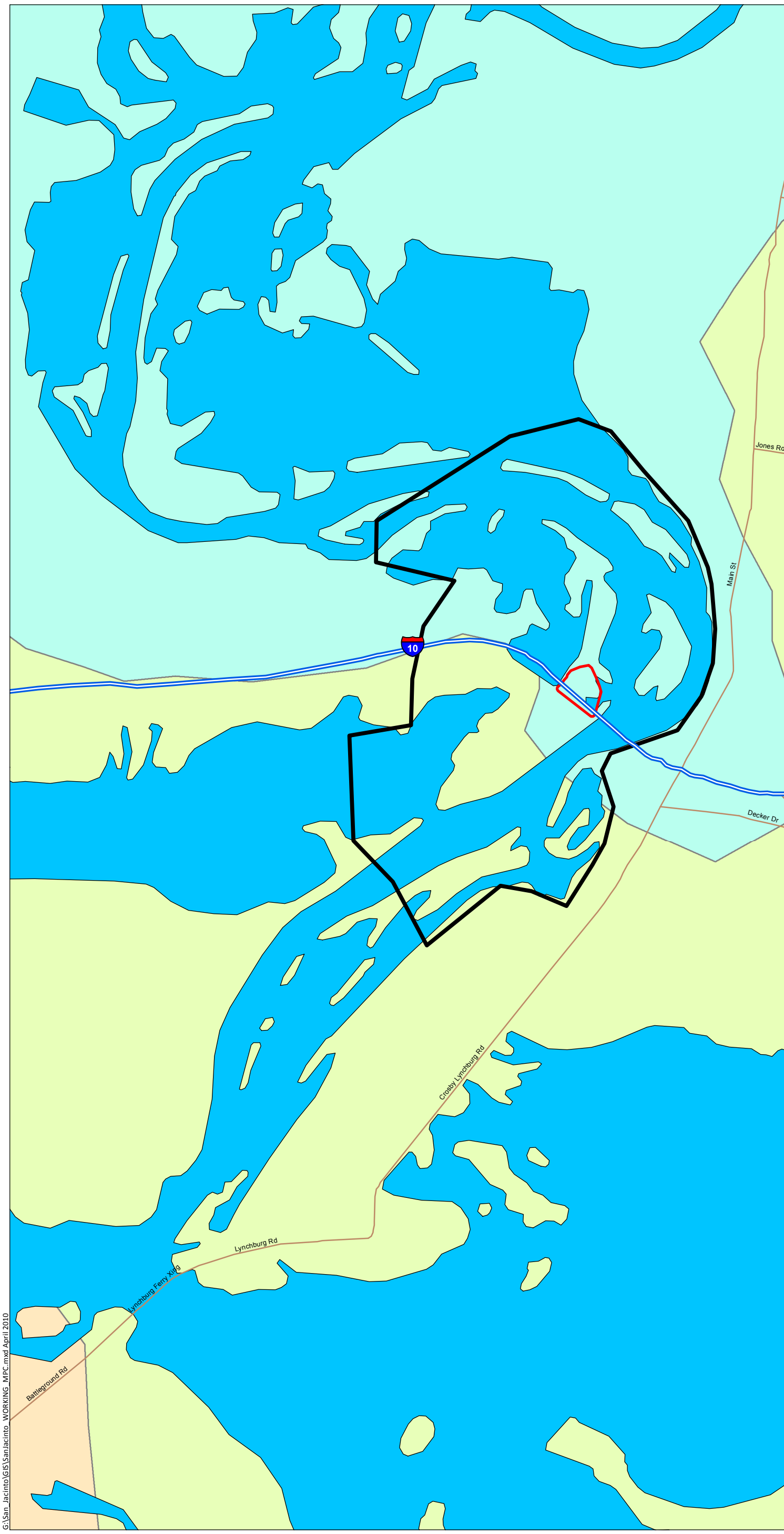
Preliminary Site Perimeter
Tax Parcel Boundary

0 0.5
Scale in Miles

FEATURE SOURCES:
Zoning: Houston-Galveston Area Council
Parcel Boundaries: Harris County Appraisal District

Figure 2-2
Land Use in the Vicinity of the Site
SJRWP RI/FS Workplan
SJRWP Superfund/MIMC and IPC

DRAFT
DO NOT QUOTE OR CITE



NOTES:

Legend

- Preliminary Site Perimeter
- Original (1966) Perimeter of the Impoundments
- San Jacinto River

San Jacinto Watershed Sub-basins

- HSC
- Houston Ship Ch./San Jacinto River
- San Jacinto River Tidal

G:\San_Jacinto\GIS\SanJacinto_WORKING_MPC.mxd April 2010

ANCHOR QEA

integral consulting inc.

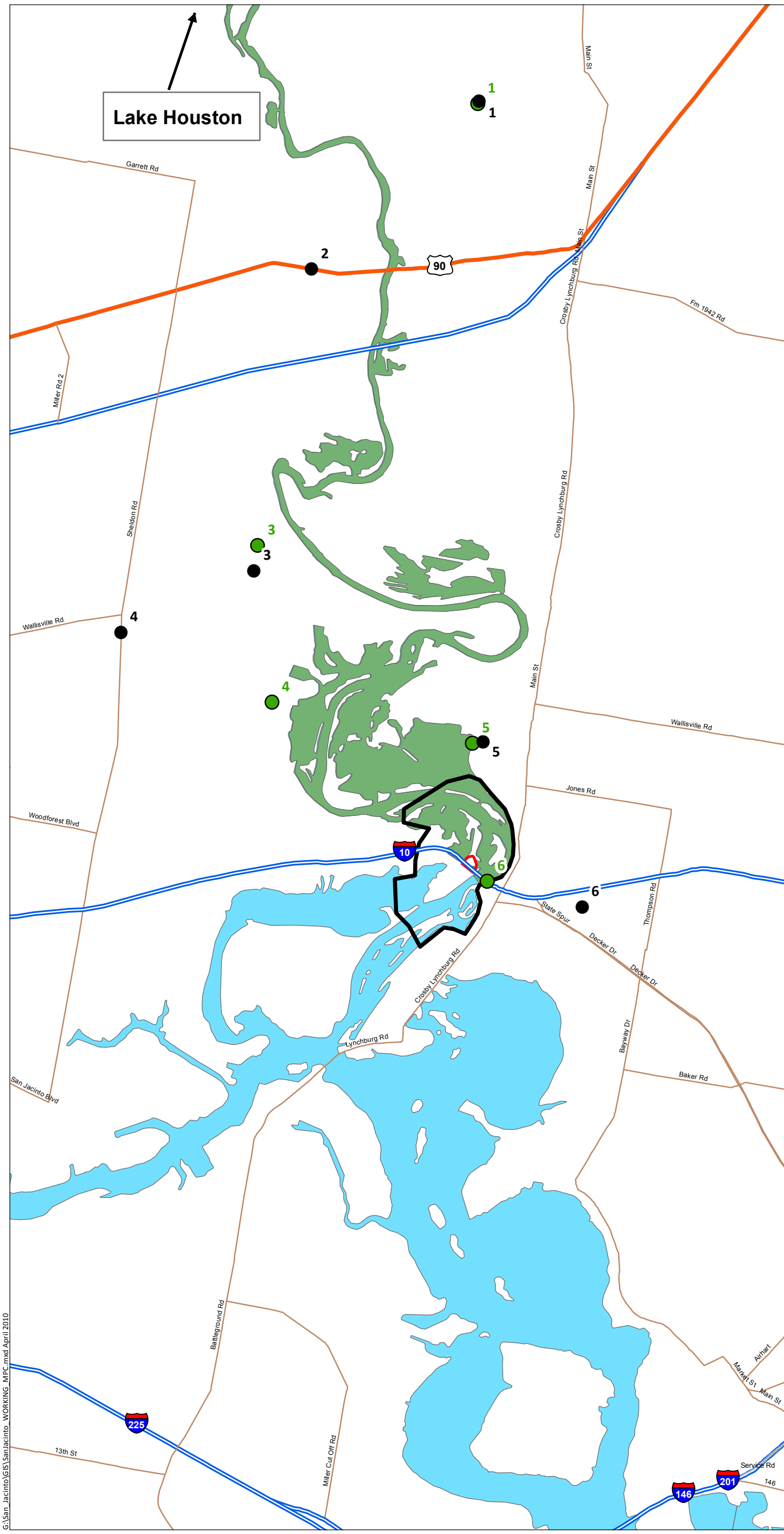
Miles
0 0.25 0.5

Figure 2-3

San Jacinto River Watersheds and Sub-basins

SJRWP RI/FS Work Plan

SJRWP Superfund/ MIMC and IPC



NOTES:
Approximate San Jacinto River segments shown, as defined in "Draft Texas 303(d)" published February 5, 2010.

Numbers shown correspond to Table 2-1 in text.

Legend

- Original (1966) Impoundments Perimeter
- Preliminary Site Perimeter
- SJR Segment 1001
- Other River Segments
- Permitted Facility
- Sludge or Effluent Sampling Location

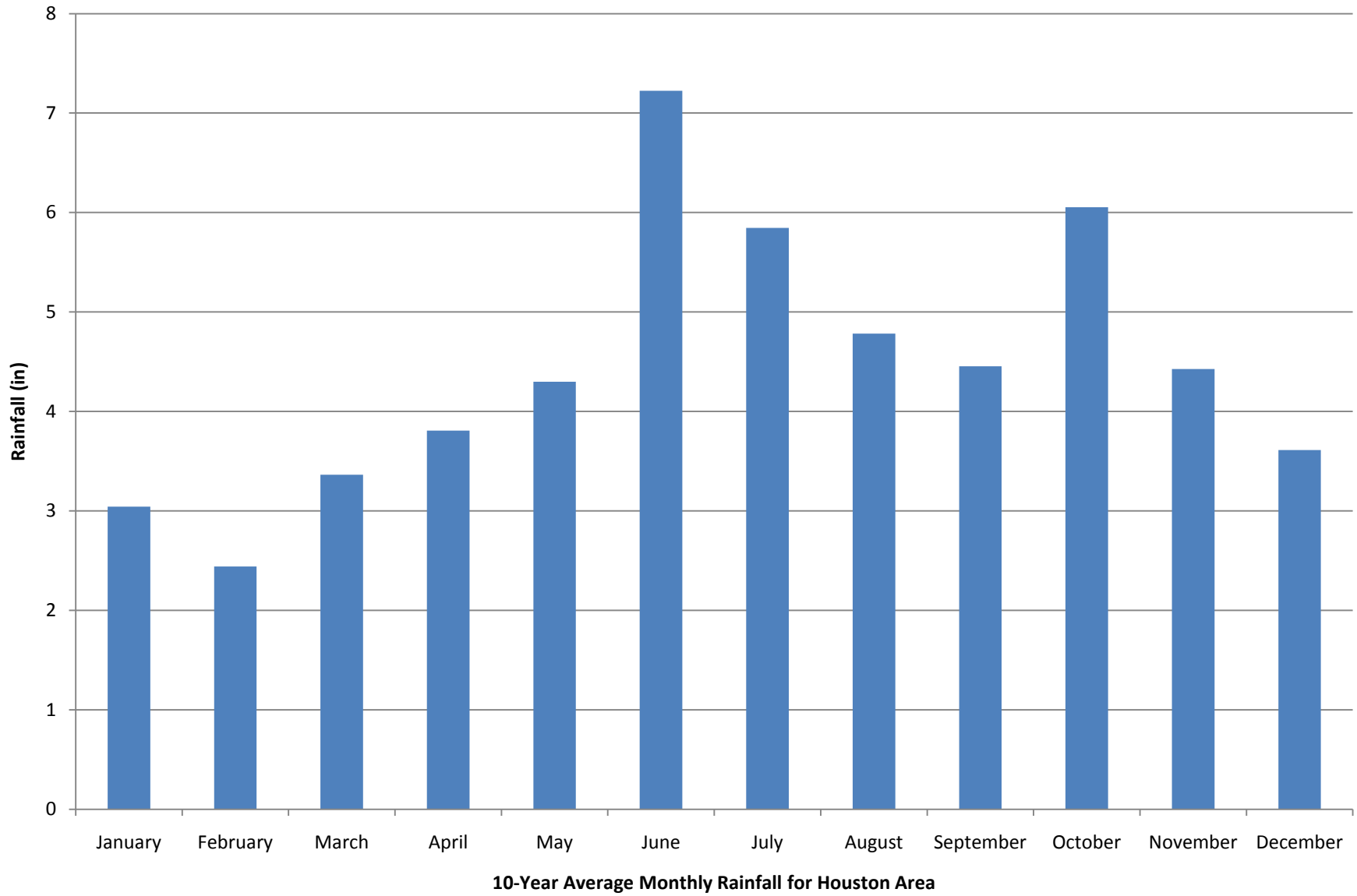
G:\San_Jacinto\GIS\Sanjacinto_WORKING_MPC.mxd April 2010

ANCHOR QEA

integral consulting inc.

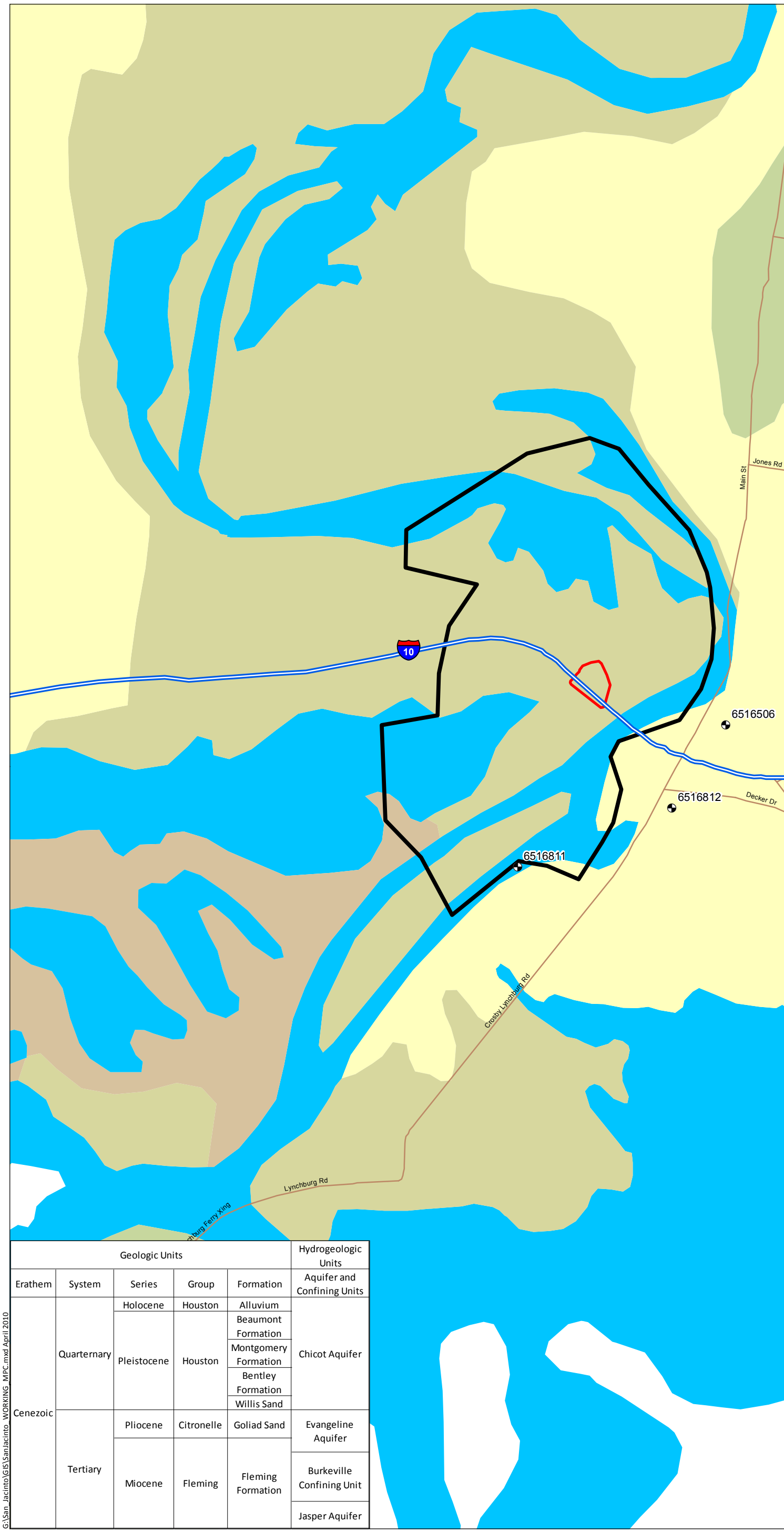
Miles 0 0.5 1

Figure 2-4
Permitted Dischargers and TMDL Sampling Locations
SJRWP RI/FS Work Plan
SJRWP Superfund/ MIMC and IPC



\\gfalls1\gfalls\San_Jacinto\documents\Draft_wkpl\Figure_2-5_20100401_MPC.docx

Figure 2-5
10-Year Average Monthly Rainfall for Houston Area
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC



NOTES:

Legend

- Original (1966) Impoundments Perimeter
- Preliminary Site Perimeter
- Holocene Fluvial Sands
- Holocene Alluvium
- Pleistocene Beaumont Formation
- Pleistocene Beaumont Formation
- Water (approximate)
- Groundwater Wells

Geologic Units					Hydrogeologic Units
Erathem	System	Series	Group	Formation	Aquifer and Confining Units
Cenezoic	Quarternary	Holocene	Houston	Alluvium	Chicot Aquifer
		Pleistocene	Houston	Beaumont Formation	
				Montgomery Formation	
				Bentley Formation	
				Willis Sand	
	Tertiary	Pliocene	Citronelle	Goliad Sand	Evangeline Aquifer
		Miocene	Fleming	Fleming Formation	Burkeville Confining Unit
					Jasper Aquifer

G:\San_Jacinto\GIS\SanJacinto_WORKING_MPC.mxd April 2010

ANCHOR QEA

integral consulting inc.

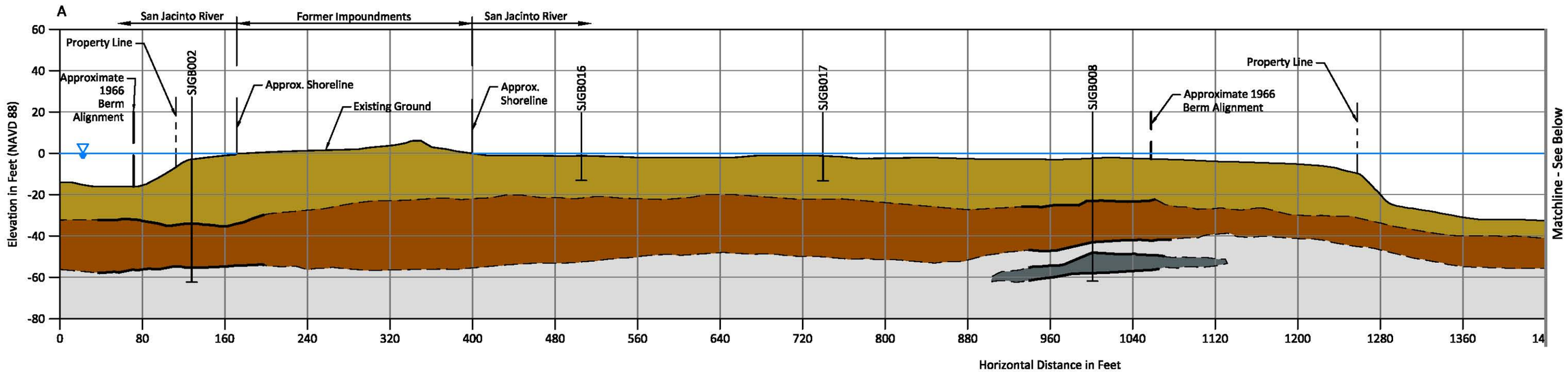
Miles 0 0.25 0.5

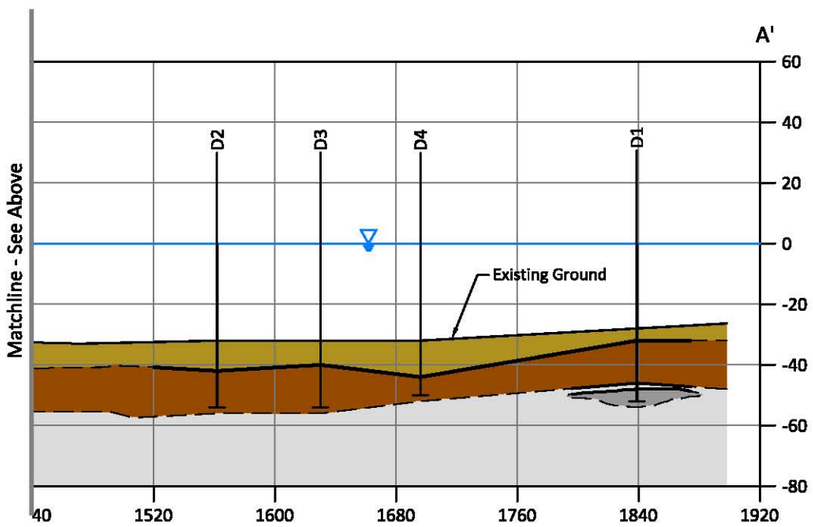
Figure 2-6

Surficial Geology and Nearby Groundwater Wells

SJRWP RI/FS Work Plan

SJRWP Superfund/ MIMC and IPC





LEGEND:

- Boring location
- Stratigraphic Boundary
- Inferred Stratigraphic Boundary
- Approximate Water Surafce
- Interbedded Recent Alluvial Sediments (Clay, Silt, Sand)
- Beaumont Formation (Brown, Red-Brown)
- SAND (Grey, Blue-Grey)
- Silt (Grey)
- Clay (Grey, Blue-Grey)

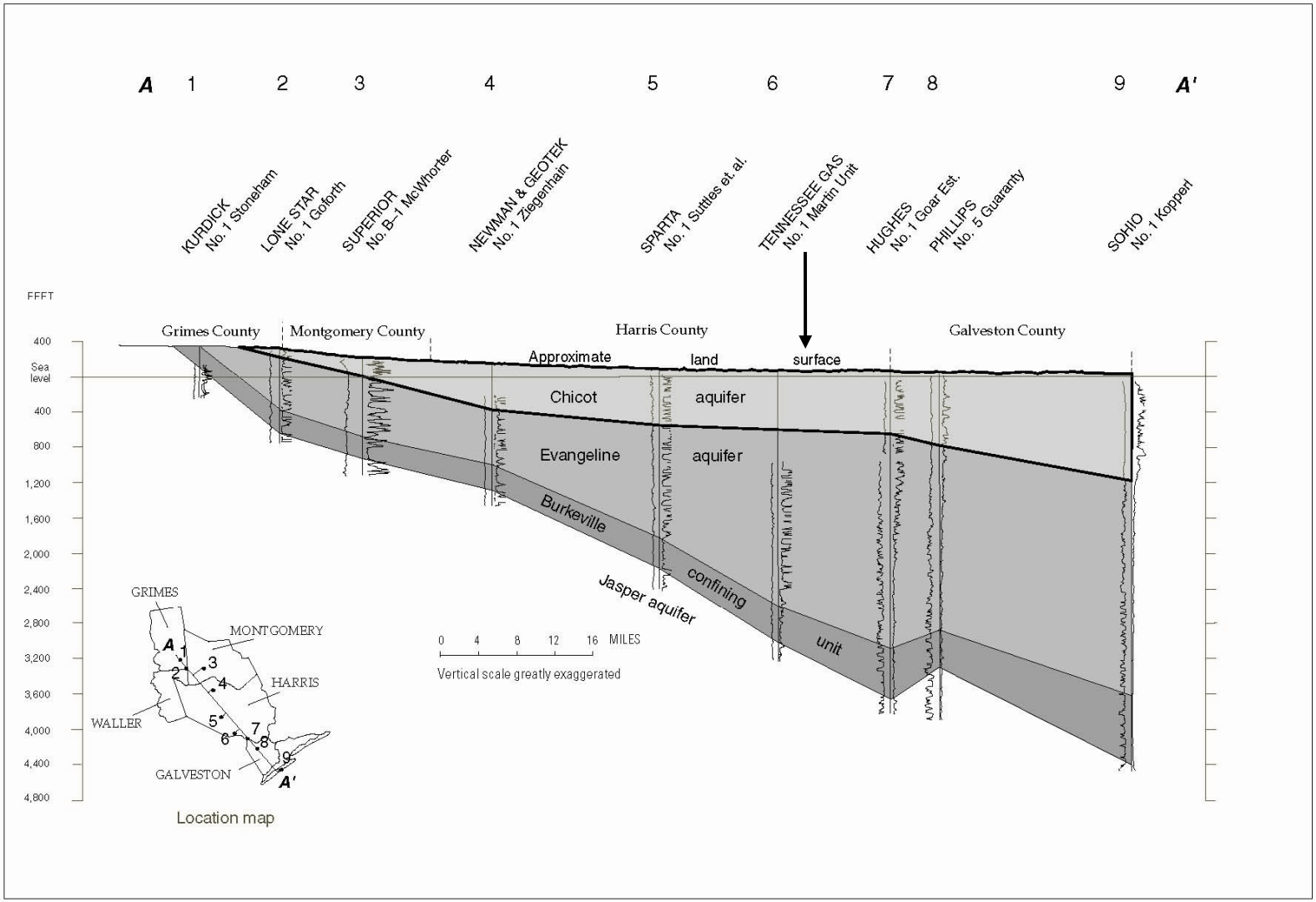
HORIZONTAL DATUM: Texas South Central NAD 83, US Survey Feet.
VERTICAL DATUM: NAVD 88.
Note:
BGS - Below Ground Surface
SJGB - Borings by MIMC / IPC
D - Borings by TxDOT

Horizontal Scale in Feet
0 100
0 50
Vertical Scale in Feet
(Vertical Exaggeration x2)

K:\Jobs\090557-San Jacinto\090557-01 - San Jacinto\09055701-RP-040.dwg FIG 2-7
Jun 25, 2010 9:25am ghowell

ANCHOR QEA

Figure 2-7
Fence Diagram A-A'
Draft RI/FS Work Plan
San Jacinto River Waste Pits Superfund Site/MIMC and IPC



From USGS, 2002

↓ Indicates approximate Site location

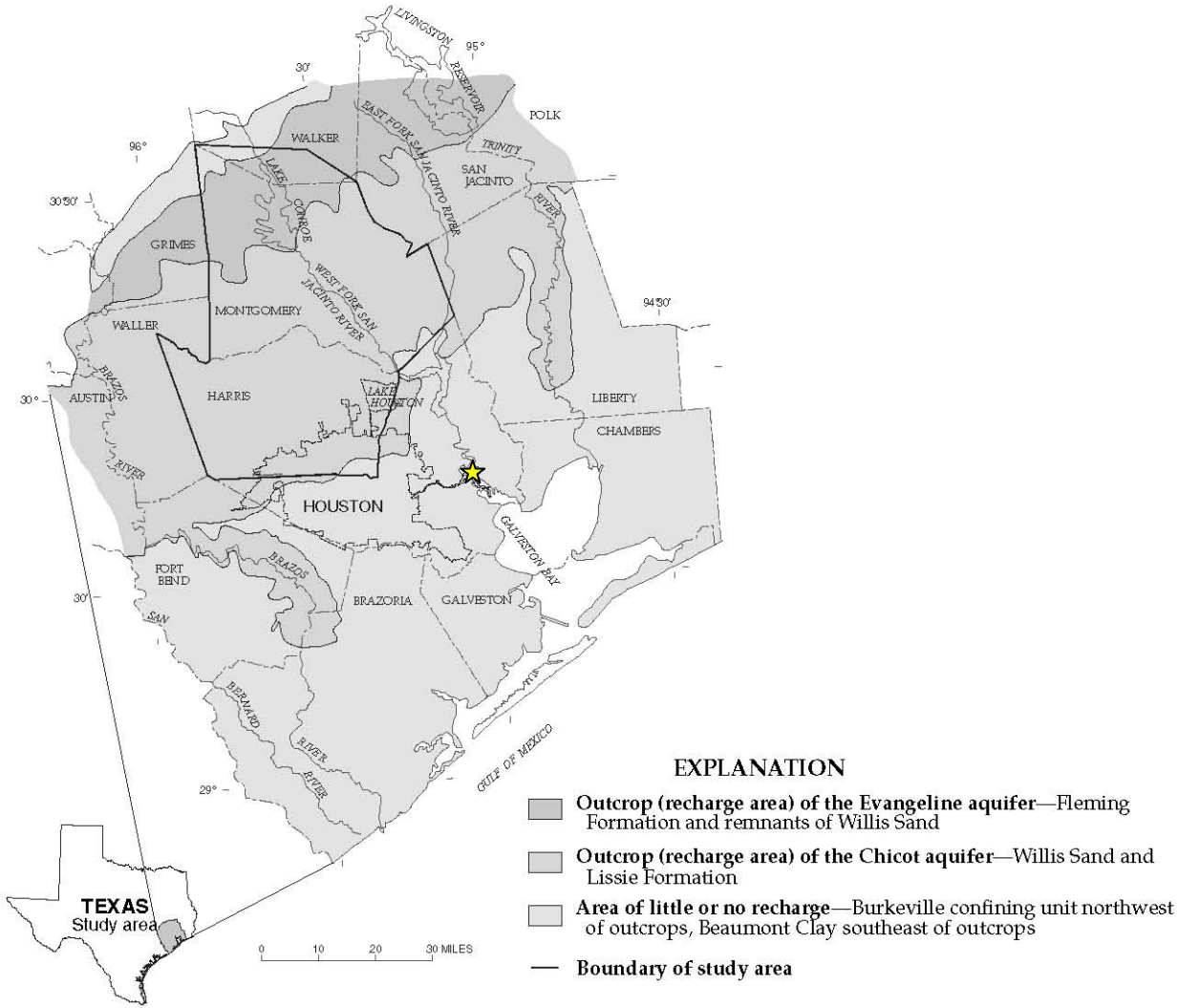
\\gfalls1\gfalls\San_Jacinto\documents\Draft_wkp\Figure-2-8_Cross-section_20100401_MPC.docx

Figure 2-8

Generalized Cross-Section Showing Hydrogeologic Units of Interest in Houston, TX area

SJRWP RI/FS Work Plan

SJRWP Superfund/MIMC and IPC



From USGS, 1997

Approximate Site location

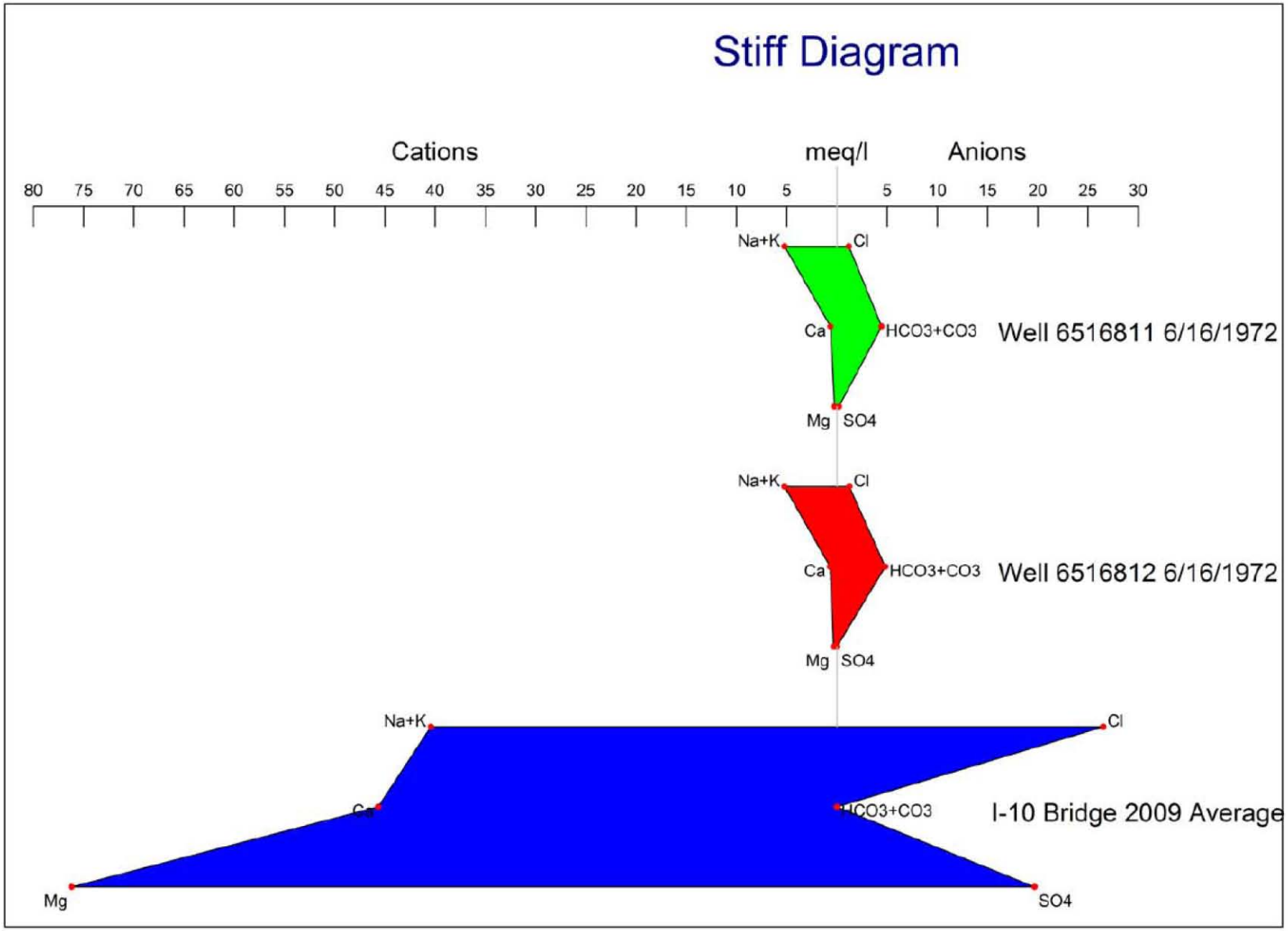
\\gfalls1\gfalls\San_Jacinto\documents\Draft_wkpl\Figure-2-8_Cross-section_20100401_MPC.docx

Figure 2-9

Map of Recharge Areas in Chicot and Evangeline Aquifers north of Houston, TX area

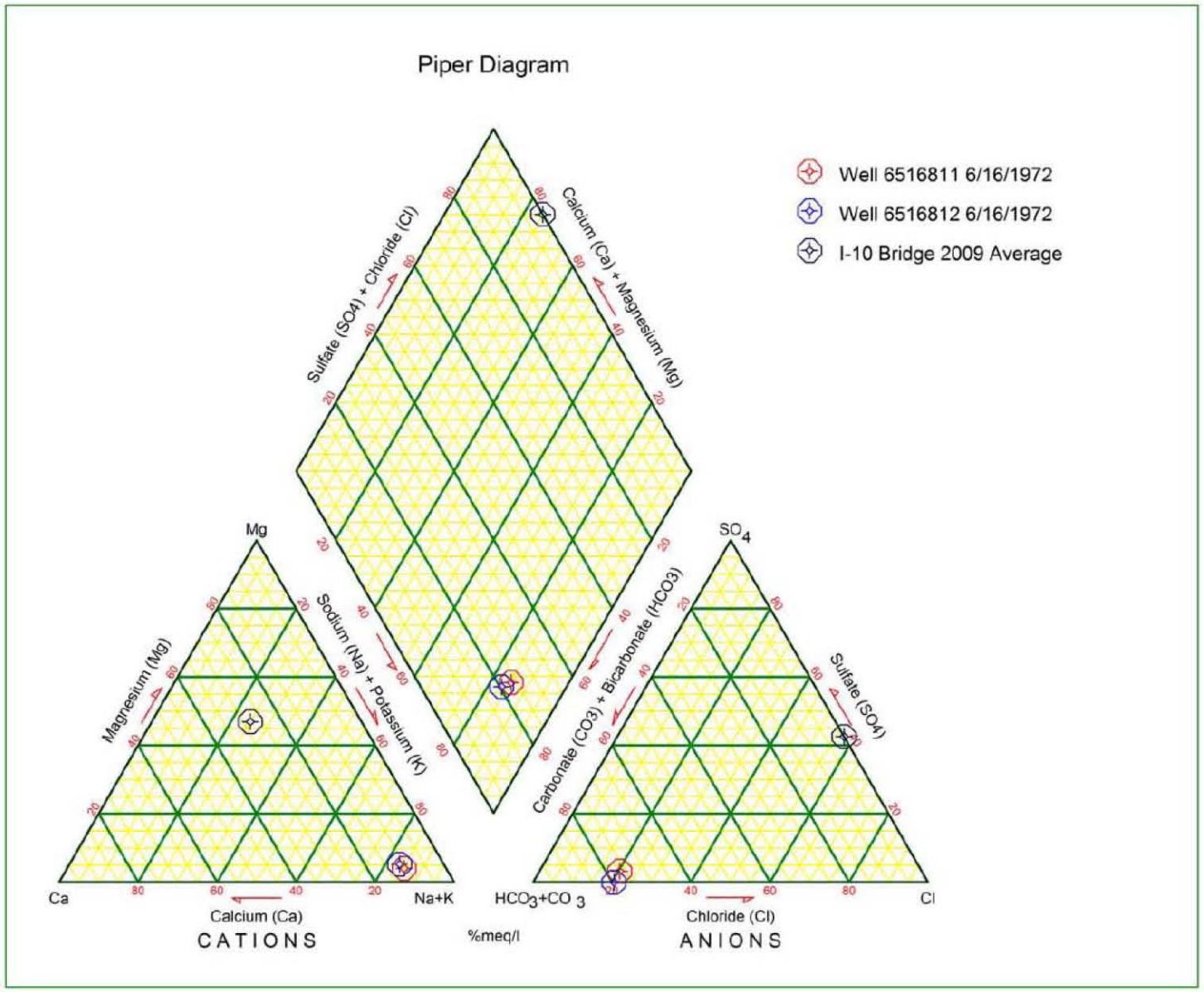
SJRWP RI/FS Work Plan

SJRWP Superfund/MIMC and IPC



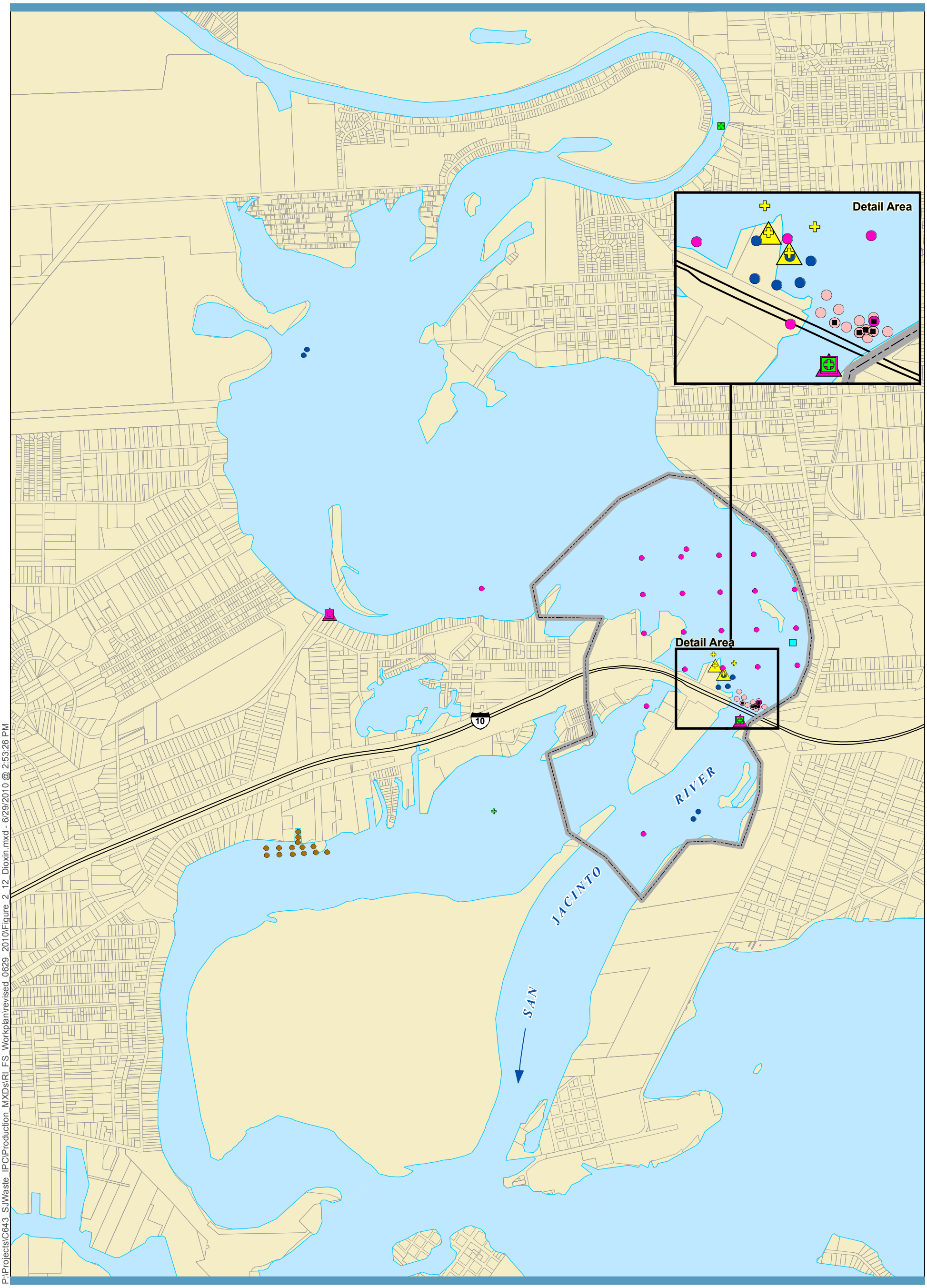
\\gfalls1\gfalls\San_Jacinto\documents\Draft_wkpl\Figure-2-8_Cross-section_20100401_MPC.docx

Figure 2-10
Stiff Diagrams of Private Wells and San Jacinto River
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC



\\gfalls1\gfalls\San_Jacinto\documents\Draft_wkpl\Figure-2-8_Cross-section_20100401_MPC.docx

Figure 2-11
Piper Diagram of Private Wells and San Jacinto River
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC



P:\Projects\C643_SJWaste_IPC\Production_MXDs\RI_FS_Workplan\revised_0629_2010\Figure_2_12_Dioxin.mxd - 6/29/2010 @ 2:53:26 PM

ANCHOR QEA

integral consulting inc.

0 0.5
Scale in Miles

FEATURE SOURCES:
Parcel Boundaries:
Harris County Appraisal District
Hydrology:
Harris County Flood Control District

Preliminary Site Perimeter
Tax Parcel Boundary

Dioxin/Furans Surface Water Sample
- URS (2010)
- University of Houston and Parsons (2006)

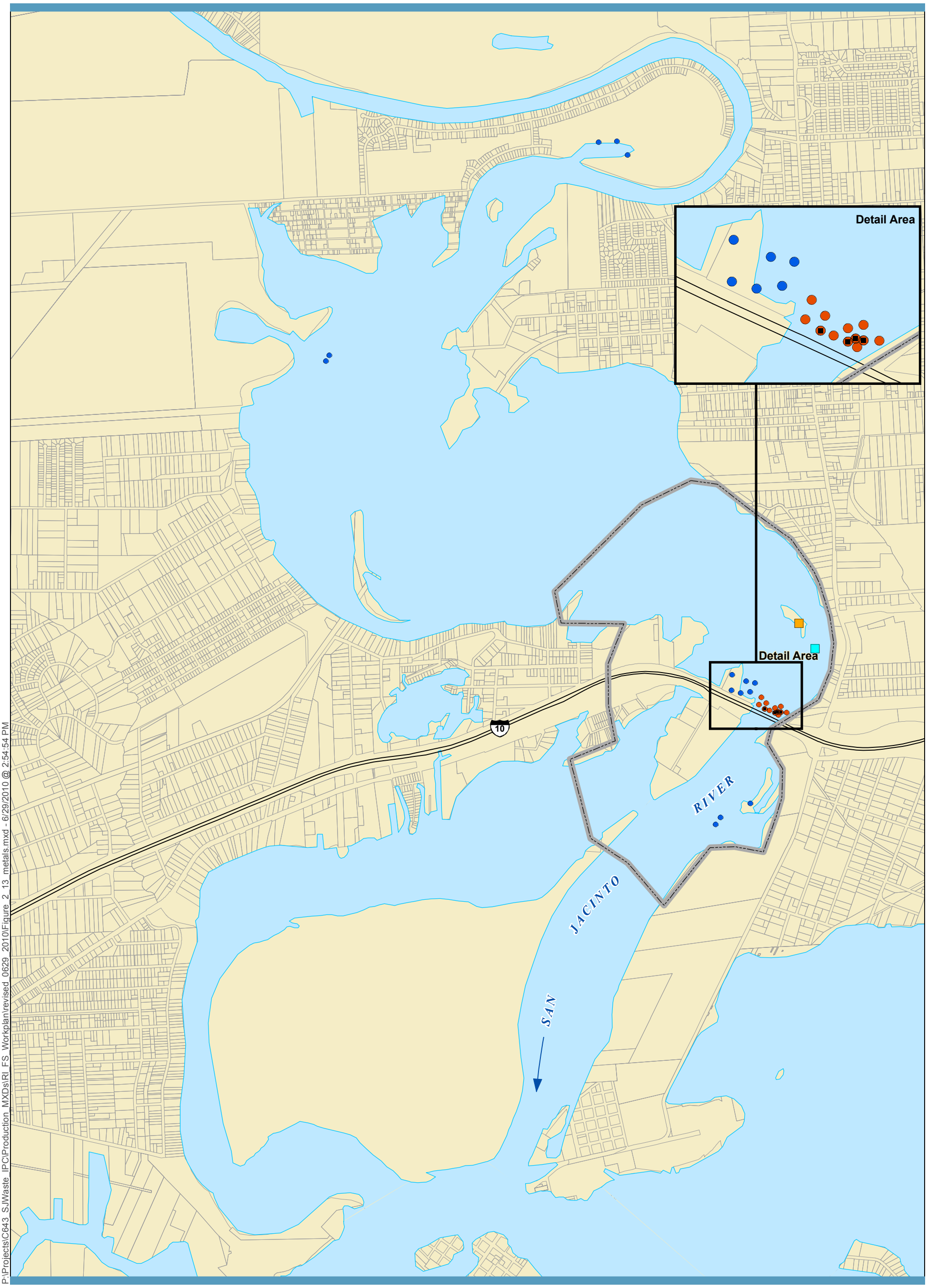
Dioxin/Furans Tissue Sample
- ENSR and EHA (1995)
- TDSHS (2004)
- University of Houston and Parsons (2006)

Dioxin/Furans Surface Sediment Sample
- ENSR and EHA (1995)
- TCEQ and USEPA (2006)
- University of Houston and Parsons (2006)
- Weston (2006)
- URS (2010)
- Orion (2009)

Dioxin/Furans Subsurface Sediment Sample
- Co-located with surface sample; study listed above.

Figure 2-12
Dioxin Sampling Locations at the Site
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC

DRAFT
DO NOT QUOTE OR CITE



P:\Projects\C643_SJWaste_IPC\Production_MXDs\RI_FS_Workplan\revised_0629_2010\Figure_2_13_metals.mxd - 6/29/2010 @ 2:54:54 PM

ANCHOR QEA integral consulting inc.

0 0.5
Scale in Miles

Preliminary Site Perimeter
Tax Parcel Boundary

Metals Tissue Sample
- TDSHS (1999)
- TDSHS (2004)

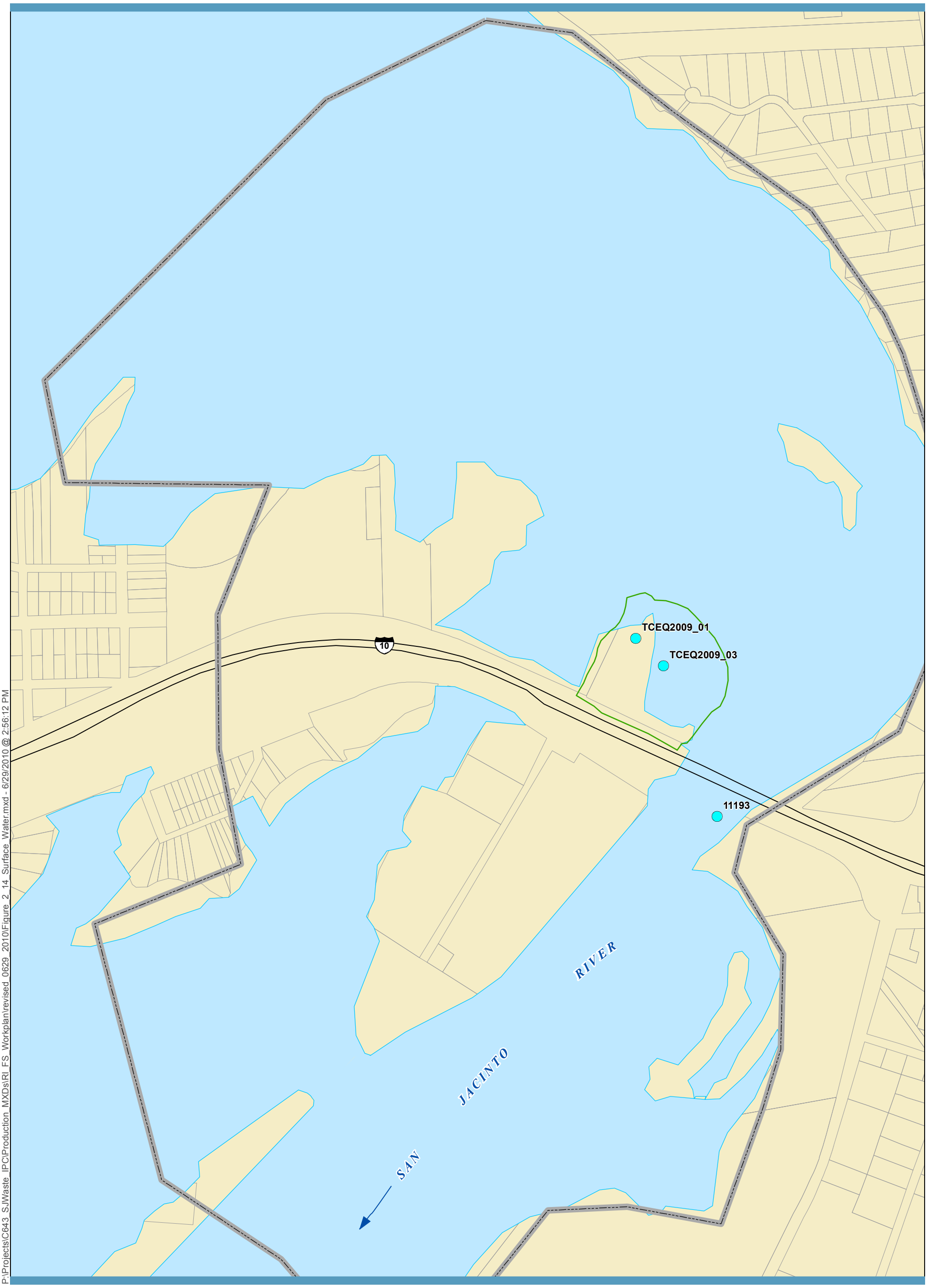
Metals Surface Sediment Sample
- TCEQ and USEPA (2006)
- Weston (2006)

Metals Subsurface Sediment Sample
- Co-located with surface sample; study listed above.

FEATURE SOURCES:
Parcel Boundaries: Harris County Appraisal District
Hydrology: Harris County Flood Control District

Figure 2-13
Metals Sampling Locations at the Site
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC

DRAFT
DO NOT QUOTE OR CITE



P:\Projects\C643_SJWaste_IPC\Production_MXDs\RI_FS_Workplan\revised_0629_2010\Figure_2_14_Surface_Water.mxd - 6/29/2010 @ 2:56:12 PM

ANCHOR QEA integral consulting inc.

Preliminary Site Perimeter
Tax Parcel Boundary
Original (1966) Perimeter of the Impoundments

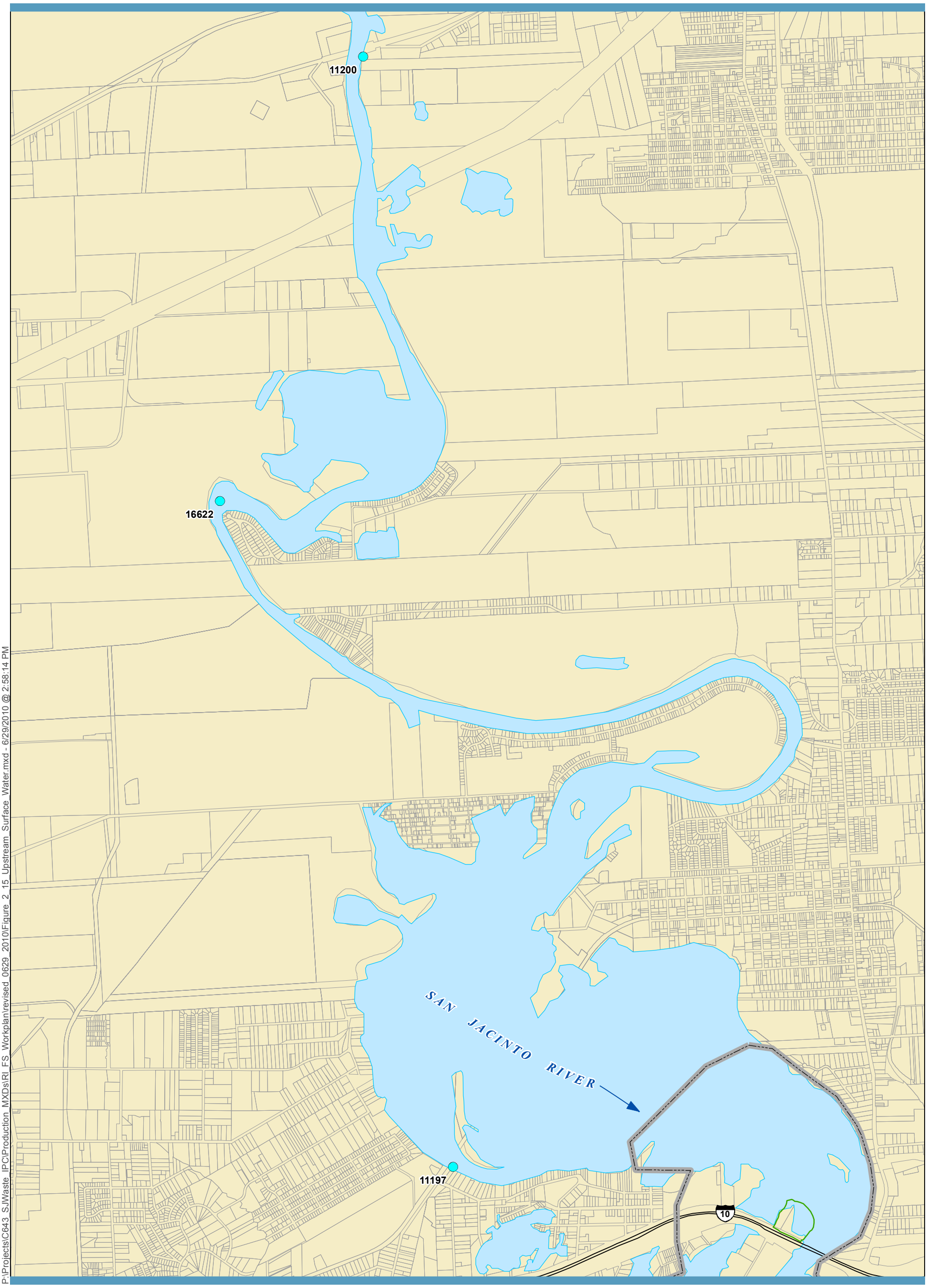
Surface Water Sampling Location

0 800
Scale in Feet

FEATURE SOURCES:
Parcel Boundaries: Harris County Appraisal District
Hydrology: Harris County Flood Control District

Figure 2-14
Surface Water Locations Within the Site
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC

DRAFT
DO NOT QUOTE OR CITE



P:\Projects\C643_SJWaste_IPC\Production_MXDs\RI_FS_Workplan\revised_0629_2010\Figure_2_15_Upstream_Surface_Water.mxd - 6/29/2010 @ 2:58:14 PM

ANCHOR QEA integral consulting inc.

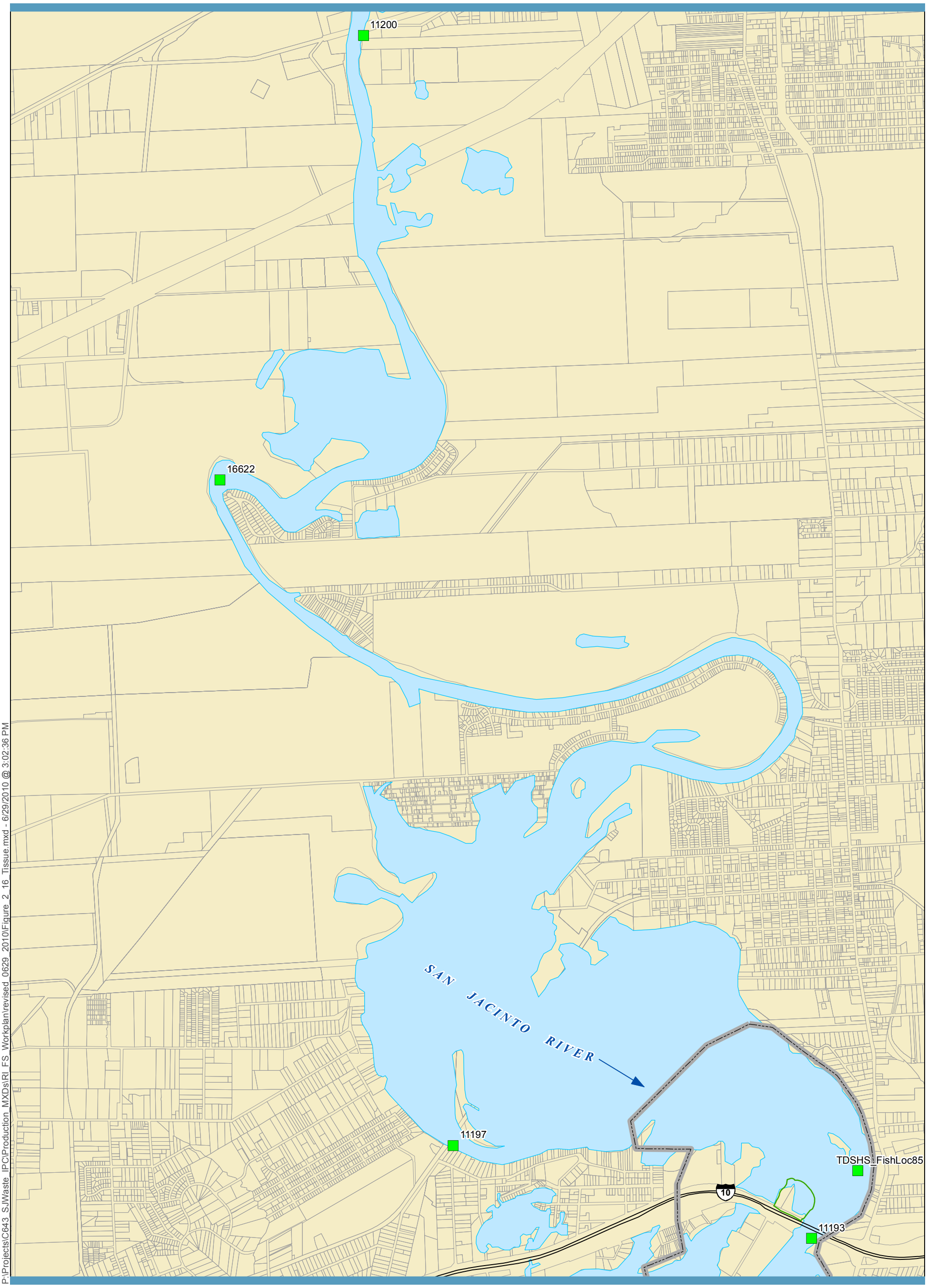
Preliminary Site Perimeter
Tax Parcel Boundary
Original (1966) Perimeter of the Impoundments
Surface Water Sampling Location

0 0.5
Miles

FEATURE SOURCES:
Parcel Boundaries: Harris County Appraisal District
Hydrology: Harris County Flood Control District

Figure 2-15
Upstream Surface Water Sampling Locations Used by the TMDL Study
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC

DRAFT
DO NOT QUOTE OR CITE



P:\Projects\C643_SJWaste_IPC\Production_MXDs\RI_FS_Workplan\revised_0629_2010\Figure_2_16_Tissue.mxd - 6/29/2010 @ 3:02:36 PM

ANCHOR QEA integral consulting inc.

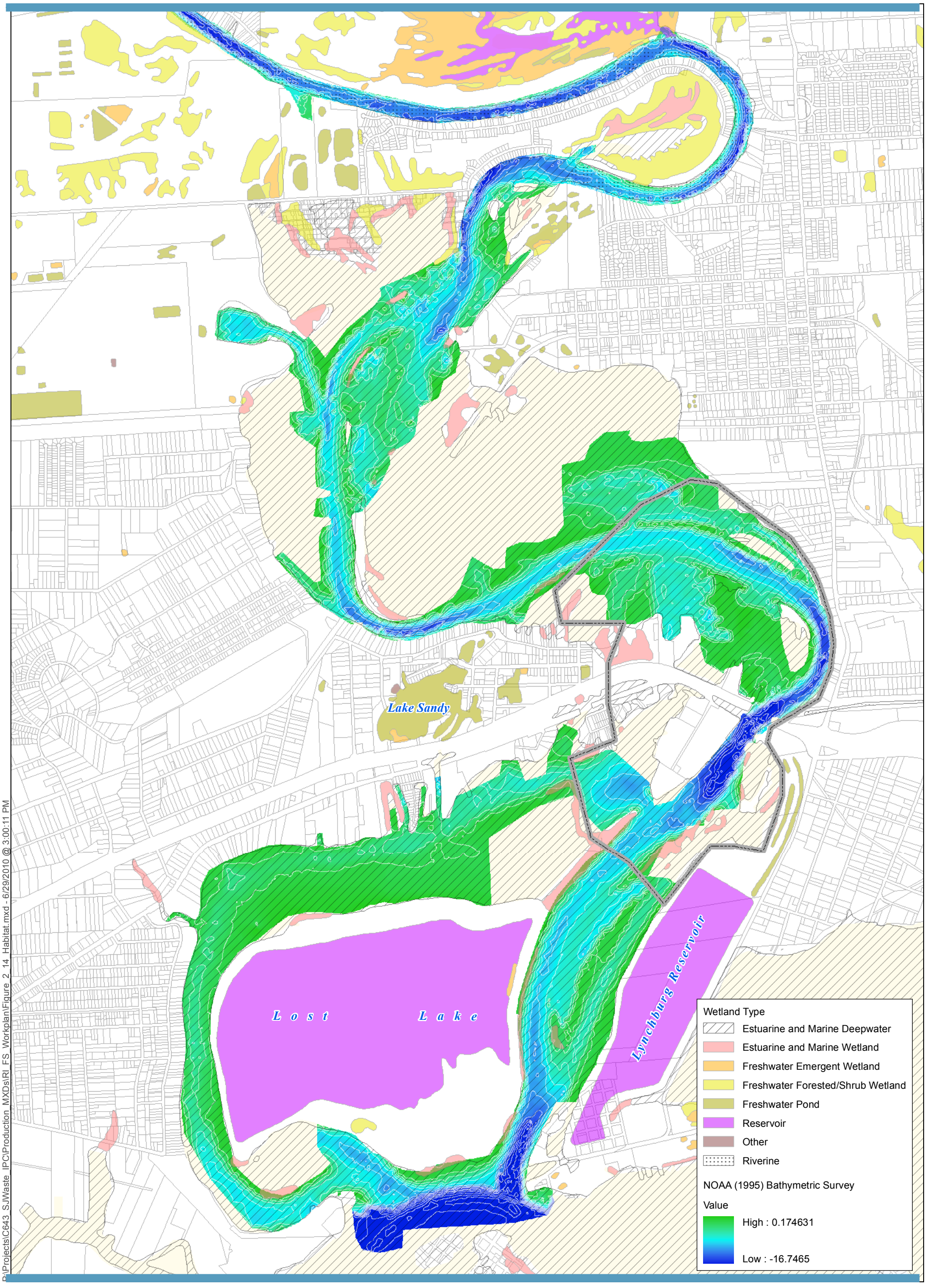
Preliminary Site Perimeter
Tax Parcel Boundary
Original (1966) Perimeter of the Impoundments
Tissue Sample Locations

0 0.5
Miles

FEATURE SOURCES:
Parcel Boundaries: Harris County Appraisal District
Hydrology: Harris County Flood Control District

Figure 2-16
Locations of Tissue Samples Collected Between 2002 and 2004 in the Nearby Area
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC

DRAFT
DO NOT QUOTE OR CITE



P:\Projects\C643_SJWaste_IPC\Production_MXDs\RI_FS_Workplan\Figure_2_14_Habitat.mxd - 6/29/2010 @ 3:00:11 PM

ANCHOR QEA integral consulting inc.

Preliminary Site Perimeter

1-Meter 1995 Bathymetric Contour

0 0.125 0.25 0.5 Miles

N

FEATURE SOURCES:
Bathymetry and Contours: NOAA. 1995. Hydrographic Survey No. H10619: in the vicinity of Lynchburg Landing to Muleshoe Lake, Texas.
Wetlands: U.S. Fish and Wildlife Service.
Parcel Boundaries: Harris County Appraisal District.

Figure 2-17
Habitats in the Vicinity of the Site
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC

DRAFT
DO NOT QUOTE OR CITE

Figure 2-18
1718 Map, Guillaume Delisle (David Rumsey Map Collection)
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC

Figure 2-19
1944 Aerial Photograph
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC

Figure 2-20
1957 Aerial Photograph
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC

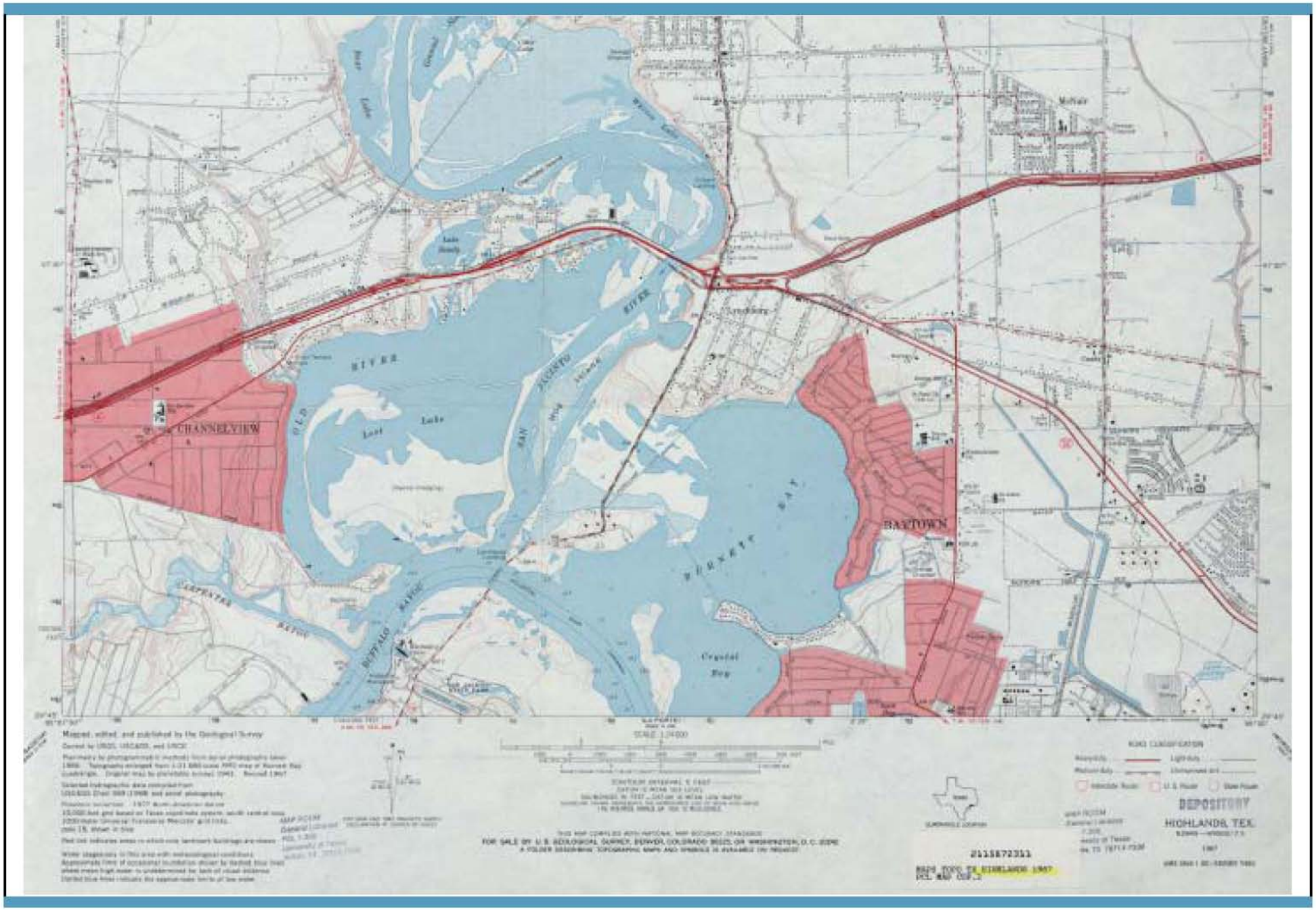
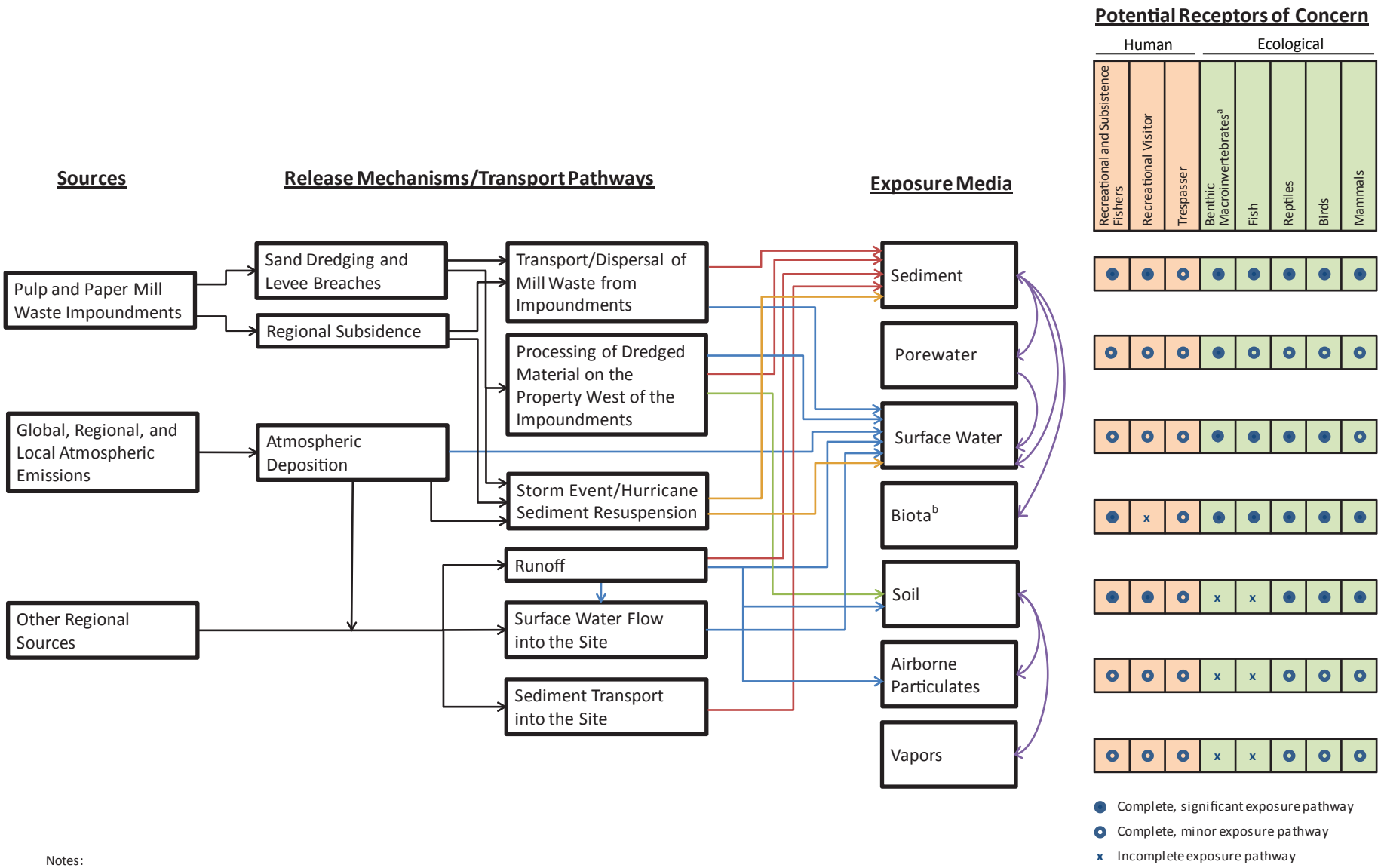


Figure 2-21
1967 Topographic Map
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC



Notes:

Other regional sources may include industrial effluents, publicly owned treatment works, and stormwater.

Curved lines indicate potential transport pathways for chemicals of potential concern among exposure media.

[a]Benthic invertebrates include crabs and other crustaceans and shellfish consumed by all receptors, as well as polychaetes and other infauna consumed by fish, other marine life, birds and mammals.

[b]Biota consumed by human receptors are expected to be fish and shellfish.

ANCHOR QEA integral consulting inc.

Figure 4-1
CSM Pathway Diagram
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC

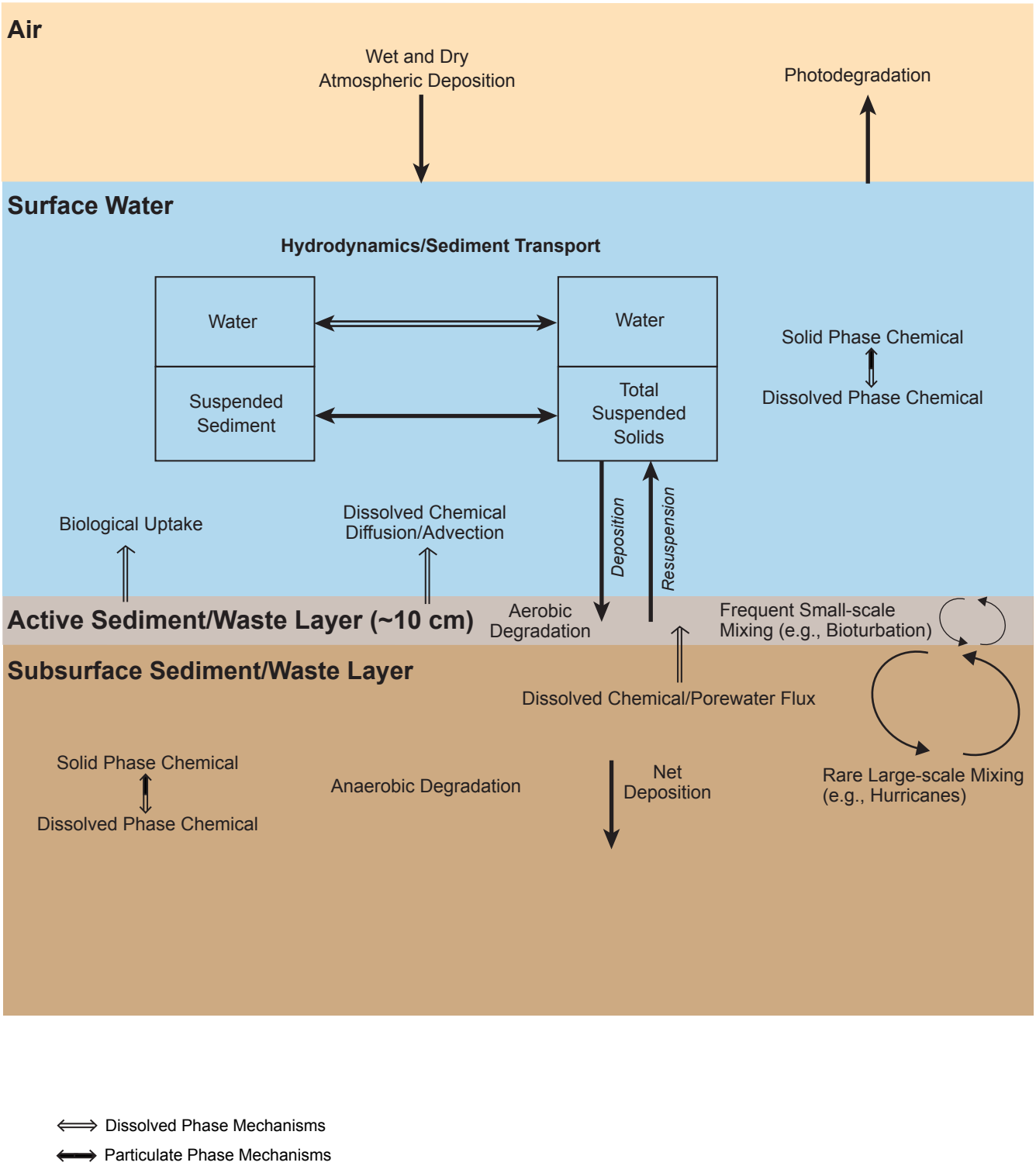
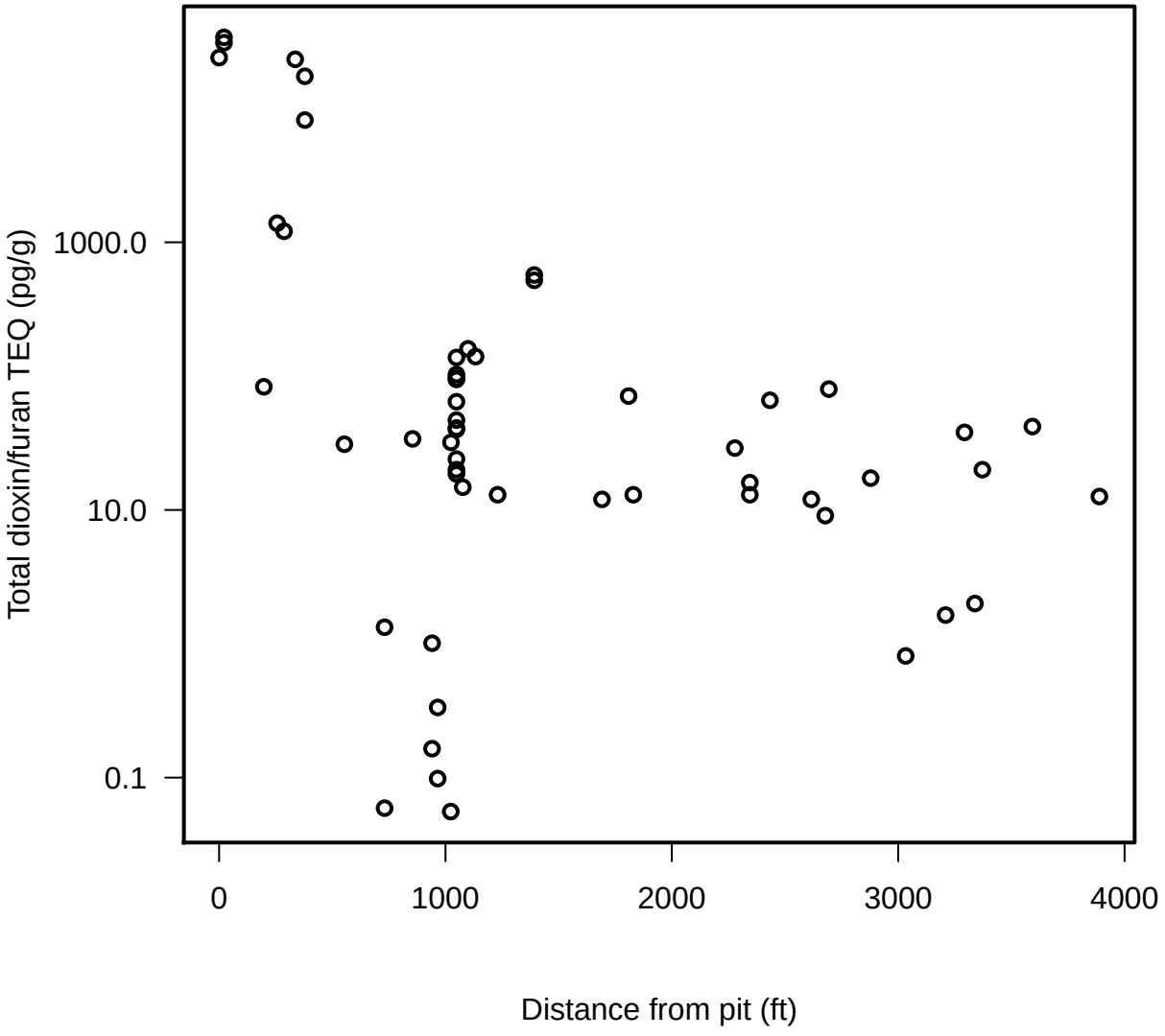


Figure 4-2
Physical/Chemical Fate and Transport Processes
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC



TEQ – toxicity equivalent

Figure 4-3
Change in Toxicity Equivalent Concentration with Distance from the San Jacinto Impoundment
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC

Exposure Media	Exposure Route	Potential Human Receptors of Concern: Recreational and Subsistence Fishers	Recreational Visitor	Trespasser
Sediment	Ingestion	●	●	○
	Dermal Contact	●	●	○
Porewater	Dermal Contact	○	○	○
Surface Water	Ingestion	○	○	○
	Dermal Contact	○	○	○
Fish and Shellfish	Ingestion	●	x	○
Soil	Ingestion	●	●	○
	Dermal Contact	●	●	○
Airborne Particulates	Inhalation	○	○	○
Vapors	Inhalation	○	○	○

● Potentially complete and significant exposure pathway

○ Potentially complete but minor exposure pathway

x Incomplete exposure pathway

ANCHOR QEA integral consulting inc.

Figure 4-4
Conceptual Site Model for Human Health
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC

Potential Receptors of Concern

Exposure Media	Exposure Routes	Ecological: Benthic Macroinvertebrates[a]	Fish	Reptiles	Birds	Mammals
Sediment	Ingestion	●	●	●	●	●
	Direct Contact	●	○	○	○	○
Porewater	Ingestion	●	○	x	○	x
	Direct Contact	●	○	○	○	○
	Respiration	●	○	x	x	x
Surface Water	Ingestion[b]	●	●	●	●	x
	Direct Contact	●	○	○	○	○
	Respiration	●	●	x	x	x
Biota	Ingestion	●	●	●	●	●
Soil	Ingestion	x	x	●	●	●
	Direct Contact	x	x	○	○	○
Airborne Particulates	Inhalation	x	x	○	○	○

● Potentially complete and significant exposure pathway

○ Potentially complete but minor exposure pathway

x Incomplete exposure pathway

Notes:

[a]Benthic invertebrates include crabs and other crustaceans and shellfish consumed by all receptors, as well as polychaetes and other infauna consumed by fish, other marine life, birds, and mammals.

[b]Mammals and terrestrial birds are assumed not to ingest surface water for drinking, as surface water is estuarine.

ANCHOR QEA integral consulting inc.

Figure 4-5
Conceptual Site Model for Ecological Exposures
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC

Exposure Media	Exposure Routes	Benthic Macro-invertebrates	Fish		Reptiles	Aquatic Birds		Terrestrial Birds	Mammals
			Omnivores	Benthic Piscivores		Piscivore	Wading Invertivores/ Omnivores	Invertivore	
Sediment	Ingestion	●	○	●	●	●	●	x	●
	Direct Contact	●	○	○	○	○	●	x	○
Porewater	Ingestion	●	○	○	x	○	○	○	x
	Direct Contact	●	○	○	○	○	○	○	○
	Respiration	●	○	○	x	x	x	x	x
Surface Water	Ingestion[a]	●	●	●	●	●	●	x	x
	Direct Contact	●	○	○	○	○	○	○	○
	Respiration	●	●	●	x	x	x	x	x
Biota	Ingestion	●	●	●	●	●	●	●	●
Soils	Ingestion	x	x	x	●	x	x	●	●
	Direct Contact	x	x	x	○	○	○	○	○
Airborne Particulates	Inhalation[b]	x	x	x	○	○	○	○	○

Notes:

● Potentially complete and significant exposure pathway

○ Potentially complete but minor exposure pathway

x Incomplete exposure pathway

[a] Mammals and terrestrial birds are assumed not to ingest surface water for drinking, as surface water is estuarine.

[b] Inhalation of contaminated vapor or particles is a minor exposure route for reptiles, birds, and mammals.

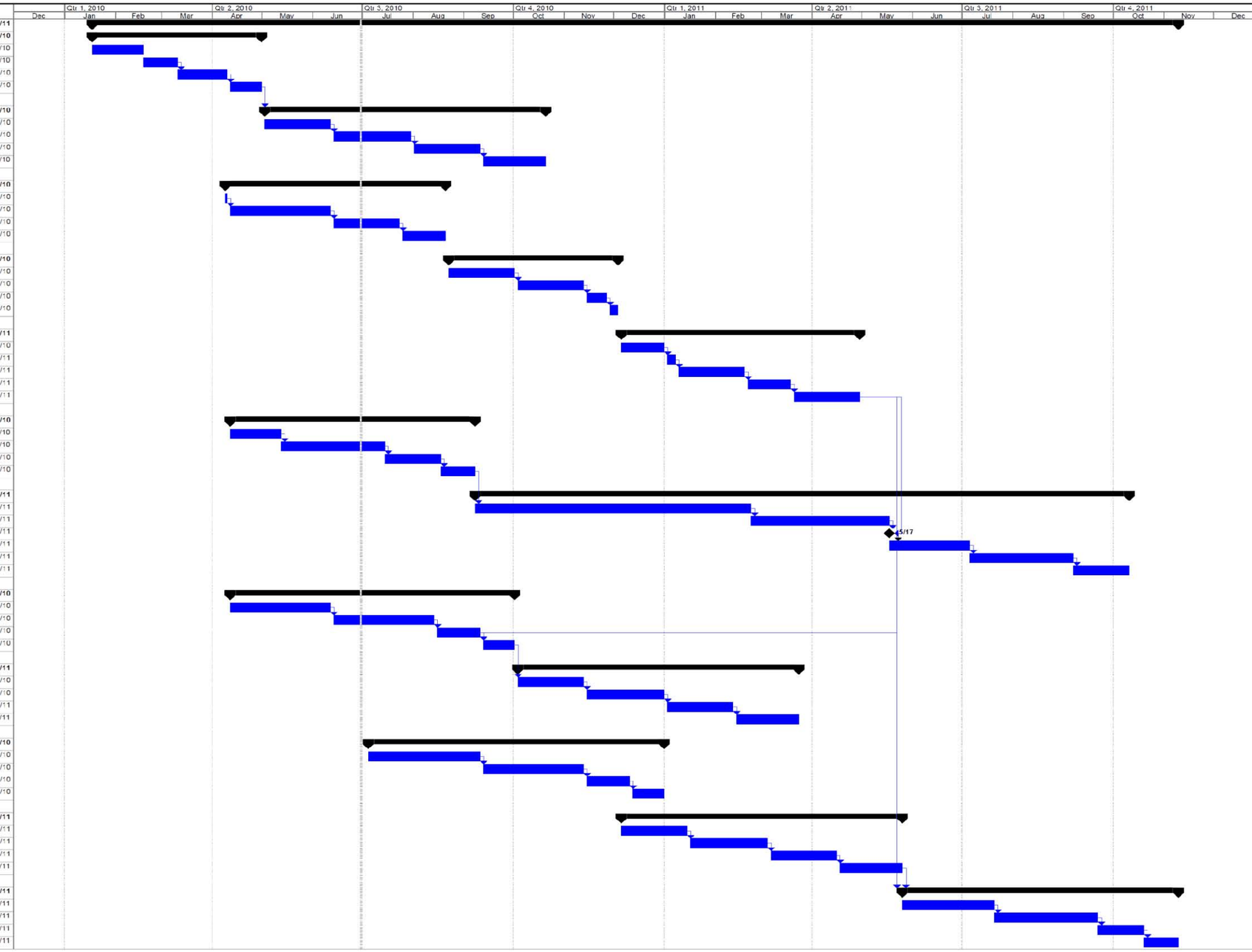
ANCHOR QEA

integral consulting inc.

Figure 4-6

Conceptual Site Model for Ecological Exposures:
Exposure Details for Receptor Feeding Guilds and Habitat Associations
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC

ID	Task Name	Duration	Start	Finish
1	**Preliminary Site Characterization Report Studies and Preparation**	**473 days**	**Mon 1/18/10**	**Wed 11/9/11**
2	**San Jacinto Sediment Sampling and Analysis Plan**	**75 days**	**Mon 1/18/10**	**Fri 4/30/10**
3	Draft Sediment QAPP/FSP	23 days	Mon 1/18/10	Wed 2/17/10
4	Agency Review	15 days	Thu 2/18/10	Wed 3/10/10
5	Final Sediment SAP Submitted	22 days	Thu 3/11/10	Fri 4/9/10
6	EPA Approval of Sediment SAP	15 days	Mon 4/12/10	Fri 4/30/10
7				
8	**Field Sampling, Sediment Study**	**123 days**	**Mon 5/3/10**	**Wed 10/20/10**
9	Mobilization/Field Implementation	30 days	Mon 5/3/10	Fri 6/11/10
10	Laboratory Analysis	35 days	Mon 6/14/10	Fri 7/30/10
11	Data Validation	30 days	Mon 8/2/10	Fri 9/10/10
12	Data Management	28 days	Mon 9/13/10	Wed 10/20/10
13				
14	**RI/FS Work Plan and SLERA**	**96 days**	**Fri 4/9/10**	**Fri 8/20/10**
15	Draft of Work Plan and SLERA	1 day	Fri 4/9/10	Fri 4/9/10
16	Agency Review	45 days	Mon 4/12/10	Fri 6/11/10
17	Final RI/FS Work Plan and SLERA	30 days	Mon 6/14/10	Fri 7/23/10
18	EPA Approval of RI/FS Work Plan	20 days	Mon 7/26/10	Fri 8/20/10
19				
20	**Groundwater QAPP/FSP**	**75 days**	**Mon 8/23/10**	**Fri 12/3/10**
21	Draft Groundwater QAPP/FSP	30 days	Mon 8/23/10	Fri 10/1/10
22	Agency Review	30 days	Mon 10/4/10	Fri 11/12/10
23	Final Groundwater QAPP/FSP Submitted	10 days	Mon 11/15/10	Fri 11/26/10
24	EPA Approval of Groundwater QAPP/FSP	5 days	Mon 11/29/10	Fri 12/3/10
25				
26	**Field Sampling, Groundwater**	**105 days**	**Mon 12/6/10**	**Fri 4/29/11**
27	Mobilization/Well Installation	20 days	Mon 12/6/10	Fri 12/31/10
28	Sampling	5 days	Mon 1/3/11	Fri 1/7/11
29	Laboratory Analysis	30 days	Mon 1/10/11	Fri 2/18/11
30	Data Validation	20 days	Mon 2/21/11	Fri 3/18/11
31	Data Management	30 days	Mon 3/21/11	Fri 4/29/11
32				
33	**Technical Memorandum on Fate & Transport Modeling**	**107 days**	**Mon 4/12/10**	**Tue 9/7/10**
34	Draft Tech Memo on Fate & Transport Modeling & QAPP/FSP	23 days	Mon 4/12/10	Wed 5/12/10
35	Agency Review	45 days	Thu 5/13/10	Wed 7/14/10
36	Final Tech. Memo. and QAPP/FSP Submitted	24 days	Thu 7/15/10	Tue 8/17/10
37	EPA Approval of Tech. Memo. On Fate&Transport Modeling Memo and QAPP/FSP	15 days	Wed 8/18/10	Tue 9/7/10
38				
39	**Field Sampling, Fate &Transport Study**	**264 days**	**Wed 9/8/10**	**Mon 10/10/11**
40	Mobilization and Field Study	120 days	Wed 9/8/10	Tue 2/22/11
41	Calibrate/Validate and Test Models	60 days	Wed 2/23/11	Tue 5/17/11
42	Model Presentation	0 days	Tue 5/17/11	Tue 5/17/11
43	Submit Draft F&T Modeling Report	35 days	Wed 5/18/11	Tue 7/5/11
44	Agency Review and Response	45 days	Wed 7/6/11	Tue 9/6/11
45	Final F&T Modeling Report	24 days	Wed 9/7/11	Mon 10/10/11
46				
47	**Technical Memorandum on Bioaccumulation**	**125 days**	**Mon 4/12/10**	**Fri 10/1/10**
48	Draft Tech. Memo. on Bioaccumulation & QAPP/FSP	45 days	Mon 4/12/10	Fri 6/11/10
49	Agency Review	45 days	Mon 6/14/10	Fri 8/13/10
50	Final Tech Memo on Bioaccumulation Submitted	20 days	Mon 8/16/10	Fri 9/10/10
51	EPA Approval of Tech Memo on Bioaccumulation & QAPP/FSP	15 days	Mon 9/13/10	Fri 10/1/10
52				
53	**Field Sampling Tissue**	**123 days**	**Mon 10/4/10**	**Wed 3/23/11**
54	Mobilization and Field Study	30 days	Mon 10/4/10	Fri 11/12/10
55	Laboratory Analysis	35 days	Mon 11/15/10	Fri 12/31/10
56	Data Validation	30 days	Mon 1/3/11	Fri 2/11/11
57	Data Management	28 days	Mon 2/14/11	Wed 3/23/11
58				
59	**Soil QAPP/FSP**	**130 days**	**Mon 7/5/10**	**Fri 12/31/10**
60	Draft Soil QAPP/FSP	50 days	Mon 7/5/10	Fri 9/10/10
61	Agency Review	45 days	Mon 9/13/10	Fri 11/12/10
62	Final Soil QAPP/FSP Submitted	20 days	Mon 11/15/10	Fri 12/10/10
63	EPA Approval of Soil QAPP/FSP	15 days	Mon 12/13/10	Fri 12/31/10
64				
65	**Field Sampling Soil**	**123 days**	**Mon 12/6/10**	**Wed 5/25/11**
66	Mobilization and Field Study	30 days	Mon 12/6/10	Fri 1/14/11
67	Laboratory Analysis	35 days	Mon 1/17/11	Fri 3/4/11
68	Data Validation	30 days	Mon 3/7/11	Fri 4/15/11
69	Data Management	28 days	Mon 4/18/11	Wed 5/25/11
70				
71	**Preliminary Site Characterization Report**	**120 days**	**Thu 5/26/11**	**Wed 11/9/11**
72	Draft PSC Report	40 days	Thu 5/26/11	Wed 7/20/11
73	Agency Review	45 days	Thu 7/21/11	Wed 9/21/11
74	Final PSC Report Submitted	20 days	Thu 9/22/11	Wed 10/19/11
75	EPA Approval of PSC Report	15 days	Thu 10/20/11	Wed 11/9/11



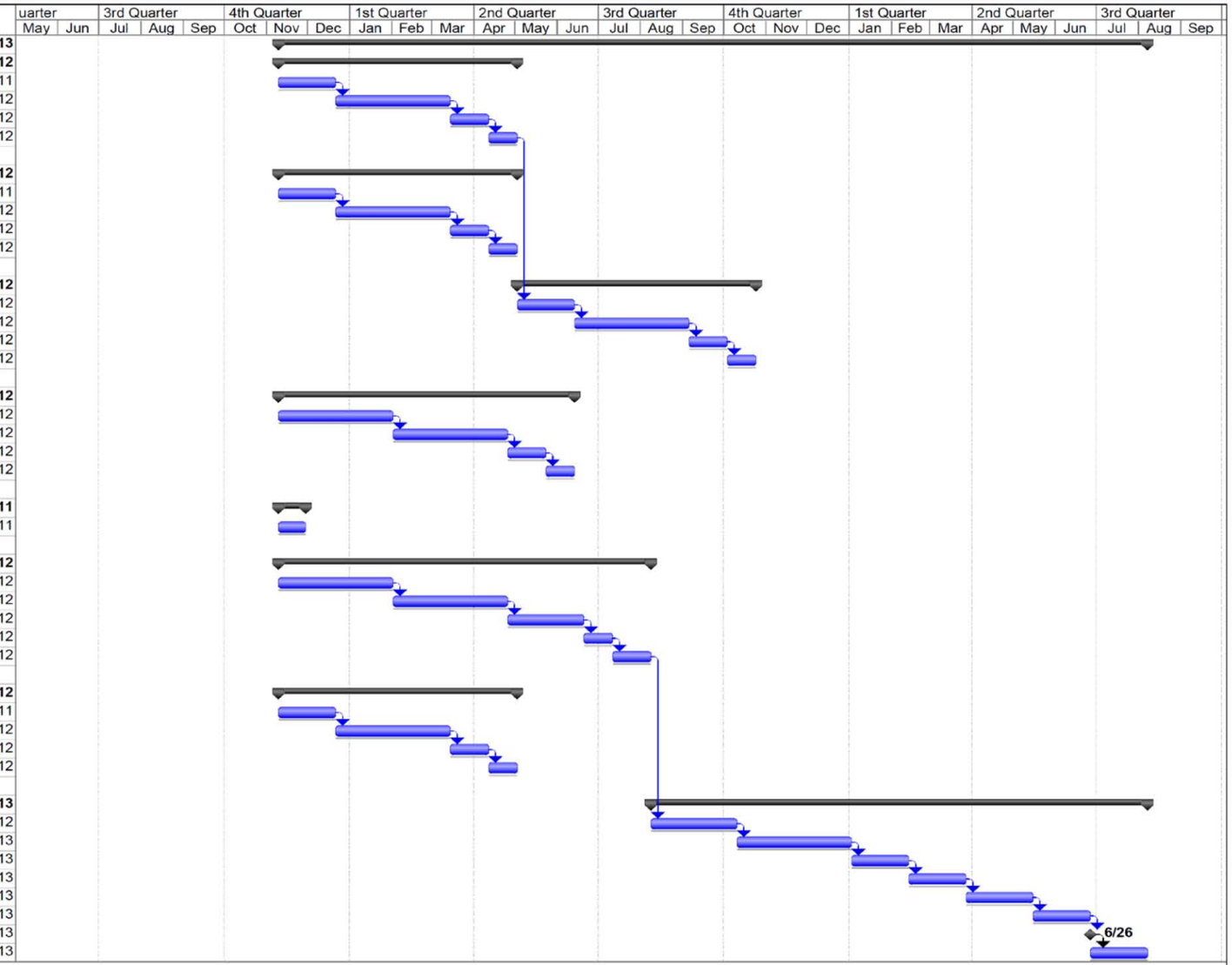
Project: Draft San Jac Schedule Pre-P
Date: Wed 6/30/10

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

ANCHOR QEA

Figure 8-1a
Schedule of Deliverables Pre Preliminary Site Characterization Report
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC

ID	Task Name	Duration	Start	Finish
1	**Post Site Characterization Report Deliverables**	**455 days**	**Thu 11/10/11**	**Wed 8/7/13**
2	**Exposure Assessment (EA) Memorandum**	**125 days**	**Thu 11/10/11**	**Wed 5/2/12**
3	Submit Draft of EA Memo	30 days	Thu 11/10/11	Wed 12/21/11
4	Agency Review	60 days	Thu 12/22/11	Wed 3/14/12
5	Final EA Memorandum Submitted	20 days	Thu 3/15/12	Wed 4/11/12
6	EPA Approval of EA Memorandum	15 days	Thu 4/12/12	Wed 5/2/12
7				
8	**Toxicological and Epidemiological Studies (TES) Memorandum**	**125 days**	**Thu 11/10/11**	**Wed 5/2/12**
9	Submit Draft of TES Memo	30 days	Thu 11/10/11	Wed 12/21/11
10	Agency Review	60 days	Thu 12/22/11	Wed 3/14/12
11	Final TES Memorandum Submitted	20 days	Thu 3/15/12	Wed 4/11/12
12	EPA Approval of TES Memorandum	15 days	Thu 4/12/12	Wed 5/2/12
13				
14	**Baseline Human Health Risk Assessment BHHRA Report**	**125 days**	**Thu 5/3/12**	**Wed 10/24/12**
15	Submit Draft of BHHRA Report	30 days	Thu 5/3/12	Wed 6/13/12
16	Agency Review	60 days	Thu 6/14/12	Wed 9/5/12
17	Final BHHRA Submitted	20 days	Thu 9/6/12	Wed 10/3/12
18	EPA Approval of BHHRA Memorandum	15 days	Thu 10/4/12	Wed 10/24/12
19				
20	**Baseline Ecological Risk Assessment (BERA) Report**	**155 days**	**Thu 11/10/11**	**Wed 6/13/12**
21	Submit Draft of BERA Report	60 days	Thu 11/10/11	Wed 2/1/12
22	Agency Review	60 days	Thu 2/2/12	Wed 4/25/12
23	Final BERA Submitted	20 days	Thu 4/26/12	Wed 5/23/12
24	EPA Approval of BERA Memorandum	15 days	Thu 5/24/12	Wed 6/13/12
25				
26	**Treatability Studies (TS)**	**14 days**	**Thu 11/10/11**	**Tue 11/29/11**
27	To be determined	14 days	Thu 11/10/11	Tue 11/29/11
28				
29	**Remedial Investigation (RI) Report**	**195 days**	**Thu 11/10/11**	**Wed 8/8/12**
30	Submit Draft of RI Report	60 days	Thu 11/10/11	Wed 2/1/12
31	Agency Review	60 days	Thu 2/2/12	Wed 4/25/12
32	Final RI Report Submitted	40 days	Thu 4/26/12	Wed 6/20/12
33	Presentation to EPA of RI Report	15 days	Thu 6/21/12	Wed 7/11/12
34	EPA Approval of RI Report	20 days	Thu 7/12/12	Wed 8/8/12
35				
36	**Remedial Alternatives Memorandum**	**125 days**	**Thu 11/10/11**	**Wed 5/2/12**
37	Submit Draft of RA Memorandum	30 days	Thu 11/10/11	Wed 12/21/11
38	Agency Review	60 days	Thu 12/22/11	Wed 3/14/12
39	Prepare Final Draft RA Report	20 days	Thu 3/15/12	Wed 4/11/12
40	EPA Approval of Final RA Report	15 days	Thu 4/12/12	Wed 5/2/12
41				
42	**Feasibility Study (FS) Report**	**260 days**	**Thu 8/9/12**	**Wed 8/7/13**
43	Submit Draft Interim Final FS Report	45 days	Thu 8/9/12	Wed 10/10/12
44	Agency Review	60 days	Thu 10/11/12	Wed 1/2/13
45	Final Interim FS Report	30 days	Thu 1/3/13	Wed 2/13/13
46	Submit Final FS Report	30 days	Thu 2/14/13	Wed 3/27/13
47	EPA Prepares "Proposed Plan"	35 days	Thu 3/28/13	Wed 5/15/13
48	EPA Accepts Public Comment on Proposed Plan	30 days	Thu 5/16/13	Wed 6/26/13
49	EPA Provides Comments to Respondents	0 days	Wed 6/26/13	Wed 6/26/13
50	Prepare Final FS Report	30 days	Thu 6/27/13	Wed 8/7/13



Project: EPAs UAO-RI Schedule after
Date: Wed 3/31/10

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

Page 1

ANCHOR QEA integral consulting inc

Figure 8-1b
Schedule of Deliverables Post Preliminary Site Characterization Report
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC