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3 April 2014

Mr. Brian Mueller
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U.S. Environmental Protection Agency (EPA) Region 6
1445 Ross Avenue, Suite 1200
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RE: Human Health Risk Assessment for AOC-5
Falcon Refinery Superfund Site
Remedial Investigation/Feasibility Study
EPA Region 6 Remedial Action Contract 2
Contract: EP-W-06-004
Task Order: 0088-RICO-06MC

Dear Mr. Mueller:

EA Engineering, Science, and Technology, Inc. (EA) is enclosing two hard copies and one electronic copy on a compact disk of the Human Health Risk Assessment for AOC-5 for the above-referenced Task Order to EPA.

If you have any questions regarding this submittal, please call me at (972) 315-3922.

Sincerely,

Robert M. Owens
Project Manager

RMO/ab

Enclosure

cc: Michael Pheeny, EPA Contracting Officer (letter only)
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TRANSMITTAL OF DOCUMENTS FOR ACCEPTANCE BY EPA		DATE: 3 April 2014	TRANSMITTAL NO.: **0016**
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7.3	Human Health Risk Assessment for AOC-5 Falcon Refinery Superfund Site Remedial Investigation/Feasibility Study	EPA - 1 electronic copy on compact disk and 2 hard copies	
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Final Human Health Risk Assessment
Area of Concern 5 (AOC-5)

Remedial Investigation/Feasibility Study

Falcon Refinery Superfund Site
Ingleside, San Patricio County, Texas
EPA Identification No. TXD086278058

Remedial Action Contract 2 Full Service
Contract: EP-W-06-004
Task Order: 0088-RICO-06MC

Prepared for

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LIST OF ACRONYMS AND ABBREVIATIONS

95UCL	Upper confidence limit on the mean
µg/L	Microgram(s) per liter
$\mu g/m^3$	Microgram(s) per cubic meter
µg/mg	Microgram(s) per milligram
ABS	Absorption factor
ADAF	Age-dependent adjustment factor
ADI	Average daily intake
AF	Adherence factor
AOC	Area of Concern
ARAR	Applicable or Relevant and Appropriate Requirements
AST	Above ground storage tank
AT	Averaging time
ATSDR	Agency for Toxic substances and Disease Registry
BW	Body weight
CF	Conversion factor
cm^2	Square centimeter(s)
cm^3	Cubic centimeter(s)
COPC	Chemical(s) of potential concern
CR	Ingestion rate
CSM	Conceptual site model
DAD	Dermal absorbed dose
DA_{event}	Dermal absorbed dose per event
DAF	Dosimetric Adjustment Factor
DFSMadj	Mutagenic dermal contact factor
EA	EA Engineering, Science, and Technology, Inc.
EC	Exposure concentration
ED	Exposure duration
EF	Exposure frequency
EPA	U.S. Environmental Protection Agency
EPC	Exposure point concentration
ERG	Environmental remedial goal
ET	Exposure time
FM	Farm-to-Market
FOD	Frequency of detection

LIST OF ACRONYMS AND ABBREVIATIONS (continued)

FS	Feasibility Study
GIABS	Gastrointestinal dermal absorption factor
HEC	Human Equivalent Concentration
HHRA	Human Health Risk Assessment
HI	Hazard index
HQ	Hazard quotient
IEUBK	Integrated Exposure Uptake Biokinetic Model
IFSMadj	Mutagenic Ingestion Rate
IRIS	Integrated Risk Information System
IUR	Inhalation Unit Risk
kg	Kilogram(s)
kg/mg	Kilogram(s) per milligram
Lazarus	Lazarus Texas Refining I, LLC
L	Liter(s)
L/day	Liter(s) per day
(L)ADI	(Lifetime) average daily intake
LEC_{10}	10 percent response level concentration
LOAEL	Lowest observed adverse effect level
MCL	Maximum contaminant level
mg/cm^2	Milligram(s) per square centimeter
mg/cm^2-event	Milligram(s) per square centimeter per event
mg/day	Milligram(s) per day
mg/kg	Milligram(s) per kilogram
mg/kg-BW/day	Milligram(s) per kilogram body weight per day
mg/kg/day	Milligram(s) per kilogram per day
mg/L	Milligram(s) per liter
mg/m^3	Milligram(s) per cubic meter
mg-year/kg-day	Milligram-year per kilogram-day
M^3/kg	Meter(s) cubed per kilogram
NCP	National Contingency Plan
NOAEL	No observed adverse effect level
NORCO	National Oil Recovery Corporation
PAH	Polycyclic aromatic hydrocarbon
PEF	Particulate emission factor

LIST OF ACRONYMS AND ABBREVIATIONS (continued)

RAGS	Risk Assessment Guidance for Superfund
RfC	Reference concentration
RfD	Reference dose
RI	Remedial Investigation
RL	Reporting limit
RME	Reasonable maximum exposure
RSL	Regional screening level
SA	Surface area
SF	Slope factor
Site	Falcon Refinery Superfund Site
UF	Uncertainty factor

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1. INTRODUCTION

The U.S. Environmental Protection Agency (EPA) has retained EA Engineering, Science, and Technology, Inc. (EA), under Remedial Action Contract No. EP-W-006-004: Task Order 0088-RICO-06MC, to conduct a human health risk assessment (HHRA) for Areas of Concern (AOCs) 4 and 5 of the Falcon Refinery Superfund Site (Site), located in Ingleside, San Patricio County, Texas. This HHRA was prepared in support of potential site closure for AOC-5 of the site.

The HHRA is an integral part of the remedial investigation (RI) process included in the Oil and Hazardous Substance National Contingency Plan (NCP) (40 Code of Federal Regulation 300.430) pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (42 U.S. Code 9605). The risk assessment estimates the potential risk and hazard to potential human receptors for exposure to media affected by past activities related to the Site.

1.1 SITE HISTORY

The Site is located 1.7 miles southeast of State Highway 361 on Farm-to-Market (FM) 2725 at the north and south corners of the intersection of FM 2725 and Bishop Road near the City of Ingleside in San Patricio County, Texas (Figure 1). The Site occupies approximately 104 acres and consists of a refinery that operated intermittently and has not produced hydrocarbon products in several years. The refinery is currently inactive, except for a crude oil storage operation being conducted by Superior Crude Gathering, Inc. When in operation the refinery had a capacity of 40,000 barrels per day and the primary products consisted of naphtha, jet fuel, kerosene, diesel, and fuel oil. The refinery also historically transferred and stored vinyl acetate, a substance not excluded under the petroleum exclusion.

The Site was proposed to the National Priorities List on September 5, 2002. The Potentially Responsible Party for the Site, National Oil Recovery Corporation (NORCO), entered into an "Administrative Order on Consent" with the EPA on 9 June 2004, to perform and finance the removal action and RI/Feasibility Study (FS) for the site.

In 2012, NORCO sold the former Falcon Refinery to Lazarus Texas Refining I, LLC (Lazarus), which operates the former refinery as a crude oil bulk storage and transfer facility. Lazarus is attempting to obtain a notice of no further action for the barge dock facility to obtain a “bridge loan” until additional funding can be obtained (TRC 2013). Lazarus plans to further develop the Site through remedial actions and upgrades.

The Site has been divided into AOCs based upon former use and location (Figure 2). AOC-1 consists of the Former Operational Units and includes the entire North Site and a drum disposal area and metal waste disposal area of the South Site. AOC-2 includes areas of the refinery that were not used for operations or storage and have no record of releases. AOC-3 encompasses the wetlands immediately adjacent to the Site that are bordered by Bay Avenue, Bishop Road, and a dam on the upstream side; wetlands located between Bishop Road, Sunray Road, Bay Avenue, and residences along Thayer Avenue; and the wetlands between Sunray Road, residences along FM 2725, Gulf Marine Fabricators, Offshore Specialty Fabricators, and the outlet of the wetlands

into Redfish Bay. Within AOC-3, there are one active and several abandoned pipelines that lead from the refinery to the barge dock facilities. During June 2006, the abandoned pipelines were cut, the contents of the pipelines were removed, and plates were welded on the pipelines. AOC-4 includes the barge docking facility. AOC-4 is approximately 0.5 acres and is located on Redfish Bay. The fenced facility, which is connected to the refinery by pipelines, is used to load and unload barges. Currently only crude oil passes through the docking facility. Historically, refined products were also loaded and unloaded. AOC-5 encompasses the sediments and surface water within the Intracoastal Waterway adjacent to the barge dock facility. AOC-6 includes the neighborhood along Thayer Road, across from the refinery. AOC-7 includes the neighborhood along Bishop Road, across from the North Site.

1.2 SITE INVESTIGATIONS

Phase I sampling was conducted at the Site in 2008 by the Potentially Responsible Parties. EA conducted Phase II investigation activities in accordance with the Field Sampling Plan (EA 2012a) and Quality Assurance Project Plan (EA 2012b) under this task order in 2013.

1.3 OBJECTIVE

The overall objective of this HHRA is to evaluate potential human health risk under current and potential future conditions at AOC-5 of the site. Specifically, the HHRA presents the following objectives:

- Outline the regulatory basis and guidance for conducting the HHRA
- Outline the methods for determining chemical(s) of potential concern (COPC) for the HHRA
- Present the exposure setting for the site that details local land use, nearby human populations, and potential site activities
- Develop a conceptual site model (CSM) that characterizes relevant contaminant pathways and receptors of concern
- Calculate potential carcinogenic and non-carcinogenic risk to receptors of concern (e.g., any human contact at the site under present or future scenarios)
- Identify areas or media that pose no unacceptable risks to human health and require no further action
- Determine COPC that contribute significantly to overall site risks, which will be used to determine risk-based preliminary remediation goals in the FS

- Provide baseline risks for the no-action alternative in the FS that are used to evaluate risk reduction for each proposed alternative.

1.4 GENERAL HUMAN HEALTH RISK ASSESSMENT APPROACH

The HHRA follows guidance as recommended by EPA. Specific application of guidance throughout the risk assessment process is detailed in Section 2 of this document. The following guidance documents were used for this HHRA:

- Risk Assessment Guidance for Superfund (RAGS), *Volume I: Human Health Evaluation Manual (Part A) (Interim Final)*, EPA/540/1-89/002 (EPA 1989)

- RAGS, Volume I: Human Health Evaluation Manual Supplemental Guidance – *Standard Default Exposure Factors* (Interim Final), Publication 9285.6-03 (EPA 1991a)

- RAGS, Volume I – Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals). EPA/540/R-92/003. December. (EPA 1991b)

- *Guidelines for Data Usability in Risk Assessment (Part A)*. Office of Solid Waste and Emergency Response, Publication OSWER9285.7-09A (EPA 1992)

- *Exposure Factors Handbook*, Volumes I, II, and III (EPA 1997a)

- RAGS, Volume I: Human Health Evaluation Manual (Part D, Standardized Planning, Reporting and Review of Superfund Risk Assessments). Office of Emergency and Remedial Response (EPA 2002a)

- *Human Health Toxicity Values in Superfund Risk Assessments*. OSWER9285.7-53. Office of Emergency and Remedial Response (EPA 2003)

- RAGS, *Volume I: Human Health Evaluation Manual (Part E: Supplemental Guidance for Dermal Risk Assessment)* Final, EPA/540/R/99/005, OSWER9285.7-02EP, Office of Superfund Remediation and Technology Innovation, July (EPA 2004)

- *Guidelines for Carcinogen Risk Assessment*. Risk Assessment Forum. EPA/630/P-03/001F (EPA 2005a)

- Supplemental Guidance for Assessing Susceptibility From Early-Life Exposure to Carcinogens. Risk Assessment Forum, EPA/630/R-03/003F (EPA 2005b)

- Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual (Part F: Supplemental Guidance for Inhalation Risk Assessment) Final. Office of Superfund Remediation and Technology Innovation, EPA-540-R-070-002 (EPA 2009a)

- *Exposure Factors Handbook*, *2011 Edition*. EPA/600/R-090/052F (EPA 2011a)

- Regional Screening Levels (RSLs) for Chemical Contaminants at Superfund Sites. Available at: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm. November (EPA 2013a).

2. HUMAN HEALTH RISK ASSESSMENT METHODOLOGY

The purpose of this HHRA is to evaluate potential human health concerns from exposure to environmental media within AOC-5 that have been affected by past activities. To determine human health concerns, the HHRA evaluates potential sources of contamination and routes of migration based on current and potential future site uses. The HHRA results are based upon potential exposure pathways that can occur or are reasonably likely to occur in the future. Risks determined in the HHRA are considered baseline risks associated with exposure to media affected by the site. The baseline risk assumes no remedial actions or other means of exposure reduction (i.e., the use of personal protective equipment, digging restrictions, etc.). The HHRA evaluates the reasonable maximum exposure (RME) that has the potential to occur at the site. Therefore, HHRA results are considered potential and should be used as a guideline in making risk management decisions.

Following EPA guidance (EPA 1989), the HHRA methodology involves a four-step process: data evaluation and hazard assessment, exposure assessment, toxicity assessment, and risk characterization. The following sections detail each step.

2.1 DATA EVALUATION AND HAZARD ASSESSMENT

In the data evaluation and hazard assessment, available environmental data were compiled and reviewed. The site environmental data are analyzed for data quality and compared to risk-based screening values. The comparison to risk-based screening values allows the HHRA to focus on analytes that may contribute significantly to overall sites risks. Analytes that are below risk-based screening values are below a level that is not considered a concern for human health and do not require further evaluation.

2.1.1 Data Included in the Human Health Risk Assessment

Initial field sampling was conducted in 2008 as a result of an EPA approved RI/FS Field Sampling Plan and Quality Assurance Plan for the former refinery, adjacent properties, and background sampling locations (TRC 2013). Analytical data obtained during the sampling was evaluated for ecological exposures, and results indicated that further sampling was necessary to adequately assess certain portions of the Site. Field activities conducted in 2013 as part of the Phase II Field Sampling Plan had objectives relating to this HHRA which included providing data to identify and delineate the extent of COPCs in environmental media, identify potential and complete exposure pathways, and provide data for completion of human health and ERAs as well as the FS. Appendix A presents the samples collected in 2008 and 2013 that were used in this risk assessment. Sample locations are presented in Figure 3.

2.1.2 Data Quality Evaluation

The inclusion or exclusion of data within the HHRA on the basis of analytical qualifiers was performed in accordance with EPA guidance (EPA 1989, 1992). The following procedures were followed if qualifiers were present:

- Analytical results bearing the U qualifier (indicating that the analyte was not detected at the given reporting limit [RL]) were retained in the data set and considered non-detects at the given RL.

- Analytical results for organic and inorganic analytes bearing the J qualifier (indicating that the reported value was estimated because the analyte was detected at a concentration below the RL or for other reasons) and L qualifier (indicating the reported value may be biased low) were retained at the reported concentration.

- Inorganic analytical results bearing the B qualifier (indicating the analyte was detected between the method detection limit and the RL) were retained at the reported concentration.

If duplicate samples were collected or duplicate analyses were conducted on a single sample, the following guidelines were employed to select the appropriate sample measurement:

- If both samples/analyses show that the analyte was present, the maximum detected concentration of the two results was retained in the dataset.

- If both samples/analyses show no detect values, the maximum of the two non-detect RLs was retained in the dataset.

- If only one sample/analysis indicated that the analyte was present, it was retained in the dataset and the non-detect value was discarded.

Laboratory quality control samples, spikes, and blanks were not included in the HHRA. The frequency of detection (FOD) is based on the number of detected concentrations out of the total number of samples. Since samples were sometimes analyzed for different sets of analytes, the total number of samples used in calculation of the FOD may vary by analyte.

2.1.3 Risk-Based Screening

Risk-based screening was conducted by comparing maximum detected analyte concentrations to risk-based screening concentrations. Any analyte in any medium for which the maximum measured concentration exceeded the risk-based screening concentration was retained as a COPC.

The EPA RSLs (EPA 2013a) were used for risk-based screening purposes in the HHRA. The EPA RSLs combine human health toxicity values with “standard” exposure scenarios to estimate analyte concentrations in environmental media that are considered by the EPA to be protective of human exposures (including sensitive populations) over a lifetime. For instance, a residential scenario assumes a standard exposure of 350 days per year over a 30-year duration. The screening values are based on specific, conservative, fixed levels of risk. For carcinogens, this is

10^{-6}, which is the lower bound for excess lifetime potential carcinogenic risk as defined by the NCP (EPA 1990). For non-carcinogens, the screening values are based on a hazard quotient of 1.0. To account for potential cumulative effects of multiple contaminants affecting the same target organ, one-tenth of the acceptable non-carcinogenic threshold was used for screening. The EPA RSL table identifies some carcinogenic contaminants where the carcinogenic RSL is greater than one-tenth the non-carcinogenic RSL (identified in the EPA RSL tables as "c^{**}"). In these instances, the more conservative one-tenth the non-carcinogenic RSL was used.

Essential nutrients (calcium, magnesium, potassium, and sodium) were eliminated from consideration on the basis of their essential nutrient status. Essential nutrients were not compared to risk-based screening values.

Ground water analytical results were compared to the EPA tap water RSL. For sediment and surface water samples, EPA RSLs are not available. The residential soil RSLs were used for sediment, and the tap water RSLs were used for surface water. Human contact with both surface water and sediment is expected at a reduced level in comparison to soil and tap water; however, the residential soil and tap water RSLs were not modified to allow for a conservative screening. Lead is identified as a non-carcinogenic compound in the EPA RSL table. However, the lead RSL was not modified by one-tenth because the lead RSL is based upon blood-lead modeling and not actual toxicity values. The maximum detected lead concentration in groundwater and surface water was compared to the EPA action level of 15 micrograms per liter (µg/L) for lead in residential and public drinking water (EPA 2009b).

For total chromium, risk-based screening values assumed trivalent chromium. Surrogate compounds were determined for detected analytes that lack specific RSL values. For example, the non-carcinogenic polycyclic aromatic hydrocarbon (PAH) pyrene was used as a surrogate for the non-carcinogenic PAH benzo(g,h,i)perylene. Surrogate compounds were identified on the basis of similarity in chemical structure and toxic properties. The example listed above demonstrates this process; a surrogate non-carcinogenic PAH was chosen to represent other non-carcinogenic PAHs that lack RSL values. Each screening table notes which surrogates were used in the screening process.

2.2 EXPOSURE ASSESSMENT

The second step of the HHRA process is the exposure assessment. In the exposure assessment, the receptors of concern and potential exposure pathways are identified. The COPC in site environmental media are converted into systemic doses, taking into account contaminant concentrations, rates of contact (e.g., ingestion rates), and absorption rates of different COPCs. The magnitude, frequency, and duration of these exposures are then integrated to obtain estimates of daily doses over a specified period of time (e.g., lifetime, activity-specific duration).

The exposure assessment includes several steps:

- Evaluating the exposure setting, including a description of the land uses and the potentially exposed human populations

- Developing the CSM identifying the source of contamination, contamination transport and release mechanisms, exposure media, exposure routes, and potentially exposed populations

- Calculating exposure point concentrations (EPCs) for each COPC for each of the complete exposure pathways identified in the CSM

- Identifying the exposure models and parameters with which to calculate the exposure doses

- Calculating exposure doses.

2.2.1 Exposure Setting

AOC-5 encompasses the sediments and surface water adjacent to the barge dock facility. The Site is bordered by wetlands to the northeast and southeast, residential areas to the north and southwest, an abandoned refinery to the northwest, and a construction company to the southwest.

AOC-5 consists of Redfish Bay adjacent to AOC-4. Redfish Bay is a saltwater waterway with "prime" fishing habitat (TPWD 2014).

The site is located in the San Antonio-Nueces Coastal Basin adjacent to Redfish Bay, which connects Corpus Christi Bay to the Gulf of Mexico. Surface water drainage from the site enters the wetlands along the southeastern section of the abandoned refinery. A culvert connects the on-site palustrine/estuarine wetlands to estuarine wetlands. The wetlands then connect to the Intracoastal Waterway and Redfish Bay. Ground water at the site is located approximately two feet below ground surface.

2.2.2 Conceptual Site Model

Based upon the site history and exposure setting, a CSM was formulated for AOC-5. The CSM presents the potential sources of contamination, routes of migration, and potential receptors. Exposure pathways begin from potential source areas and progress through the environment via various fate and transport processes to potential human receptors. Figure 4 illustrates the CSM. The CSM identifies which exposure pathways are complete and require further evaluation in the HHRA. An exposure pathway describes a mechanism by which a population or individual may be exposed to COPC migrating from the landfill. A completed exposure pathway requires the following four components:

- Source and mechanism of chemical release to the environment
- Environmental transport medium for the released chemical
- Point of potential human contact with the contaminated medium
- Human exposure route at the point of exposure.

All four components must exist for an exposure pathway to be complete and for exposure to occur. Incomplete exposure pathways do not result in actual human exposure and are not included in the exposure assessment and resulting risk characterization.

2.2.2.1 Media of Concern

Media of concern for AOC-5 include surface water and sediment. Additionally, there is a potential for chemicals in surface water to bioaccumulate in fish within Redfish Bay. Fish tissue is also a potential medium of concern for AOC-5.

2.2.2.2 Receptors of Concern

Within the exposure assessment, EPA (1989, 1991b) guidance requires that plausible exposure under both current and future land use be evaluated in the HHRA. For AOC-5, there is a possibility for recreational users to fish within Redfish Bay. There is a potential for recreational users to have limited contact with surface water and sediment while fishing. It was also assumed that watermen may access the area while fishing. It is expected that watermen will visit various areas other than Redfish Bay during a week and not spend the entire work week within AOC-5.

The following exposure pathways are identified as complete for AOC-5:

- Ingestion of and dermal contact with surface water
- Ingestion of and dermal contact with sediment
- Ingestion of fish tissue.

2.2.3 Selection of Exposure Point Concentrations

EPCs were derived to quantify concentrations of COPC. For the HHRA, the EPC represents the concentration of COPC in media of concern that a potential receptor is expected to contact over a designated exposure period. Reported concentrations of COPC were used to calculate the 95th percentile upper confidence limit on the mean (95UCL) in each medium of concern (EPA 1989, 1992). For calculation of the 95UCL, each non-detected analyte was assigned a numerical value equal to its RL (EPA 2013b). For U qualified data resulting from higher dilution levels, the result from the undiluted or initial run was included as the result.

The 95UCL was used because assuming long-term contact with the maximum concentration is not reasonable (EPA 1989). The 95UCL was determined through the EPA ProUCL program version 5.0.00 (EPA 2013b). The EPA ProUCL program determines the distribution, sample size, variance, and 95UCL of each COPC data set (EPA 2013b). The EPC is based on the lesser of the maximum detected concentration for a medium or the 95UCL (EPA 2013b). Outputs for the ProUCL program are presented in Appendix B.

2.2.4 Exposure Equations

The next step in the exposure assessment is to estimate COPC intake or exposure for each exposure pathway considered in the HHRA. In the exposure assessment, two different measures of intake are provided, depending on the nature of the effect being evaluated. When evaluating longer-term (i.e., subchronic and chronic) exposures to chemicals that produce adverse non-carcinogenic effects, intakes are averaged over the period of exposure (i.e., the averaging time [AT]) (EPA 1989). This measure of intake is referred to as the average daily intake (ADI) and is less than a lifetime exposure. For chemicals that produce carcinogenic effects, intakes are averaged over an entire lifetime and are referred to as the lifetime average daily intake ([L]ADI) (EPA 1989). Detailed equations for determining intake are provided on Tables 7 through 15.

2.2.4.1 Surface Water Intake Equations

The generic equation to calculate surface water ingestion intakes is given below:

$$LADI = \frac{EPC \ x \ CR \ x \ EF \ x \ ED}{BW \ x \ AT}$$

where

(L)ADI	=	(Lifetime) Average daily intake (milligrams per kilogram per day [mg/kg/day])
EPC	=	Concentration of a COPC in surface water (milligrams per liter [mg/L])
CR	=	Ingestion Rate (liter per day [L/day])
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kilograms [kg])
AT	=	Averaging time (days) For non-carcinogens, AT = ED × 365 days/year For carcinogens, AT = 70 years × 365 days/year.

The following equation is used to assess dermal absorbed dose (DAD) from surface water:

$$DAD = \frac{DA_{event} \ x \ SA \ x \ EF \ x \ ED \ x \ CF}{BW \ x \ AT}$$

where

CF	=	Conversion factor
DAD	=	Dermal absorbed dose (mg/kg/day)
DA_{event}	=	Dermal absorbed dose (milligrams per square centimeter per event [mg/cm^2-event])
SA	=	Skin-surface area available for contact (square centimeters [cm^2])
EF	=	Exposure frequency (days/year)

ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (days) For non-carcinogens, AT = ED × 365 days/year For carcinogens, AT = 70 years × 365 days/year.

The absorbed dose per event (DA_{event}) is estimated using a non-steady state approach for organic compounds and a steady-state approach for inorganics. For organics, the following equations apply:

$$If\ t_{event} < t^{*}\ then: DA_{event} = (2)(K_p)(FA)(C_w)(CF)\left(\sqrt{\frac{6\tau\, t_{event}}{\pi}}\right)$$

$$If\ t_{event} > t^{*}\ then: DA_{event} = (K_p)(FA)(C_w)(CF)\left(\frac{t_{event}}{1+B} + 2\tau\left[\frac{1+3B+3B^2}{(1+B)^2}\right]\right)$$

where

t_{event}	=	Event duration (hour/event)
t^*	=	Time to reach steady-state conditions (hour)
K_p	=	Permeability coefficient of water through skin (centimeters per hour)
FA	=	Chemical-specific fraction absorbed (dimensionless)
C_w	=	Chemical concentration in water (mg/L)
τ	=	Lag time (hour)
π	=	Pi (dimensionless; equal to 3.14)
CF	=	Conversion factor (0.011 liters per cubic centimeter [L/cm^3])
B	=	Dimensionless ratio of the permeability of the stratum corneum relative to permeability across the viable epidermis

For inorganics, the following steady-state equation is used to estimate DA_{event}:

$$DA_{event} = (K_p) \times (C_w) \times (t_{event})$$

A majority of the exposure assumptions for dermal contact with water are based on default assumptions presented in EPA RAGS E guidance (EPA 2004).

2.2.4.2 Fish Tissue Intake Equations

The determination of potential chemicals concentrations in fish tissue are based upon chemical concentration measured in surface water. Literature-based water-to-fish uptake factors or bioaccumulation equations are used to estimate concentrations of COPCs in fish tissue using the following equation:

$$C_{fish} = C_{surface\ water} * BAF_{fish\text{-}water}$$

where

C_{fish}	=	Concentration of chemical in fish (milligrams per kilogram [mg/kg])
C_{water}	=	Maximum detected (for screening) or 95UCL (for intake) of chemical in surface water (mg/L)
$BAF_{fish\text{-}water}$	=	Uptake factor for chemicals in fish (mg/L dry weight to mg/kg dry weight)

$$(L)ADI = \frac{EPC \ x \ CR \ x \ EF \ x \ ED}{BW \ x \ AT}$$

where

(L)ADI	=	(Lifetime) Average daily intake (mg/kg/day)
EPC	=	Concentration of a COPC in fish tissue (mg/kg)
CR	=	Ingestion Rate (kg/meal)
EF	=	Exposure frequency (meals/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (days) For non-carcinogens, AT = ED × 365 days/year For carcinogens, AT = 70 years × 365 days/year.

2.2.4.3 Soil and Sediment Intake Equations

The generic equation to calculate ingestion intake from soil is given below; note ingestion of sediment is not considered a complete exposure pathway:

$$(L)ADI = \frac{EPC \ x \ CR \ x \ EF \ x \ ED \ x \ CF}{BW \ x \ AT}$$

where

(L)ADI	=	(Lifetime) Average daily intake (mg/kg/day)
EPC	=	Concentration of a COPC in soil (mg/kg)
CR	=	Ingestion Rate (milligrams per day [mg/day])
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (days) For non-carcinogens, AT = ED × 365 days/year For carcinogens, AT = 70 years × 365 days/year
CF	=	Conversion Factor (10^{-6} kilograms per milligram [kg/mg]).

For chemicals that are considered mutagenic (described in Section 2.3.2), the generic equation to calculate ingestion intake from sediment is modified as identified below:

$$(L)ADI = \frac{EPC\ x\ IFSMadj\ x\ EF\ x\ CF}{AT}$$

where

(L)ADI	=	(Lifetime) Average daily intake (mg/kg/day)
EPC	=	Concentration of a COPC in soil (mg/kg)
IFSMadj	=	Mutagenic Ingestion Rate (CR × ED × Mutagenic adjustment factor/BW), (milligram-year per kilogram-day [mg-year/kg-day])
EF	=	Exposure frequency (days/year)
AT	=	Averaging time (days)
CF	=	Conversion Factor (10^{-6} kg/mg).

The generic equation to calculate dermal intake from soil and sediment is given below:

$$(L)ADI = \frac{EPC\ x\ SA\ x\ DA\ x\ EF\ x\ ED\ x\ CF}{BW\ x\ AT}$$

where

(L)ADI	=	(Lifetime) Average daily intake (mg/kg/day)
EPC	=	Concentration of a COPC in soil and sediment (mg/kg)
SA	=	Surface Area for Contact (square centimeter [cm^2])
DA	=	Absorbed Dose For soil DA = Absorption Factor (ABS) × Adherence Factor (AF) (mg/cm^2)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (days) For non-carcinogens, AT = ED × 365 days/year For carcinogens, AT = 70 years × 365 days/year
CF	=	Conversion Factor (10^{-6} kg/mg).

For chemicals that are considered mutagenic (described in Section 2.3.2), the generic equation to calculate dermal intake from soil and sediment is modified as identified below:

$$(L)ADI = \frac{EPC\ x\ DFSMadj\ x\ DA\ x\ EF\ x\ CF}{AT}$$

where

(L)ADI	=	(Lifetime) Average daily intake (mg/kg/day)

EPC	=	Concentration of a COPC in soil and sediment (mg/kg)
DFSMadj	=	Mutagenic Dermal Contact Factor For soil (mg-year/kg-day) = (SA × ED × AF × Mutagenic Adjustment Factor/BW)
DA	=	Absorbed Dose For soil DA = ABS (unitless)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
CF	=	Conversion Factor (10^{-6} kg/mg).

The intake of particulates and vapors/gases were calculated using the same equation (EPA 2009a):

$$EC = \frac{C_{air}\ x\ ET\ x\ EF\ x\ ED\ x\ CF_1}{AT\ x\ CF_2}$$

where

EC	=	Exposure concentration (milligrams per cubic meter [mg/m^3] or micrograms per cubic meter [µg/m^3])
C_{air}	=	Concentration of chemical in air (mg/m^3)
ET	=	Exposure time (hours)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
CF_1	=	Conversion Factor (1,000 micrograms per milligram [µg/mg]) (carcinogenic intakes only)
CF_2	=	Conversion Factor (24 hours/day)
AT	=	Averaging time (days) For non-carcinogens, AT = ED x 365 days/yr For carcinogens, AT = 70 years x 365 days/yr

The concentration of chemicals in air resulting from emissions from soil is developed following procedures presented in the EPA Soil Screening guidance (EPA 2002c). The chemical concentration in air is calculated from:

$$C_{air} = C_{soil}\ x \left[\frac{1}{PEF} \right]$$

where

C_{air}	=	Concentration of chemical in air (mg/m^3)
C_{soil}	=	Chemical concentration in soil (mg/kg)
PEF	=	Particulate emission factor (cubic meter per kilogram [m^3/kg])

The PEF relates the concentration of a chemical in soil with the concentration of dust particles in air. For residential exposures, a PEF value of $2.78x10^9$ is used based a 1.7 acre site and using EPA guidance values for Houston, TX (EPA 2002). For a construction worker, the PEF is based upon potential construction that may occur at the site. The PEF was calculated based upon excavation, grading, and tilling at the site which results in a PEF from other than vehicle traffic (EPA 2013a).

2.2.5 Selection of Exposure Parameters

The second step in quantifying intake requires the identification of exposure parameters. Exposure parameters include rates of contact (e.g., ingestion rates, skin surface areas, etc.), EF and duration, BW, and averaging time. The contact rate reflects the amount of contaminated media contacted per unit time or event. EF and duration are used to estimate the total time of exposure to COPC in media of concern. The BW represents the average BW over an exposure period (EPA 1989). Specific exposure parameters for each receptor are chosen based on EPA guidance (EPA 1989, 1991a, 1991b, 1997a, 2004, 2011a, and 2013a) and other appropriate resources. Exposure parameters specific to AOC-5 are discussed in Section 3.

2.3 TOXICITY ASSESSMENT

Toxicity assessment is the third step of the HHRA process. The toxicity assessment considers the types of potential adverse health effects associated with exposures to COPC, the relationship between the magnitude of exposure and potential adverse effects, and related uncertainties, such as the weight of evidence of a particular COPC carcinogenicity in humans. EPA guidance (EPA 1989) specifies that the assessment be accomplished in two steps: hazard identification and dose-response assessment. Hazard identification is the process of determining whether studies demonstrate that exposure to a COPC may cause the incidence of an adverse effect. EPA specifies the dose-response assessment, which involves: (1) EPA's quantitative evaluation of the existing toxicity information, and (2) EPA's characterization of the relationship between the dose of the COPC administered or received, and the incidence of potentially adverse health effects in the exposed population. From this quantitative dose-response relationship, specific toxicity values are derived by EPA that can be used to estimate the incidence of potentially adverse effects occurring in humans at different exposure levels (EPA 1989).

Toxicity values were selected in keeping with appropriate exposure durations and EPA guidance (EPA 2003). Tier 1 values were found using the Integrated Risk Information System (IRIS) (EPA 2014) for established, current values. When toxicity values were not available from IRIS, Tier 2 values were then examined.

Tier 2 values were EPA's Provisional Peer Reviewed Toxicity Values, which are developed by the Office of Research and Development, the National Center for Environmental Assessment, and the Superfund Health Risk Technical Support Center on a chemical-specific basis when requested by the Superfund program.

Tier 3, other toxicity values, were considered when Tier 1 or Tier 2 toxicity values were not available. These toxicity values were taken from additional EPA and non-EPA sources and were chosen based on the most current and best peer-reviewed source available. The California EPA Office of Environmental Health Hazard Assessment Toxicity Criteria Database (California Environmental Protection Agency 2014), California EPA Cancer Potency Values (California Environmental Protection Agency 2009), and the Health Effects Assessment Summary Tables (EPA 1997b) are the Tier 3 sources utilized for this HHRA.

2.3.1 Toxicity Assessment for Non-Carcinogens

The methodology used by EPA for deriving non-cancer reference values for non-carcinogens, and site-specific considerations for modifying or using these concentrations are discussed in detail in Barnes and Dourson (1988) and EPA guidance (EPA 2014). Non-carcinogens are typically judged to have a threshold daily dose below which deleterious or harmful effects are unlikely to occur. This concentration is called the no-observed-adverse-effect-level (NOAEL), and may be derived from either animal laboratory experiments or human epidemiology investigations (usually workplace studies). In developing a toxicity value or human NOAEL for non-carcinogens (i.e., a reference dose [RfD]), the regulatory approach is to (1) identify the critical toxic effect associated with chemical exposure (i.e., the most sensitive adverse effect); (2) identify the threshold dose in either an animal or human study; and (3) modify this dose to account for interspecies variability (where appropriate), differences in individual sensitivity (within-species variability), and other uncertainty and modifying factors. For the Reference Concentrations (RfCs), experimental exposures are extrapolated to a Human Equivalent Concentration (HEC). The HEC is determined through a two-step process that begins with a point of departure, which is adjusted (multiplied) by a Dosimetric Adjustment Factor (DAF) (EPA 2009a). The point of departure can represent a NOAEL, lowest-observed-adverse-effect-level (LOAEL), benchmark concentration, lower confidence limit, and the lower limit on an effective concentration using a 10 percent response level (LEC_{10}). The DAF is for the specific site of the chemical's effects (e.g., respiratory tract, etc.). The DAF is dependent upon the nature of the contaminant and the target site of the toxic effect.

Uncertainty factors (UFs) are intended to account for specific types of uncertainty inherent in extrapolation from the available data. The UFs are generally 10-fold, default factors used in operationally deriving the RfD and RfC from experimental data. UFs less than 10 can be used. A UF of 3 can be used in place of one-half power ($10^{0.5}$) when appropriate. The UFs are intended to account for (1) variation in susceptibility among the members of the human population (i.e., inter-individual or intraspecies variability), (2) uncertainty in extrapolating animal data to humans (i.e., interspecies uncertainty), (3) uncertainty in extrapolating from data obtained in a study with less-than-lifetime exposure (i.e., extrapolating from subchronic to chronic exposure), (4) uncertainty in extrapolating from a LOAEL rather than from an NOAEL, and (5) uncertainty associated with extrapolation when the database is incomplete. The maximum UF for the derivation of the RfCs used in this HHRA is 3,000. The maximum UF for the derivation of the RfDs used in this HHRA is 3,000. To calculate the RfD, the appropriate NOAEL is divided by the product of all the applicable UFs. This is expressed as:

$$RfD = NOAEL / (UF_1 \times UF_2 \times UF_3 \times UF_4)$$

The resulting RfD is expressed in units of milligrams of chemical per kilogram of body weight per day (mg/kg-BW/day). To calculate the RfC, the HEC is divided by UFs and is expressed in units of mg/m^3.

2.3.2 Toxicity Assessment for Carcinogenicity

Unlike non-carcinogens, carcinogens are generally assumed to have no threshold. There is presumed to be no level of exposure below which carcinogenic effects will not manifest themselves. This "non-threshold" concept supports the idea that there are small, finite probabilities of inducing a carcinogenic response associated with every level of exposure to a potential carcinogen. EPA uses a two-part evaluation for carcinogenic effects. This evaluation includes the assignment of a weight-of-evidence classification and the quantification of a cancer toxic potency concentration. Quantification is expressed as a slope factor (SF) for oral and dermal exposures and an Inhalation Unit Risk (IUR) for inhalation exposures, which reflects the dose-response data for the carcinogenic endpoint(s) (EPA 1989, 2009a).

The weight-of-evidence classification system assigns a letter or alphanumeric (A through E) to each potential carcinogen that reflects an assessment of its potential to be a human carcinogen (EPA 1986).[1] The EPA has established five recommended standard hazard descriptors: "*Carcinogenic to Humans*," "*Likely to Be Carcinogenic to Humans*," "*Suggestive Evidence of Carcinogenic Potential*," "*Inadequate Information to Assess Carcinogenic Potential*," and "*Not Likely to Be Carcinogenic to Humans*" (EPA 2005a). The weight-of-evidence classification is based on a thorough scientific examination of the body of available data. Only compounds that have a weight-of-evidence classification of C or above are considered to have carcinogenic potential in this HHRA.

The SF and the IUR are the upper 95th percentile confidence limit of the probability of response per unit daily intake of a chemical over a lifetime. The SF is expressed in units of proportion (of a population) affected per mg/kg/day. The IUR is expressed in $\mu g/m^3$. Typically, the SF and the IUR are used to estimate the upper-bound lifetime probability of a person developing cancer from exposure to a given concentration of a carcinogen. SFs and IURs are generally based on experimental animal data, unless suitable epidemiological studies are available. Because of the difficulty in detecting and measuring carcinogenic endpoints at low exposure concentrations, SFs and IURs are typically developed by using a model to fit the available high dose, experimental animal data, and then extrapolating downward to the low-dose range to which humans are typically exposed. EPA recommends the linear multistage model to derive an SF and IUR. The model is conservative and provides an upper bound estimate of excess lifetime cancer risk.

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[1]A = A known human carcinogen; B1 = A probable human carcinogen, based on sufficient animal data and limited human data; B2 = A probable human carcinogen based on sufficient animal data and inadequate or no human data; C = A possible human carcinogen; D = Not classifiable as to human carcinogenicity; and E = Evidence of non-carcinogenicity for humans.

These methods and approaches are discussed in greater detail within the EPA *Cancer Guidelines* (EPA 2005a).

Carcinogenic compounds were also assessed for mutagenic modes of action. The mutagenic mode of action is assessed with a linear approach (EPA 2005b). Benz(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene are the COPCs that have been identified with a mutagenic mode of action. COPCs identified as mutagenic have sensitivity pertaining to cancer risks associated with early-life exposures. To account for the early-life exposure and the mutagenic mode of action, the cancer potency estimates are adjusted by an age-dependent adjustment factor (ADAF). The EPA recommends, for mutagenic chemicals, when no chemical-specific data exist, a default approach using estimates from chronic studies (i.e., cancer slope factors) with appropriate modifications to address the potential for differential risk of early life stage exposure (EPA 2005a,b). An ADAF modification for early life stage exposure to mutagenic COPC is required because available studies indicate higher cancer risks resulting from a given exposure occurring early in life when compared with the same amount of exposure during adulthood (EPA 2005b). For this HHRA, the intakes for COPC identified with a mutagenic mode of action are modified by an ADAF for the following (EPA 2005b, 2014):

- For exposures before 2 years of age (i.e., spanning a 2-year time interval from the first day of birth up until a child's second birthday), a 10-fold adjustment.

- For exposures between 2 and <16 years of age (i.e., spanning a 14-year time interval from a child's second birthday up until their sixteenth birthday), a 3-fold adjustment.

- For exposures after turning 16 years of age, no adjustment.

For this HHRA, the resident is within the age range that requires adjustment for a mutagenic mode of action. Two age groups are considered for the residential scenario, an adult and a child. The age group for the child is assumed at 0-6 years. The resident adult is evaluated from an age range of 7-30 years old (EPA 1991b). Although adults are typically assumed at an age range of greater than 16 years of age, the resident adult is evaluated for a long-term exposure typical of residents (EPA 1991b). Residents are typically assumed at a duration of 30 years, so the resident adult spans that 7-30 years beyond childhood (EPA 1991a). Therefore, both the resident child and the resident adult require an adjustment for potential mutagenic modes of action.

2.3.3 Toxicity Assessment Modification for Dermal Contact

Toxicity values specific to dermal exposures are not available and require adjustment of the oral toxicity values (oral RfDs or SFs). This adjustment accounts for the difference between the daily intake dose through dermal contact as opposed to ingestion. Most toxicity values are based on the actual administered dose and must be corrected for the percent of chemical-specific absorption that occurs across the gastrointestinal tract prior to use in dermal contact risk assessment (EPA 1989, 2004). EPA recommends utilizing oral absorption efficiency factors in

converting oral toxicity values to dermal toxicity values (EPA 2004). This adjustment accounts for the absorption efficiency in the "critical study," which is utilized in determining the RfD and SF. Where oral absorption in the critical study is essentially complete (i.e., 100 percent), the absorbed dose is equivalent to the administered dose, and no adjustment of oral toxicity values is necessary when evaluating dermal exposures. When gastrointestinal absorption of a chemical in the critical study is poor (e.g., 1 percent), the absorbed dose is much smaller than the administered dose, and toxicity values for dermal exposure are adjusted to account for the difference in the absorbed dose relative to the administered dose. To account for the differences between the administered (oral) and the absorbed (dermal) dose, RfDs and SFs are modified by the gastrointestinal dermal absorption factor (GIABS).

In addition to the GIABS modification of the toxicity values for dermal contact, dermal contact rates are also evaluated based upon a chemical's ability to be absorbed through the skin surface. This absorption rate is dependent upon the medium evaluated. For sediment, the EPA recommends following the same approach used for soil (EPA 2004). For soil and sediment, the EPA has identified a dermal absorption factor (ABS) that is chemical-specific. The ABS value reflects the desorption of a chemical from soil and the absorption of the chemical across the skin and into the blood stream. Recommended values are presented that take into account ranges of values that result from different soil types, loading rates, chemical concentrations, and other conditions. Values specific to sediment are not available. The EPA recommends the use of soil ABS values for sediment (EPA 2004).

2.4 RISK CHARACTERIZATION

Risk characterization is the fourth step of the HHRA process. In this step, the toxicity values are combined with the calculated chemical intakes for the receptor populations to quantitatively estimate both carcinogenic and non-carcinogenic risks. Risks were calculated for each receptor of concern.

2.4.1 Hazard Index for Non-Carcinogenic Effects

The potential human health risks associated with exposures to non-carcinogenic COPC are calculated by comparing the ADI or the EC with the chemical-specific RfD or RfC, as per EPA Guidance (EPA 1989, 2009a). A hazard quotient (HQ) is derived for each COPC, as shown in the equation below:

$$HQ = \frac{ADI}{RfD} \quad \text{or} \quad HQ = \frac{EC}{RfC}$$

where

HQ	=	Hazard Quotient; ratio of average daily intake level to acceptable daily intake level (unitless)
ADI	=	Calculated non-carcinogenic average daily intake (mg/kg/day or mg/m^3)

EC	=	Exposure Concentration (mg/m^3)
RfD	=	Reference dose (mg/kg/day)
RfC	=	Reference concentration (mg/m^3).

If the average daily dose exceeds the RfD or RfC, the HQ will exceed a ratio of one (1.0) and there may be concern that potential adverse systemic health effects will be observed in the exposed populations. If the ADI does not exceed the RfD or the RfC, the HQ will not exceed 1.0 and there will be no concern that potential adverse systemic health effects will be observed in the exposed populations. However, if the sum of several HQs exceeds 1.0, and the COPC affect the same target organ, there may be concern that potential adverse systemic health effects will be observed in the exposed populations. In general, the greater the value of the HQ above 1.0, the greater the level of concern. However, the HQ does not represent a statistical probability that an adverse health effect will occur.

For consideration of exposures to more than one chemical causing systemic toxicity via several different pathways, the individual HQs are summed to provide an overall hazard index (HI). If the HI is less than 1.0, then no adverse health effects are likely to be associated with exposures at the site. However, if the total HI is greater than 1.0, separate endpoint-specific HIs may be calculated based on toxic endpoint of concern or target organ (e.g., HQs for neurotoxins are summed separately from HQs for renal toxins). Only if an endpoint-specific HI is greater than 1.0 is there reason for concern about potential health effects for that endpoint.

2.4.2 Carcinogenic Risks

Carcinogenic risk is calculated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen. The numerical estimate of excess lifetime cancer risk is calculated by multiplying the (L)ADI by the risk per unit dose (the SF) or multiplying the EC by the IUR.

This is shown in the following equation:

$$Risk = (L)ADI \times SF$$
$$Risk = EC \times IUR$$

where

Risk	=	Unitless probability of an exposed individual developing cancer
(L)ADI	=	Lifetime cancer average daily intake (mg/kg/day)
EC	=	Exposure Concentration ($\mu g/m^3$)
SF	=	Cancer slope factor $(mg/kg/day)^{-1}$
IUR	=	Inhalation Unit Risk $(\mu g/m^3)^{-1}$.

Because the SF and the IUR are the statistical 95th percent upper-bound confidence limit on the dose-response slope, this method provides a conservative, upper-bound estimate of risk. It

should be noted that the interpretation of the significance of the cancer risk estimate is based on the appropriate public policy. EPA in the NCP (40 Code of Federal Regulation Part 300) (EPA 1990) states that:

> *...For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6}.*

3. AOC-5, REDFISH BAY HHRA

3.1 DATA EVALUATION AND HAZARD ASSESSMENT

Sample locations evaluated for AOC-5 are presented in Appendix A. Risk-based screening, as discussed in Section 2.1.3, was conducted to determine COPCs for AOC-5.

3.1.1 Analytes Exceeding Risk-Based Screening Levels

The occurrence, distribution, and selection of COPCs at the site are represented in Tables 1 through 3 following the RAGS D format (EPA 2002a). The tables present the minimum and maximum detected concentrations, the location of the maximum detected concentrations as well as frequency of detection for each chemical detected. Analytes that exceeded the screening criteria and are considered COPCs are presented in bold type and highlighted.

3.1.1.1 COPCs in Sediment

The following COPCs in sediment (Table 1) were identified based on the modified residential soil RSL risk-based screen: arsenic, hexavalent chromium, and benzo(a)pyrene.

3.1.1.2 COPCs in Surface Water

The following COPCs in surface water (Table 2) were identified based on the modified tap water RSL risk-based screen: selenium and thallium.

3.1.1.3 COPCs in Fish Tissue

The following COPCs in fish (Table 3) were identified based on the fish tissue RSL risk-based screen: copper, selenium, thallium, and bis(2-ethylhexyl)phthalate.

3.2 EXPOSURE ASSESSMENT

Media evaluated for AOC-5 includes sediment, surface water, and fish tissue. EPCs were calculated in accordance with Section 2.2.3. ProUCL outputs for the determination of EPCs are provided for each COPC in Appendix B. The results of the EPC selection are summarized in Tables 4 through 6, including the rationale for EPC selection.

Receptors evaluated for AOC-5 include adult and adolescent recreational user and waterman. A CSM presenting pathways that were considered is provided in Figure 4. Exposure parameters and equations for each receptor and pathway are presented in medium-specific Tables 7 through 15.

As part of the exposure assessment, the determination of intake requires the identification of exposure parameters. Exposure parameters include rates of contact (e.g., ingestion rates, skin surface areas, etc.), EF, duration, BW, and averaging time. The contact rate reflects the amount

of contaminated media contacted per unit time or event. EF and duration are used to estimate the total time of exposure to COPCs in media of concern. The BW represents the average BW over an exposure period (EPA 1989). Specific exposure parameters for each receptor are chosen based on EPA guidance (EPA 1989, 1991a, 1991b, 1997a, 2004, 2011, and 2013a).

Surface Water

The exposure to surface water for the recreational user assumes a swimming scenario. The offshore area near the site is not considered a high use area for swimming or other water activities. Additionally, other public access areas are located near but not immediately adjacent to the site that present a more attractive area for swimming and other water activities. However, access is not controlled to the waters; therefore, swimming is a possibility for this area. Swimming and other water activities are assumed on a limited basis.

During swimming, a recreational user will have dermal (skin) contact with surface water and ingest very small amounts of surface water. Any ingestion is expected to be incidental due to the brackish nature of the water. Incidental ingestion is assumed at 1/100th of the EPA default drinking water rates (Agency for Toxic Substances and Disease Registry [ATSDR] 2003). The incidental ingestion rate is therefore 0.02 liter/day for the adult and 0.01 liter/day for the adolescent recreational users (ASTDR 2003). The recommended SA for adult is 18,000 cm^2, based on the mean surface area for the total body (EPA 2004). For the adolescent, the mean total body area is 15,900 cm^2 for 12 to16 years of age and 10,800 cm^2 for 6 to 11 years. An average of the two age ranges yields a body SA of 13,350 cm^2 for the adolescent aged 6 to 16 years (EPA 2011).

An EF of 4 days per year is used. It is also estimated that recreational users swim for two hours a day. The swim time takes into account that boaters are primarily on the water from noon to 5:00 p.m. with 2 hours of that time spent swimming or in the water.

For the watermen, exposure to surface water is likely limited to the hands and arms (forearms and upper arms). The mean arm SA (2,910 cm^2) combined with the mean hand SA (990 cm^2) results in an SA of 3,900 cm^2 for watermen (EPA 2011). It is expected that watermen would not fish exclusively within the area of AOC-5, but instead would fish near AOC-5 one day per week for 52 weeks. Watermen are expected to contact surface water for 2 hours a day. This assumes that watermen will perform other activities (i.e., driving the boat, fixing nets, etc.) that will result in less frequent direct water contact than a typical 8 to 10 hour day.

Sediment

Due to the depth of surface water, recreational users are expected to contact sediment primarily with the feet and maybe lower legs. For the adult, the sum of the mean lower legs SA (2,560 cm^2) and mean feet (1,310 cm^2) is 3,870 cm^2 (EPA 2011). For the adolescent, lower leg estimates are not available in EPA guidance (EPA 2004, 2011). Therefore, the SA identified for the adult is used for the adolescent as a conservative measure. For skin exposure to sediment, an AF is determined that represents the ability of sediment to adhere to the skin surface

(EPA 2004). AFs for sediments are likely to be less than for soils because contact with water may wash the sediment off the skin (EPA 2004). However, AFs for soil are used to represent the sediment AFs as a protective measure. For the adult recreational user, the recommended weighted AF for an adult resident is used (0.07 mg/cm^2) as a conservative measure. The recommended weighted AF for a child recreational user is 0.2 mg/cm^2 for children playing in wet soil (EPA 2004). The adolescent is conservatively estimated with the same AF as the child.

Watermen contact with sediment is limited to the hands and forearms as contact to sediment is expected to occur while hauling fishing nets into boats. The mean arm SA (2,910 cm^2) and mean hand SA (990 cm^2) sum is 3,900 cm^2. The recommended AF for a commercial or industrial worker contact with soil is 0.2 mg/cm^2, based upon actual body parts exposed (face, forearms, and hands) and high-end contact activity (EPA 2004). This worker AF is conservatively assumed for watermen.

The EF for contact with sediment is assumed at the same number of days per year as surface water.

Fish Ingestion

Ingestion rates for the recreational user are taken from EPA guidance (2011). Table 10-62 of EPA Exposure Factors Handbook identifies the number of meals and portion sizes of self-caught fish consumed by recreational anglers in Lavaca Bay, Texas. Lavaca Bay is approximately 70 miles from Redfish Bay and is a similar waterbody. The portion size for an adult male, based upon the 95UCL, is 8.2 ounces, which equals 0.232 kg. The number of meals for the adult male is 3.5 meals per month. It is assumed that fishing will occur throughout the year for a total of 42 meals/year. The portion size for youths (6 to 19 years) is 6.9 ounces or 0.196 kg. The number of meals for the youth is 2.7 meals per months for a total of 32 meals/year.

The intake rate identified for the adult recreational user is also used for the watermen, since the watermen are not expected to fish exclusively near the site. The EF identified for the surface water and sediment pathways is used as the number of meals per year (52 meals per year) of fish.

3.3 TOXICITY ASSESSMENT

EPA-derived toxicity values for evaluating potential chronic non-carcinogenic effects for COPCs are summarized in Tables 16 and 17. Toxicity information presented in these tables includes the following EPA-provided/derived information: chronic RfD or RfC values for exposures via the oral and inhalation pathway; reported target organs, uncertainty, and modifying factors specific to the EPA-derived RfD or RfC; and the scientific source of the information. The toxicity values presented by EPA for thallium are provisional values (EPA 2012). The studies utilized in determining a RfD are of low quality and result in high uncertainty factors that the EPA considers unreliable. Therefore, the RfD presented for thallium is only to be used for screening purposes (EPA2012). The maximum concentrations of thallium in surface water and fish tissue are above the risk-based screening criteria. However, thallium is not evaluated quantitatively in the risk calculations for these media. Thallium is evaluated qualitatively in Section 5.4.

Table 18 presents relative chemical-specific parameters utilized in calculating dermal exposure for COPCs.

EPA-derived toxicity values for evaluating potential carcinogenic effects for COPCs are summarized in Tables 19 and 20. Toxicity information presented in these tables includes the following EPA-provided/derived information: a chemical-specific SF or IUR (cancer potency factor) for exposures via the oral and inhalation pathway; EPA's weight-of-evidence cancer classification; and the source of the information.

3.4 RISK CHARACTERIZATION

The methodologies used to quantify carcinogenic risks and chronic hazards for non-carcinogens are described further in Section 2.2. Calculations are presented by receptor in Tables 21 through 23. Estimates of cumulative risks across all pathways for non-carcinogenic and carcinogenic effects for all receptors are presented in Tables 24 through 26. If cumulative non-carcinogenic hazards are greater than 1.0, a breakdown by target organ is provided.

3.4.1 Recreational User

Calculations for the adult recreational user are presented in Table 21. Estimates of cumulative risks across all pathways for non-carcinogenic and carcinogenic effects are presented in Table 24. The total non-carcinogenic HI for the adult recreational user is 2, which is above the acceptable threshold of 1.0 (Table 24). Selenium in fish tissue is the only COPC with an HQ greater than 1. Carcinogenic risk for the adult recreational user is 3×10^{-6}, which is within the EPA acceptable risk range (Table 24).

Calculations for the adolescent recreational user are presented in Table 22. Estimates of cumulative risks across all pathways for non-carcinogenic and carcinogenic effects are presented in Table 25. The total non-carcinogenic HI for the adolescent recreational user is 2, which is above the acceptable threshold of 1.0 (Table 25). Selenium in fish tissue is the only COPC with an HQ greater than 1. Carcinogenic risk for the adolescent recreational user is 1×10^{-6}, which is within the EPA acceptable risk range (Table 25).

3.4.2 Watermen

Calculations for the watermen are presented in Table 23. Estimates of cumulative risks across all pathways for non-carcinogenic and carcinogenic effects are presented in Table 26. The total non-carcinogenic HI for the watermen is 2, which is above the acceptable threshold of 1.0 (Table 26). The carcinogenic risk for the watermen is 5×10^{-6} (Table 26), which is within the EPA's target risk range.

3.5 AOC-5 CONCLUSIONS

The AOC-5 HHRA evaluated potential cumulative risks for the adult recreational user, adolescent recreational user, watermen exposure to surface water, sediment, and fish tissue within Redfish Bay adjacent to the site. Non-carcinogenic hazards exceeded 1.0 for all of the receptors evaluated. Selenium in fish tissue was the only contributor to the non-carcinogenic hazards exceedance. It is noted that the concentrations of all chemicals in fish tissue are modeled based upon surface water concentrations; therefore, these results are not actual, measured concentrations. Background surface water samples were collected from Redfish Bay for comparison to the AOC-5 results. Selenium was only detected in 1 of 11 background surface water samples. As a result, a comparison to background concentrations cannot be completed.

Carcinogenic risks for all receptors evaluated are within EPA's "acceptable risk range."

4. RISK ASSESSMENT UNCERTAINTY

There are numerous uncertainties involved in the HHRA process. These are discussed briefly in the following sections.

4.1 SAMPLING AND ANALYSIS UNCERTAINTIES

The sampling plan can have a significant impact on the results obtained in calculating human health risks at a site. There are uncertainties associated with the data set used in the HHRA. In particular, surface water is a fluid medium and chemical concentrations may vary spatially and temporally. Uncertainty due to spatial and temporal variability is especially relevant to surface water results because surface water is subject to mixing and variable upstream input.

There is also uncertainty associated with the concentrations of metals detected in the surface water samples from the investigation area. All of the surface water data included in the quantitative risk calculations were from unfiltered samples. As a result, the concentration of metals detected in surface water samples very likely include metals that are sorbed to suspended particulate matter (sediment). These sorbed metals are less available for uptake by receptors of concern. Therefore, the detected concentrations may not be representative of the amount of bioavailable metals, and the use of these water pathway data could overestimate the potential for risk from surface water related to metals.

4.2 UNCERTAINTIES ANALYSIS OF EXPOSURE ASSESSMENT

An analysis of uncertainties is an important aspect of the exposure assessment. It provides the risk assessor and reviewer with information relevant to the individual uncertainties associated with exposure factor assumptions and their potential impact on the final assessment. Exposure is evaluated only within the AOC boundaries.

For AOC-5, the assumption that fishing and swimming occur with a long-term regularity in the offshore environment of this industrialized area is conservative. Additionally, surface water and sediment, and to an extent fish tissue, are only evaluated within the confines of AOC-5. Most exposures within Redfish Bay would occur within an area larger than AOC-5. Therefore, potential exposures evaluated for AOC-5 are conservative and risk results may be overestimated.

The only exceedance of acceptable risk thresholds for AOC-5 was the ingestion of fish tissue. Selenium in fish tissue resulted in potential non-carcinogenic hazards greater than the acceptable threshold of 1. This exceedance is highly dependent upon the intake calculated for fish tissue. Two exposure parameters used in determining fish tissue intake that are highly variable are the BAF, for determining uptake from surface water to fish tissue, and the number of meals per year. The BAF is a modeled value that does not necessarily represent actual fish tissue concentrations, only an estimation. Therefore, actual fish tissue concentrations could be significantly different.

The number of meals for fish ingestion was taken from a study performed near the site. The Texas Saltwater Angler Survey was conducted in 1996/1997 to evaluate the quantity and species

of finfish and shellfish consumed by individuals who fish at Lavaca Bay (EPA 2011). The survey included both telephone interviews and mail surveys. It was noted, "The study authors noted that because the survey relied on the anglers' recall of meal frequency and portion, fish consumption may have been overestimated. There was evidence of overestimation when the data were validated, and approximately 10 percent of anglers reported consuming more fish than what they caught and kept (EPA 2011)." Based upon the use of the BAF for the determination of chemical concentrations in fish tissue and the overestimation of fish consumption, the risk results for the ingestion of fish tissue pathway are most likely overestimated.

4.2.1 Dermal Exposures

Dermal contact rates for COPC in soil and sediment are evaluated based upon a chemical's ability to be absorbed through the skin surface. The EPA has identified a dermal ABS that reflects the desorption of a chemical from soil and the absorption of the chemical across the skin and into the blood stream. For sediment, the EPA recommends using the soil ABS values. ABS values are not available for most inorganics in EPA RAGS E guidance (EPA 2004). Dermal contact with skin is expected to be a significant exposure, especially for children. However, inorganics are often not well-absorbed through the skin. It is difficult to estimate the effects of generic ABS values on risk results. The absorption of inorganics is primarily a concern if skin is occluded (EPA 1995). However, non-occluded skin is not expected to have absorption. Therefore, risks determined for the dermal contact exposure pathway are most likely overestimated.

4.3 UNCERTAINTIES OF TOXICITY ASSESSMENT

There are numerous uncertainties associated with the toxicity assessment. These are generally due to the unavailability of data to thoroughly calculate the toxicity of COPC. These uncertainties are described in more detail in the following sections.

4.3.1 Uncertainties Associated with Non-Carcinogenic Effects

4.3.1.1 Interspecies Extrapolation

The majority of toxicological information comes from experiments with laboratory animals. Experimental animal data have been relied on by regulatory agencies to assess the hazards of chemical exposures to humans. Interspecies differences in chemical absorption, metabolism, excretion, and toxic response are not well understood; therefore, conservative assumptions are applied to animal data when extrapolating to humans. These probably result in an overestimation of toxicity.

4.3.1.2 Intraspecies Extrapolation

Differences in individual human susceptibilities to the effects of chemical exposures may be caused by such variables as genetic factors (e.g., glucose-6-phosphate dehydrogenase deficiency), lifestyle (e.g., cigarette smoking and alcohol consumption), age, hormonal status (e.g., pregnancy), and disease. To take into account the diversity of human populations and their

differing susceptibilities to chemically induced injury or disease, a safety factor is used. EPA uses a factor between 1 and 10. This uncertainty may lead to overestimates of human health effects at given doses.

4.3.2 Exposure Routes

When experimental data available on one route of administration are different from the actual route of exposure that is of interest, route-to-route extrapolation must be performed before the risk can be assessed. Several criteria must be satisfied before route-to-route extrapolation can be undertaken. The most critical assumption is that a chemical injures the same organ(s) regardless of route, even though the injury can vary in degree. Another assumption is that the behavior of a substance in the body is similar by all routes of contact. This may not be the case when, for example, materials absorbed via the gastrointestinal tract pass through the liver prior to reaching the systemic circulation, whereas by inhalation the same chemical will reach other organs before the liver. However, when data are limited, these extrapolations are made and may result in overestimates of human toxicity.

4.3.3 Uncertainties Associated with Carcinogenic Effects

4.3.3.1 Interspecies Extrapolation

The majority of toxicological information for carcinogenic assessments comes from experiments with laboratory animals. There is uncertainty about whether animal carcinogens are also carcinogenic in humans. While many chemical substances are carcinogenic in one or more animal species, only a very small number of chemical substances are known to be human carcinogens. The fact that some chemicals are carcinogenic in some animal species, but not in others, raises the possibility that not all animal carcinogens are human carcinogens. Regulatory agencies assume that humans are as sensitive to carcinogens as the most sensitive animal species. This policy decision, designed to prevent underestimation of risk, introduces the potential to overestimate carcinogenic risk.

4.3.3.2 High-Dose to Low-Dose Extrapolation

Typical cancer bioassays provide limited low-dose data on responses in experimental animals for chemicals being assessed for carcinogenic or chronic effects. The usual dose regime involves three dose groups per assay. The first dose group is given the highest dose that can be tolerated, the second is exposed to one-half that dose, and the third group is unexposed (control group) (National Research Council 1983). Because this dosing method does not reflect how animals would react to much lower doses of a chemical, a dose-response assessment normally requires extrapolation from high to low doses using mathematical modeling that incorporates to varying degrees information about physiologic processes in the body (National Research Council 1983).

A central problem with the low-dose extrapolation models is that they often fit the data from animal bioassays equally well, and it is not possible to determine their validity based on goodness of fit. Several models may fit experimental data equally well, but all may not be

equally plausible biologically. The dose-response curves derived from different models diverge substantially in the dose range of interest (National Research Council 1983). Therefore, low-dose extrapolation is more than a curve-fitting process, and considerations of biological plausibility of the models must be taken into account before choosing the best model for a particular set of data.

4.3.4 Modification for Mutagenic Compounds

Carcinogenic slope factors for compounds identified with a mutagenic mode of action for early-life exposure are modified by a default adjustment factor. The default adjustment factors are used because chemical-specific data are not available to directly assess cancer susceptibility from early-life exposure to a carcinogen acting through a mutagenic mode of action. The default adjustment factors are derived from a weighted geometric mean tumor incidence ratio. Therefore, the use of the default adjustment factors may both over-estimate and under-estimate the potential potency for early-life exposure for chemicals with a mutagenic mode of action for carcinogenesis (EPA 2005b). However, the analysis of potential exposure over a lifetime reduces the effects and uncertainty of the mutagenic adjustments on estimated lifetime cancer risk. Carcinogenic risks for receptors identified within the early-life exposure age range are determined based upon a lifetime exposure. The resulting uncertainty in the use of the mutagenic default adjustment factors is reduced but some uncertainty still remains in the use of default factors over a specified age range rather than chemical-specific data.

4.4 CHEMICALS NOT ASSESSED IN THE RISK ASSESSMENT

Thallium is considered a COPC in AOC-5 surface water and fish tissue based upon a comparison to the applicable RSL. However, thallium was not evaluated quantitatively in the HHRA. The support documentation for the RfD derivation notes, “The conclusion reached in the IRIS Toxicological Review of Thallium and Compounds was that the available toxicity database for thallium contains studies that are generally of poor quality…Therefore, a RfD for soluble thallium salts was not derived (EPA 2012b).” As a result, the EPA has provided a screening values RfD which the EPA notes, “For the reasons noted in the main document, it is inappropriate to derive a subchronic or chronic provisional RfD for thallium. However, information is available which, although insufficient to support derivation of a provisional toxicity value, under current guidelines, may be of limited use to risk assessors. In such cases, the Superfund Health Risk Technical Support Center summarizes available information in an appendix and develops a screening value. Users of screening toxicity values in an appendix to a PPRTV assessment should understand that there is considerably more uncertainty associated with the derivation of a supplemental screening toxicity value than for a value presented in the body of the assessment (EPA 2012).”

Table 2 presents the maximum detected concentration and frequency of detection of thallium in surface water. The maximum detected concentration was 4.7 µg/L. Thallium was only detected in two out of 12 surface water samples. Additionally, thallium in fish tissue is a COPC based upon the surface water concentrations.

5. CONCLUSIONS

The HHRA estimated the risk and hazard to potential human receptors for exposure to media within AOC-5 of the former Falcon Refinery Superfund Site. The Site is an inactive refinery located 1.7 miles southeast of State Highway 361 on FM 2725 at the north and south corners of FM 2725 and Bishop Road. The site occupies approximately 104 acres in Ingleside, San Patricio County, Texas.

The site has been divided into AOCs based upon former use and location. AOC-1 consists of the Former Operational Units. AOC-1 includes the entire North Site and a drum disposal area and metal waste disposal area of the South Site. AOC-2 includes areas of the refinery that were not used for operations or storage and have no record of releases. AOC-3 encompasses the wetlands immediately adjacent to the site that are bordered by Bay Avenue, Bishop Road, and a dam on the upstream side; wetlands located between Bishop Road, Sunray Road, Bay Avenue and residences along Thayer Avenue; and the wetlands between Sunray Road, residences along FM 2725, Gulf Marine Fabricators, Offshore Specialty Fabricators and the outlet of the wetlands into Redfish Bay. Within AOC-3, there are one active and several abandoned pipelines that lead from the refinery to the barge dock facilities. During June 2006 the abandoned pipelines were cut, the contents of the pipelines were removed and plates were welded on the pipelines. AOC-4 includes the barge docking facility. AOC-4 is located on Redfish Bay. The fenced facility, which is connected to the refinery by pipelines, is used to load and unload barges. Currently only crude oil passed through the docking facility. Historically, refined products were also loaded and unloaded. AOC-5 encompasses the sediments and surface water adjacent to the barge dock facility (AOC-4). AOC-6 includes the neighborhood along Thayer Road, across from the refinery. AOC-7 includes the neighborhood along Bishop Road.

AOC-5 encompasses the sediments and surface water adjacent to the barge dock facility (AOC-4). The site is bordered by wetlands to the northeast and southeast, residential areas to the north and southwest, an abandoned refinery to the northwest, and a construction company to the southwest. AOC-5 is within Redfish Bay, a saltwater waterway with “prime” fishing habitat (TPWD 2014).

The site is located in the San Antonio-Nueces Coastal Basin adjacent to Redfish Bay, which connects Corpus Christi Bay to the Gulf of Mexico. Surface water drainage from the site enters the wetlands along the southeastern section of the abandoned refinery. A culvert connects the on-site palustrine/estuarine wetlands to estuarine wetlands. The wetlands then connect to the Intracoastal Waterway and Redfish Bay. Ground water at the site is located approximately two feet below ground surface.

Receptors identified for AOC-5 include the adult recreational user, adolescent recreational user, and watermen. Media of concern for AOC-5 include surface water, sediment, and fish tissue. Specific exposure pathways evaluated in the AOC-5 HHRA are presented in Figure 4. Table 27 presents a summary of the HHRA results.

The results indicate that there are no human health concerns for exposure to surface water and sediment within AOC-5. Potential non-carcinogenic hazards were determined for ingestion of fish tissue.

The AOC-5 HHRA evaluated potential cumulative risks for the adult recreational user, adolescent recreational user, and watermen exposure to surface water, sediment, and fish tissue within Redfish Bay adjacent to AOC-4. Carcinogenic risks for all receptors evaluated are within EPA's "acceptable risk range." Non-carcinogenic hazards exceeded 1.0 for all of the receptors evaluated. Selenium in fish tissue was the only contributor to the non-carcinogenic hazards exceedance. It is noted that the concentrations of all chemicals in fish tissue are modeled based upon surface water concentrations; therefore, these results are not actual, measured concentrations. Background surface water samples were collected from Redfish Bay for comparison to the AOC-5 results. Selenium was only detected in 1 of 11 background surface water samples. As a result, a comparison to background concentrations cannot be completed.

The only exceedance of acceptable risk thresholds for AOC-5 was the ingestion of fish tissue. Selenium in fish tissue resulted in potential non-carcinogenic hazards greater than the acceptable threshold of 1. This exceedance is highly dependent upon the intake calculated for fish tissue. Two exposure parameters used in determining fish tissue intake that are highly variable are the BAF, for determining uptake from surface water to fish tissue, and the number of meals per year. The BAF is a modeled value that does not necessarily represent actual fish tissue concentrations, only an estimation. Therefore, actual fish tissue concentrations could be significantly different.

The number of meals for fish ingestion was taken from a study performed near the site. It was noted, "The study authors noted that because the survey relied on the anglers' recall of meal frequency and portion, fish consumption may have been overestimated. There was evidence of overestimation when the data were validated, and approximately 10% of anglers reported consuming more fish than what they caught and kept (EPA 2011)." Based upon the use of the BAF for the determination of chemical concentrations in fish tissue and the overestimation of fish consumption, the risk results for the ingestion of fish tissue pathway are most likely overestimated.

In conclusion, the HHRA did not reveal potential concerns for human health exposure to AOC-5.

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FIGURES

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N

0 5,000 10,000

Feet

Image Source:
ESRI ArcGIS Online USA Topo Maps layer, 1:100,000 scale, Copyright:© 2011 National Geographic Society, i-cubed

Falcon Refinery Superfund Site
Ingleside, San Patricio County, Texas

Figure 1
Location Map
Human Health Risk Assessment for AOC-5

2014-04-03 R:\Federal\EPA\RAC II\0088-Falcon Refinery RI\FS\GIS\MXDs\AreaMap.mxd EA-Dallas jschwertz

N

0 250 500

Feet

Legend:

Area of Concern Boundary

Active NORCO Pipeline

Above ground

Underground

Abandonded NORCO Pipeline

Above ground

Underground

Outside Operations

Gulf South Pipeline

Boss Pipeline

Gathering Line 2'

Plains Marketing Pipeline

Source: AOC and pipeline locations from TRC, dated, March 10, 2011

Image Source: 2009 Texas Orthoimagery Program, Texas Strategic Mapping Program, TNRIS, 2009

Falcon Refinery Superfund Site
Ingleside, San Patricio County, Texas

Figure 2
Site Map
Human Health Risk Assessment for AOC-5

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N

0 150 300

Feet

Legend:

- Sediment/Surface Water Sample Location (2013)
- Sediment/Surface Water Sample Location (2008)
- Area of Concern 5 Boundary

Source: AOC and pipeline locations from TRC, dated, March 10, 2011

Image Source: 2009 Texas Orthoimagery Program, Texas Strategic Mapping Program, TNRIS, 2009

Falcon Refinery Superfund Site
Ingleside, San Patricio County, Texas

Figure 3
AOC-5 Sample Locations
Human Health Risk Assessment for AOC-5

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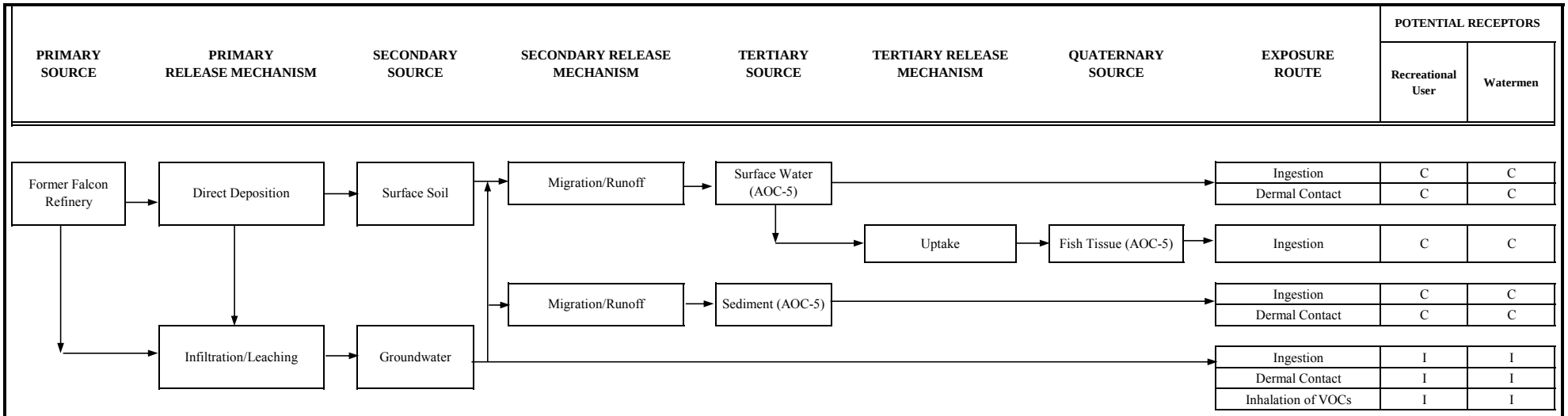
FIGURE 4
HUMAN HEALTH CONCEPTUAL SITE MODEL
AOC-5, FALCON REFINERY SUPERFUND SITE
INGLESIDE, SAN PATRICIO COUNTY, TEXAS



LEGEND

I Incomplete or negligible exposure pathway

C Potentially complete exposure pathway

TABLES

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TABLE 1
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
AOC-5, FALCON REFINERY SUPERFUND SITE - SEDIMENT - RESIDENTIAL
INGLESIDE, SAN PATRICIO COUNTY, TEXAS

Scenario Timeframe: Current-Residential
Medium: Sediment
Exposure Medium: Sediment
Exposure Point: Falcon Refinery

CAS Number	Chemical	Minimum (1) Concentration	Minimum Qualifier	Maximum (1) Concentration	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration (2) Used for Screening	Background (3) Value	Screening (4) Toxicity Value		Potential (5) ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for (6) Contaminant Deletion or Selection
							INORGANICS										
7429-90-5	Aluminum	2.76E+03		1.45E+04		mg/kg	SD5-01-0.0-0.5	6/6	0.00E+00 - 0.00E+00	1.45E+04	NA	7.70E+04	N	NA	NA	No	BSL
7440-38-2	**Arsenic**	**1.70E+00**		**7.10E+00**		**mg/kg**	**FR-222**	**6/6**	**0.00E+00 - 0.00E+00**	**7.10E+00**	**NA**	**6.10E+00**	**C**	**NA**	**NA**	**Yes**	**ASL**
7440-39-3	Barium	2.22E+02		2.29E+03		mg/kg	FR-226	6/6	0.00E+00 - 0.00E+00	2.29E+03	NA	1.50E+04	N	NA	NA	No	BSL
7440-41-7	Beryllium	1.70E-01	B	6.60E-01	B	mg/kg	FR-222	3/6	0.00E+00 - 1.10E+00	6.60E-01	NA	1.60E+02	N	NA	NA	No	BSL
7440-43-9	Cadmium	1.00E-01	J	1.50E+00	J	mg/kg	SD5-01-0.0-0.5	12/12	0.00E+00 - 0.00E+00	1.50E+00	NA	7.00E+01	N	NA	NA	No	BSL
7440-70-2	Calcium	2.08E+04		3.48E+04		mg/kg	SD5-01-0.0-0.5	3/3	0.00E+00 - 0.00E+00	3.48E+04	NA	NA		NA	NA	No	NUT
7440-47-3	Chromium	3.00E+00		2.70E+02		mg/kg	FR-222	6/6	0.00E+00 - 0.00E+00	2.70E+02	NA	1.20E+05	N	NA	NA	No	BSL
18540-29-9	**Chromium, hexavalent**	**2.00E+00**	**B**	**5.70E+00**		**mg/kg**	**FR-222**	**2/2**	**0.00E+00 - 0.00E+00**	**5.70E+00**	**NA**	**2.90E+00**	**C**	**NA**	**NA**	**Yes**	**ASL**
7440-48-4	Cobalt	1.20E+00	B	7.70E+00	B	mg/kg	FR-222	6/6	0.00E+00 - 0.00E+00	7.70E+00	NA	2.30E+01	N	NA	NA	No	BSL
7440-50-8	Copper	1.40E+00	B	1.90E+02	J	mg/kg	SD5-01-0.0-0.5	13/13	0.00E+00 - 0.00E+00	1.90E+02	NA	3.10E+03	N	NA	NA	No	BSL
7439-89-6	Iron	2.64E+03		1.29E+04		mg/kg	SD5-01-0.0-0.5	6/6	0.00E+00 - 0.00E+00	1.29E+04	NA	5.50E+04	N	NA	NA	No	BSL
7439-92-1	Lead	2.40E+00		1.58E+03		mg/kg	FR-222	13/13	0.00E+00 - 0.00E+00	1.58E+03	NA	4.00E+03		NA	NA	No	BSL
7439-95-4	Magnesium	3.48E+03		9.32E+03		mg/kg	SD5-01-0.0-0.5	3/3	0.00E+00 - 0.00E+00	9.32E+03	NA	NA		NA	NA	No	NUT
7439-96-5	Manganese	3.84E+01		2.10E+02		mg/kg	SD5-01-0.0-0.5	6/6	0.00E+00 - 0.00E+00	2.10E+02	NA	1.80E+03	N	NA	NA	No	BSL
7439-97-6	Mercury	1.20E-02	B	1.60E-01		mg/kg	FR-222	6/6	0.00E+00 - 0.00E+00	1.60E-01	NA	1.00E+01	N	NA	NA	No	BSL
7440-02-0	Nickel	1.60E+00	B	2.30E+02	J	mg/kg	SD5-01-0.0-0.5	12/13	0.00E+00 - 1.50E+00	2.30E+02	NA	1.50E+03	N	NA	NA	No	BSL
7440-09-7	Potassium	1.97E+03		4.83E+03		mg/kg	SD5-01-0.0-0.5	3/3	0.00E+00 - 0.00E+00	4.83E+03	NA	NA		NA	NA	No	NUT
7782-49-2	Selenium	5.20E-01	LJ	5.80E-01	LJ	mg/kg	SD5-03-0.0-0.5	2/3	0.00E+00 - 3.50E+00	5.80E-01	NA	3.90E+02	N	NA	NA	No	BSL
7440-23-5	Sodium	7.36E+03		2.66E+04		mg/kg	SD5-01-0.0-0.5	3/3	0.00E+00 - 0.00E+00	2.66E+04	NA	NA		NA	NA	No	NUT
7440-62-2	Vanadium	4.90E+00	B	2.11E+01		mg/kg	FR-222	6/6	0.00E+00 - 0.00E+00	2.11E+01	NA	3.90E+02	N	NA	NA	No	BSL
7440-66-6	Zinc	2.00E+01	B	2.60E+02	J	mg/kg	SD5-01-0.0-0.5	13/13	0.00E+00 - 0.00E+00	2.60E+02	NA	2.30E+04	N	NA	NA	No	BSL
							PAH										
91-57-6	2-Methylnaphthalene	7.20E-03	LJ	8.00E-03	LJ	mg/kg	SD5-03-0.0-0.5	2/10	0.00E+00 - 5.20E-02	8.00E-03	NA	2.30E+02	N	NA	NA	No	BSL
120-12-7	Anthracene	4.40E-01		4.40E-01		mg/kg	FR-222	1/11	0.00E+00 - 5.20E-02	4.40E-01	NA	1.70E+04	N	NA	NA	No	BSL
56-55-3	Benzo(a)anthracene	6.90E-03	LJ	7.10E-01		mg/kg	FR-222	11/11	0.00E+00 - 0.00E+00	7.10E-01	NA	1.50E+00	C	NA	NA	No	BSL
50-32-8	**Benzo(a)pyrene**	**7.70E-03**	**LJ**	**5.11E-01**		**mg/kg**	**FR-222**	**10/11**	**0.00E+00 - 4.70E-02**	**5.11E-01**	**NA**	**1.50E-01**	**C**	**NA**	**NA**	**Yes**	**ASL**
205-99-2	Benzo(b)fluoranthene	1.30E-02		9.08E-01		mg/kg	FR-222	11/11	0.00E+00 - 0.00E+00	9.08E-01	NA	1.50E+00	C	NA	NA	No	BSL
191-24-2	Benzo(g,h,i)perylene	2.33E-01	J	2.33E-01	J	mg/kg	FR-222	1/11	0.00E+00 - 5.20E-02	2.33E-01	NA	1.70E+03	N	NA	NA	No	BSL
207-08-9	Benzo(k)fluoranthene	4.50E-03	LJ	3.03E-01	J	mg/kg	FR-222	9/11	0.00E+00 - 5.20E-02	3.03E-01	NA	1.50E+01	C	NA	NA	No	BSL
218-01-9	Chrysene	8.80E-03	LJ	8.95E-01		mg/kg	FR-222	10/11	0.00E+00 - 4.70E-02	8.95E-01	NA	1.50E+02	C	NA	NA	No	BSL
206-44-0	Fluoranthene	7.70E-03	LJ	1.78E+00		mg/kg	FR-222	11/11	0.00E+00 - 0.00E+00	1.78E+00	NA	2.30E+03	N	NA	NA	No	BSL
86-73-7	Fluorene	2.37E-01	J	2.37E-01	J	mg/kg	FR-222	1/11	0.00E+00 - 5.20E-02	2.37E-01	NA	2.30E+03	N	NA	NA	No	BSL
193-39-5	Indeno(1,2,3-cd)pyrene	4.90E-03	LJ	2.25E-01	J	mg/kg	FR-222	9/11	0.00E+00 - 5.20E-02	2.25E-01	NA	1.50E+00	C	NA	NA	No	BSL
85-01-8	Phenanthrene	4.10E-03	LJ	3.42E-01		mg/kg	FR-222	8/11	0.00E+00 - 5.20E-02	3.42E-01	NA	1.70E+04	N	NA	NA	No	BSL
129-00-0	Pyrene	8.40E-03	LJ	1.70E+00		mg/kg	FR-222	12/12	0.00E+00 - 0.00E+00	1.70E+00	NA	1.70E+03	N	NA	NA	No	BSL
							SVOC										
98-86-2	Acetophenone	5.50E-02	LJ	5.50E-02	LJ	mg/kg	SD5-06-0.0-0.5	1/10	0.00E+00 - 2.30E+00	5.50E-02	NA	7.80E+03	N	NA	NA	No	BSL
100-52-7	Benzaldehyde	4.30E-02	LJ	4.30E-02	LJ	mg/kg	SD5-06-0.0-0.5	1/10	0.00E+00 - 2.30E+00	4.30E-02	NA	7.80E+03	N	NA	NA	No	BSL
117-81-7	Bis(2-ethylhexyl) phthalate	6.30E-02	LJ	1.10E-01	LJ	mg/kg	SD5-03-0.0-0.5	2/10	0.00E+00 - 2.30E+00	1.10E-01	NA	3.50E+02	C	NA	NA	No	BSL
131-11-3	Dimethyl phthalate	4.50E-02	LJ	4.50E-02	LJ	mg/kg	SD5-02-0.0-0.5	1/10	0.00E+00 - 2.30E+00	4.50E-02	NA	NA		NA	NA	No	BSL
108-95-2	Phenol	5.00E-02	LJ	5.00E-02	LJ	mg/kg	SD5-02-0.0-0.5	1/10	0.00E+00 - 2.30E+00	5.00E-02	NA	1.80E+04	N	NA	NA	No	BSL
							VOC										

TABLE 1
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
AOC-5, FALCON REFINERY SUPERFUND SITE - SEDIMENT - RESIDENTIAL
INGLESIDE, SAN PATRICIO COUNTY, TEXAS

Scenario Timeframe: Current-Residential
Medium: Sediment
Exposure Medium: Sediment
Exposure Point: Falcon Refinery

CAS Number	Chemical	Minimum (1) Concentration	Minimum Qualifier	Maximum (1) Concentration	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration (2) Used for Screening	Background (3) Value	Screening (4) Toxicity Value		Potential (5) ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for (6) Contaminant Deletion or Selection
78-93-3	2-Butanone (Methyl ethyl ketone)	6.70E-03	LJ	6.70E-03	LJ	mg/kg	SD5-01-0.0-0.5	1/10	0.00E+00 - 2.10E-02	6.70E-03	NA	2.80E+04	N	NA	NA	No	BSL
67-64-1	Acetone	3.00E-03	LJ	6.43E-02	J	mg/kg	FR-222	11/13	0.00E+00 - 2.10E-02	6.43E-02	NA	6.10E+04	N	NA	NA	No	BSL
75-15-0	Carbon disulfide	4.60E-04	LJ	1.40E-02	J	mg/kg	FR-222	13/13	0.00E+00 - 0.00E+00	1.40E-02	NA	8.20E+02	N	NA	NA	No	BSL
100-41-4	Ethylbenzene	1.70E-03	LJ	1.70E-03	LJ	mg/kg	SD5-01-0.0-0.5	1/10	0.00E+00 - 1.10E-02	1.70E-03	NA	5.40E+01	C	NA	NA	No	BSL
179601-23-1	m- & p-Xylenes	3.00E-04	LJ	1.50E-02		mg/kg	SD5-01-0.0-0.5	3/10	0.00E+00 - 1.80E-02	1.50E-02	NA	NA		NA	NA	No	BSL
75-09-2	Methylene chloride	3.60E-03	J	3.60E-03	J	mg/kg	FR-226	1/11	0.00E+00 - 1.80E-02	3.60E-03	NA	3.60E+02	N	NA	NA	No	BSL
95-47-6	o-Xylene	4.90E-03	LJ	4.90E-03	LJ	mg/kg	SD5-01-0.0-0.5	1/10	5.80E-03 - 1.80E-02	4.90E-03	NA	6.90E+02	N	NA	NA	No	BSL
127-18-4	Tetrachloroethene (PCE)	8.70E-04	LJ	8.70E-04	LJ	mg/kg	SD5-01-0.0-0.5	1/10	0.00E+00 - 1.10E-02	8.70E-04	NA	8.60E+01	N	NA	NA	No	BSL
108-88-3	Toluene	8.60E-04	LJ	8.60E-04	LJ	mg/kg	SD5-01-0.0-0.5	1/10	0.00E+00 - 1.10E-02	8.60E-04	NA	5.00E+03	N	NA	NA	No	BSL

NOTES:
(1) Minimum/maximum detected concentration.
(2) Maximum concentration used as screening value.
(3) Background values are not included as part of the COPC selection process.
(4) Screening Toxicity Value - Taken from State of Maryland Department of the Environment Residential Cleanup Standard for Soil, June 2008.
(5) USEPA Regional Screening Levels, USEPA, November 2013. For non-carcinogens, value shown is equal to 1/10 the residential soil value. For carcinogens the value shown is equal to the residential soil value.
(6) Rationale Codes
Selection Reason: ASL = Above Screening Toxicity Level
Deletion Reason: BSL = Below Screening Toxicity Level
NSL = No Screening Toxicity Level
NUT = Essential Nutrient

Definitions:
C = Carcinogenic
COPC = Chemical of Potential Concern
N = Non-Carcinogenic
NA = Not Applicable
mg/kg = milligrams per kilogram

Data Qualifiers:
B = Indicates analyte detected in associated method blank
J = Indicates an estimated value

Surrogates used: Chromium(III) for Chromium, Methyl Mercury for Mercury, Anthracene for Phenanthrene, Pyrene for Benzo(g,h,i)perylene.

TABLE 2
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
AOC-5, FALCON REFINERY SUPERFUND SITE - SURFACE WATER
INGLESIDE, SAN PATRICIO COUNTY, TEXAS

Scenario Timeframe: Current
Medium: Surface water
Exposure Medium: Surface water
Exposure Point: Falcon Refinery

CAS Number	Chemical	Minimum (1) Concentration	Minimum Qualifier	Maximum (1) Concentration	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration (2) Used for Screening	Background (3) Value	Screening (4) Toxicity Value		Potential (5) ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for (6) Contaminant Deletion or Selection
							INORGANICS-TOTAL										
7429-90-5	Aluminum	1.83E+02	B	7.88E+02	LJ	ug/L	SW5-05	10/13	0.00E+00 - 1.00E+03	7.88E+02	NA	1.60E+04	N	NA	NA	No	BSL
7440-36-0	Antimony	3.60E+00	B	4.90E+00	B	ug/L	FR-223	3/13	0.00E+00 - 2.00E+02	4.90E+00	NA	6.00E+00	N	NA	NA	No	BSL
7440-39-3	Barium	5.08E+01	B	5.36E+01	B	ug/L	FR-225	3/13	0.00E+00 - 1.00E+03	5.36E+01	NA	2.90E+03	N	NA	NA	No	BSL
7440-70-2	Calcium	4.80E+05		5.43E+05		ug/L	SW5-05	10/10	0.00E+00 - 0.00E+00	5.43E+05	NA	NA		NA	NA	No	NUT
7440-47-3	Chromium	1.80E+00	B/B	1.80E+00	B/B	ug/L	FR-223, FR-225	2/12	0.00E+00 - 2.00E+02	1.80E+00	NA	1.60E+04	N	NA	NA	No	BSL
7440-50-8	Copper	4.44E+01	LJ	1.12E+02	LJ	ug/L	SW5-09	7/10	0.00E+00 - 2.00E+02	1.12E+02	NA	6.20E+02	N	NA	NA	No	BSL
7439-89-6	Iron	9.04E+01	B	1.26E+02		ug/L	FR-225	3/13	0.00E+00 - 5.00E+02	1.26E+02	NA	1.10E+04	N	NA	NA	No	BSL
7439-92-1	Lead	1.13E+01		1.19E+01		ug/L	FR-225	3/13	0.00E+00 - 1.00E+02	1.19E+01	NA	NA		NA	NA	No	BSL
7439-95-4	Magnesium	1.39E+06		1.48E+06	J/ / J	ug/L	SW5-04, SW5-10, SW5-05	10/10	0.00E+00 - 0.00E+00	1.48E+06	NA	NA		NA	NA	No	NUT
7439-96-5	Manganese	1.08E+01	LJ	1.22E+01	B/ LJ	ug/L	FR-223, SW5-08	8/13	0.00E+00 - 7.50E+01	1.22E+01	NA	3.20E+02	N	NA	NA	No	BSL
7440-09-7	Potassium	4.93E+05	J	7.00E+05	J	ug/L	SW5-05	10/10	0.00E+00 - 0.00E+00	7.00E+05	NA	NA		NA	NA	No	NUT
7782-49-2	**Selenium**	**7.37E+01**	**LJ**	**9.13E+01**	**LJ**	**ug/L**	**SW5-08**	**7/10**	**0.00E+00 - 5.00E+02**	**9.13E+01**	**NA**	**7.80E+01**	**N**	**NA**	**NA**	**Yes**	**ASL**
7440-22-4	Silver	2.00E+00	B/B	2.00E+00	B/B	ug/L	FR-223, FR-225	2/12	0.00E+00 - 1.00E+02	2.00E+00	NA	7.10E+01	N	NA	NA	No	BSL
7440-23-5	Sodium	1.10E+07		1.28E+07		ug/L	SW5-05	10/10	0.00E+00 - 0.00E+00	1.28E+07	NA	NA		NA	NA	No	NUT
7440-28-0	**Thallium**	**3.90E+00**	**B**	**4.70E+00**	**B**	**ug/L**	**FR-225**	**2/12**	**0.00E+00 - 1.00E+02**	**4.70E+00**	**NA**	**1.60E-01**	**N**	**NA**	**NA**	**Yes**	**ASL**
7440-62-2	Vanadium	1.05E+00	B	1.30E+00	B	ug/L	FR-223	2/12	0.00E+00 - 5.00E+02	1.30E+00	NA	6.30E+01	N	NA	NA	No	BSL
7440-66-6	Zinc	1.21E+01	B	4.57E+02	J	ug/L	SW5-07	8/13	0.00E+00 - 2.00E+02	4.57E+02	NA	4.70E+03	N	NA	NA	No	BSL
							PAH										
91-57-6	2-Methylnaphthalene	5.10E-02	LJ	5.90E-02	LJ	ug/L	SW5-09	2/10	0.00E+00 - 1.00E-01	5.90E-02	NA	2.70E+01	N	NA	NA	No	BSL
91-20-3	Naphthalene	4.70E-02	LJ	4.80E-02	LJ	ug/L	SW5-09	2/10	0.00E+00 - 1.00E-01	4.80E-02	NA	1.40E+00	C	NA	NA	No	BSL
85-01-8	Phenanthrene	4.40E-02	LJ	6.50E-02	LJ	ug/L	SW5-02	3/10	0.00E+00 - 1.00E-01	6.50E-02	NA	1.30E+03	N	NA	NA	No	BSL
							SVOC										
98-86-2	Acetophenone	6.30E-01	LJ/ LJ	1.40E+00	LJ/ LJ	ug/L	SW5-09, SW5-10	8/10	0.00E+00 - 5.00E+00	1.40E+00	NA	1.50E+03	N	NA	NA	No	BSL
100-52-7	Benzaldehyde	5.70E-01	LJ	6.90E-01	LJ	ug/L	SW5-10	5/10	0.00E+00 - 5.00E+00	6.90E-01	NA	1.50E+03	N	NA	NA	No	BSL
117-81-7	Bis(2-ethylhexyl) phthalate	5.50E-01	LJ	2.40E+00	J	ug/L	FR-220A	3/12	0.00E+00 - 5.00E+00	2.40E+00	NA	4.80E+01	C	NA	NA	No	BSL
105-60-2	Caprolactum	2.90E+00	LJ	2.90E+00	LJ	ug/L	SW5-09	1/10	0.00E+00 - 5.00E+00	2.90E+00	NA	7.70E+03	N	NA	NA	No	BSL
131-11-3	Dimethyl phthalate	5.30E-01	LJ	6.60E-01	LJ	ug/L	SW5-02	2/10	0.00E+00 - 5.00E+00	6.60E-01	NA	NA		NA	NA	No	BSL
							VOC										
95-63-6	1,2,4-Trimethylbenzene	5.30E-01	J	3.70E+00		ug/L	FR-225	3/3	0.00E+00 - 0.00E+00	3.70E+00	NA	1.50E+01	N	NA	NA	No	BSL
108-67-8	1,3,5-Trimethylbenzene	9.20E-01	J	1.00E+00	J	ug/L	FR-225	2/2	0.00E+00 - 0.00E+00	1.00E+00	NA	8.70E+01	N	NA	NA	No	BSL
67-64-1	Acetone	1.20E+00	LJ/ LJ	1.80E+00	LJ	ug/L	SW5-09	9/10	0.00E+00 - 5.00E+00	1.80E+00	NA	1.20E+04	N	NA	NA	No	BSL
71-43-2	Benzene	1.38E+00		1.50E+00	J	ug/L	FR-225	2/12	0.00E+00 - 5.00E-01	1.50E+00	NA	3.90E+00	C	NA	NA	No	BSL
74-87-3	Chloromethane (Methyl chloride)	1.10E-01	LJ	1.30E-01	LJ/ LJ	ug/L	SW5-04, SW5-01	4/10	0.00E+00 - 5.00E-01	1.30E-01	NA	1.90E+02	N	NA	NA	No	BSL
100-41-4	Ethylbenzene	1.08E+00	J	1.10E+00	J	ug/L	FR-225	2/12	0.00E+00 - 5.00E-01	1.10E+00	NA	1.30E+01	C	NA	NA	No	BSL
103-65-1	n-Propylbenzene	5.50E-01	J	5.50E-01	J	ug/L	FR-220A	1/1	0.00E+00 - 0.00E+00	5.50E-01	NA	5.30E+02	N	NA	NA	No	BSL
108-88-3	Toluene	7.90E-01	J	6.30E+00		ug/L	FR-225	3/13	0.00E+00 - 5.00E-01	6.30E+00	NA	8.60E+02	N	NA	NA	No	BSL
1330-20-7	Xylene (total)	4.80E+00		5.70E+00	J	ug/L	FR-225	2/2	0.00E+00 - 0.00E+00	5.70E+00	NA	1.90E+02	N	NA	NA	No	BSL

TABLE 2
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
AOC-5, FALCON REFINERY SUPERFUND SITE - SURFACE WATER
INGLESIDE, SAN PATRICIO COUNTY, TEXAS

Scenario Timeframe: Current
Medium: Surface water
Exposure Medium: Surface water
Exposure Point: Falcon Refinery

CAS Number	Chemical	Minimum (1) Concentration	Minimum Qualifier	Maximum (1) Concentration	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration (2) Used for Screening	Background (3) Value	Screening (4) Toxicity Value	Potential (5) ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for (6) Contaminant Deletion or Selection

NOTES:
(1) Minimum/maximum detected concentration.
(2) Maximum concentration used as screening value.
(3) Background values are not included as part of the COPC selection process.

(5) USEPA Regional Screening Levels, USEPA, November 2013. For non-carcinogens, value shown is equal to 1/10 the tap water value. For carcinogens the value shown is equal to the tap water value.
(6) Rationale Codes
Selection Reason: ASL = Above Screening Toxicity Level
Deletion Reason: BSL = Below Screening Toxicity Level
NSL = No Screening Toxicity Level
NUT = Essential Nutrient

Definitions:
C = Carcinogenic
COPC = Chemical of Potential Concern
N = Non-Carcinogenic
NA = Not Applicable

ug/L = micrograms per liter

Data Qualifiers:
B = Indicates analyte detected in associated method blank
J = Indicates an estimated value

Surrogates used: Chromium(III) for Chromium, Anthracene for Phenanthrene.

TABLE 3
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
AOC-5, FALCON REFINERY SUPERFUND SITE - FISH TISSUE
INGLESIDE, SAN PATRICIO COUNTY, TEXAS

Scenario Timeframe: Current
Medium: Surface water
Exposure Medium: Fish
Exposure Point: Falcon Refinery

CAS Number	Chemical	Maximum (1) Concentration	Maximum Qualifier	Units	Detection Frequency	BAF (2) (mg/L dry wt. to mg/kg dry wt.)	Concentration (3) Used for Screening	Screening (4) Toxicity Value		Potential (5) ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for (6) Contaminant Deletion or Selection
						INORGANICS-TOTAL							
7429-90-5	Aluminum	7.88E-01	LJ	mg/L	10/13	2.7	2.13E+00	1.40E+02	N	NA	NA	No	BSL
7440-36-0	Antimony	4.90E-03	B	mg/L	3/13	1	4.90E-03	5.40E-02	N	NA	NA	No	BSL
7440-39-3	Barium	5.36E-02	B	mg/L	3/13	4	2.14E-01	2.70E+01	N	NA	NA	No	BSL
7440-70-2	Calcium	5.43E+02		mg/L	10/10	NA	NA	NA		NA	NA	No	NUT
7440-47-3	Chromium	1.80E-03	B/B	mg/L	2/12	200	3.60E-01	2.00E+02	N	NA	NA	No	BSL
7440-50-8	**Copper**	**1.12E-01**	**LJ**	**mg/L**	**7/10**	**460**	**5.15E+01**	**5.40E+00**	**N**	**NA**	**NA**	**Yes**	**ASL**
7439-89-6	Iron	1.26E-01		mg/L	3/13	1	1.26E-01	9.50E+01	N	NA	NA	No	BSL
7439-92-1	Lead	1.19E-02		mg/L	3/13	45	5.36E-01	NA		NA	NA	No	NSL
7439-95-4	Magnesium	1.48E+03	J/ / J	mg/L	10/10	1	1.48E+03	NA		NA	NA	No	NUT
7439-96-5	Manganese	1.22E-02	B/ LJ	mg/L	8/13	400	4.88E+00	1.90E+01	N	NA	NA	No	BSL
7440-09-7	Potassium	7.00E+02	J	mg/L	10/10	1	7.00E+02	NA		NA	NA	No	NUT
7782-49-2	**Selenium**	**9.13E-02**	**LJ**	**mg/L**	**7/10**	**242**	**2.21E+01**	**6.80E-01**	**N**	**NA**	**NA**	**Yes**	**ASL**
7440-22-4	Silver	2.00E-03	B/B	mg/L	2/12	87.7	1.75E-01	6.80E-01	N	NA	NA	No	BSL
7440-23-5	Sodium	1.28E+04		mg/L	10/10	1	1.28E+04	NA		NA	NA	No	NUT
7440-28-0	**Thallium**	**4.70E-03**	**B**	**mg/L**	**2/12**	**1000**	**4.70E+00**	**1.40E-03**	**N**	**NA**	**NA**	**Yes**	**ASL**
7440-62-2	Vanadium	1.30E-03	B	mg/L	2/12	1	1.30E-03	6.80E-01	N	NA	NA	No	BSL
7440-66-6	Zinc	4.57E-01	J	mg/L	8/13	13	5.94E+00	4.10E+01	N	NA	NA	No	BSL
						PAH							
91-57-6	2-Methylnaphthalene	5.90E-05	LJ	mg/L	2/10	186	1.10E-02	5.40E-01	N	NA	NA	No	BSL
91-20-3	Naphthalene	4.80E-05	LJ	mg/L	2/10	69.2	3.32E-03	2.70E+00	C	NA	NA	No	BSL
85-01-8	Phenanthrene	6.50E-05	LJ	mg/L	3/10	537	3.49E-02	4.10E+01	N	NA	NA	No	BSL
						SVOC							
98-86-2	Acetophenone	1.40E-03	LJ/ LJ	mg/L	8/10	1.33	1.86E-03	1.40E+01	N	NA	NA	No	BSL
100-52-7	Benzaldehyde	6.90E-04	LJ	mg/L	5/10	4.4	3.04E-03	1.40E+01	N	NA	NA	No	BSL
117-81-7	**Bis(2-ethylhexyl) phthalate**	**2.40E-03**	**J**	**mg/L**	**3/12**	**588**	**1.41E+00**	**2.30E-01**	**C**	**NA**	**NA**	**Yes**	**ASL**
105-60-2	Caprolactum	2.90E-03	LJ	mg/L	1/10	3.16	9.16E-03	6.80E+01	N	NA	NA	No	BSL
131-11-3	Dimethyl phthalate	6.60E-04	LJ	mg/L	2/10	5.28	3.48E-03	NA		NA	NA	No	NSL
						VOC							
95-63-6	1,2,4-Trimethylbenzene	3.70E-03		mg/L	3/3	120	4.44E-01	NA	N	NA	NA	No	NSL
108-67-8	1,3,5-Trimethylbenzene	1.00E-03	J	mg/L	2/2	186	1.86E-01	1.40E+00	N	NA	NA	No	BSL
67-64-1	Acetone	1.80E-03	LJ	mg/L	9/10	3.16	5.69E-03	1.20E+02	N	NA	NA	No	BSL
71-43-2	Benzene	1.50E-03	J	mg/L	2/12	4.27	6.41E-03	5.70E-02	C	NA	NA	No	BSL
74-87-3	Chloromethane (Methyl chloride)	1.30E-04	LJ/ LJ	mg/L	4/10	3.16	4.11E-04	NA	N	NA	NA	No	NSL
100-41-4	Ethylbenzene	1.10E-03	J	mg/L	2/12	55.6	6.12E-02	2.90E-01	C	NA	NA	No	BSL
103-65-1	n-Propylbenzene	5.50E-04	J	mg/L	1/1	126	6.93E-02	1.40E+01	N	NA	NA	No	BSL
108-88-3	Toluene	6.30E-03		mg/L	3/13	8.32	5.24E-02	1.10E+01	N	NA	NA	No	BSL
1330-20-7	Xylene (total)	5.70E-03	J	mg/L	2/2	1	5.70E-03	2.70E+01	N	NA	NA	No	BSL

TABLE 3
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
AOC-5, FALCON REFINERY SUPERFUND SITE - FISH TISSUE
INGLESIDE, SAN PATRICIO COUNTY, TEXAS

Scenario Timeframe: Current
Medium: Surface water
Exposure Medium: Fish
Exposure Point: Falcon Refinery

CAS Number	Chemical	Maximum (1) Concentration	Maximum Qualifier	Units	Detection Frequency	BAF (2) (mg/L dry wt. to mg/kg dry wt.)	Concentration (3) Used for Screening	Screening (4) Toxicity Value	Potential (5) ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for (6) Contaminant Deletion or Selection

NOTES:
(1) Maximum concentration used as screening value.

(2) BAFs taken from the EPI (Estimation Programs Interface) SuiteTM is a Windows-based suite of physical/chemical property and environmental fate estimation programs developed by the EPA\'s Office of Pollution Prevention Toxics and Syracuse Research Corporation (SRC).
(3) Concentration used for screening is the maximum surface water concentration in mg/L times the BAF.
(4) USEPA Regional Screening Levels, USEPA, November 2013. For non-carcinogens, value shown is equal to 1/10 the fish tissue value. For carcinogens the value shown is equal to the fish tissue value.
(6) Rationale Codes

Selection Reason: ASL = Above Screening Toxicity Level
Deletion Reason: BSL = Below Screening Toxicity Level
NSL = No Screening Toxicity Level
NUT = Essential Nutrient

Surrogates used: Chromium(III) for Chromium, Anthracene for Phenanthrene.

Definitions:
C = Carcinogenic
COPC = Chemical of Potential Concern
N = Non-Carcinogenic
NA = Not Applicable
mg/L = milligrams per liter

Data Qualifiers:
B = Indicates analyte detected in associated method blank
J = Indicates an estimated value

TABLE 4
MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY
AOC-5, FALCON REFINERY SUPERFUND SITE - SEDIMENT - RESIDENTIAL
INGLESIDE, SAN PATRICIO COUNTY, TEXAS

Scenario Timeframe: Future-Residential
Medium: Sediment
Exposure Medium: Sediment
Exposure Point: AOC-5

Chemical of Potential Concern	Units	Mean Detected Concentration	95% UCLM	Maximum Detected Concentration	Maximum Qualifier	EPC Units	Reasonable Maximum Exposure		
							Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale
INORGANICS									
Arsenic	mg/kg	4.02E+00	5.57E+00	7.10E+00		mg/kg	5.57E+00	95%UCLM-N	ProUCL
Chromium, hexavalent	mg/kg	NA	NA	5.70E+00		mg/kg	5.70E+00	Maximum	N < 5
PAH									
Benzo(a)pyrene	mg/kg	6.77E-02	3.45E-01	5.11E-01		mg/kg	3.45E-01	95%UCLM-KMC	ProUCL

NOTES:
Statistics calculated by the EPA program ProUCL.
95%UCLM-C indicates that the 95 percent upper confidence limit on the mean is based on the non-parametric Chebyshev test.
95%UCLM-KMC indicates that the 95 percent upper confidence limit on the mean is based on the non-parametric Kaplan-Meier (KM) Chebyshev test.
95%UCLM-N indicates that the 95 percent upper confidence limit on the mean is based on the student's t-test for normal distributions.
N < 5 indicates that the number of samples is less than 5, so the maximum detected value was used.
NA = Not Applicable

TABLE 5
MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY
AOC-5, FALCON REFINERY SUPERFUND SITE - SURFACE WATER
INGLESIDE, SAN PATRICIO COUNTY, TEXAS

Scenario Timeframe: Current/Future
Medium: Surface water
Exposure Medium: Surface water
Exposure Point: AOC-5

Chemical of Potential Concern	Units	Mean Detected Concentration	95% UCLM	Maximum Detected Concentration	Maximum Qualifier	EPC Units	Reasonable Maximum Exposure		
							Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale
INORGANICS-TOTAL									
Selenium	ug/L	7.96E+01	8.40E+01	9.13E+01	LJ	ug/L	8.40E+01	95%UCLM-KMt	ProUCL
Thallium	ug/L	NA	NA	4.70E+00	B	ug/L	4.70E+00	Maximum	LOW %DETECTS

NOTES:
Statistics calculated by the EPA program ProUCL.
95%UCLM-KMt indicates that the 95 percent upper confidence limit on the mean is based on the non-parametric Kaplan-Meier (KM) student's t-test.
LOW %DETECTS indicates low percentage of detects.
NA = Not Applicable

TABLE 6
MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY
AOC-5, FALCON REFINERY SUPERFUND SITE - SURFACE WATER
INGLESIDE, SAN PATRICIO COUNTY, TEXAS

Scenario Timeframe: Current/Future
Medium: Surface water
Exposure Medium: Fish tissue
Exposure Point: AOC-5

Chemical of Potential Concern	Units	95%UCLM-Surface Water	BAF [1] (mg/L dry wt. to mg/kg dry wt.)	Fish Tissue Concentration [2]	EPC Units	Reasonable Maximum Exposure	
						Medium EPC Value	Medium EPC Rationale
INORGANICS-TOTAL							
Copper	ug/L	7.54E+01	460	3.47E+01	mg/kg	3.47E+01	ProUCL
Selenium	ug/L	8.40E+01	242	2.03E+01	mg/kg	2.03E+01	ProUCL
Thallium	ug/L	4.70E+00	1000	4.70E+00	mg/kg	4.70E+00	LOW %DETECTS
SEMI-VOLATILE ORGANICS							
Bis(2-ethylhexyl)phthalate	ug/L	2.40E+00	588	1.41E+00	mg/kg	1.41E+00	LOW %DETECTS

NOTES:
Statistics calculated by the EPA program ProUCL.
(1) Bioaccumulation Factors (BAFs) shown on Table 3.
(2) Fish tissue concentration calculated = 95%UCLM-Surface water x BAF x 1 mg/1000µg

LOW %DETECTS indicates low percentage of detects.
NA = Not Applicable

TABLE 7
VALUES USED FOR ADULT RECREATIONAL USER DAILY SURFACE WATER INTAKE EQUATIONS
AOC-5, FALCON REFINERY
INGLESIDE, SAN PATRICIO COUNTY, TEXAS

Scenario Timeframe: Current
Medium: Surface Water
Exposure Medium: Surface Water
Exposure Point: AOC 5
Receptor Population: Recreational User
Receptor Age: Adult - Swimming

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/Reference	Intake Equation
Ingestion	CW	Concentration in Water	mg/L	Chemical-Specific	Chemical-Specific	CDI (mg/kg/day) =
	CR	Ingestion Rate	L/day	0.02	ATSDR 2003	CW x CR x ET x EF x ED / (BW x AT)
	EF	Exposure Frequency	day/yr	4	BPJ (2)	
	ED	Exposure Duration	yr	30	U.S. EPA 1989	
	BW	Body Weight	kg	70	U.S. EPA 1997	
	AT-NC	Averaging time-Noncancer	days	10,950	U.S. EPA 1989	
	AT-C	Averaging Time - Cancer	days	25,550	U.S. EPA 1989	
Dermal	CW	Concentration in Surface Water	mg/L	Chemical-Specific	Chemical-Specific	CDI (mg/kg/day) =
	SA	Surface Area for Contact	cm^2	18,000	U.S. EPA 2004	CW x SA x PC x ET x EF x ED x CF / (BW x AT)
	PC	Permeability Coefficient	cm/hr	Chemical-Specific	Chemical-Specific	
	ET	Exposure Time	hr/day	2	BPJ (1)	For organic compounds
	EF	Exposure Frequency	day/yr	4	BPJ (2)	CDI (mg/kg/day) =
	ED	Exposure Duration	yr	30	U.S. EPA 1989	DA_{event} x SA x EF x ED / (BW x AT)
	BW	Body Weight	kg	70	U.S. EPA 1997	
	AT-NC	Averaging Time - Noncancer	days	10,950	U.S. EPA 1989	
	AT-C	Averaging Time - Cancer	days	25,550	U.S. EPA 1989	
	CF	Conversion Factor	L/cm^3	0.001	U.S. EPA 1989	

NOTES:
BPJ = Best Professional Judgement
CDI = chronic daily intake
DA_{event} = Dermal Absorbed Dose per event, example calculated in Appendix I
(1) Swimming is estimated to occur during a 2 hour time during boating
(2) Swimming will occur only on a limited basis, 4 days/year because this is an intercoastal waterway with barge traffic

TABLE 8
VALUES USED FOR ADOLESCENT RECREATIONAL USER DAILY SURFACE WATER INTAKE EQUATIONS
AOC-5, FALCON REFINERY
INGLESIDE, SAN PATRICIO COUNTY, TEXAS

Scenario Timeframe: Current
Medium: Surface Water
Exposure Medium: Surface Water
Exposure Point: AOC 5
Receptor Population: Recreational User
Receptor Age: Adolescent - Swimming

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/Reference	Intake Equation
Ingestion	CW	Concentration in Water	mg/L	Chemical-Specific	Chemical-Specific	CDI (mg/kg/day) =
	CR	Ingestion Rate	L/day	0.01	ATSDR 2003	CW x CR x ET x EF x ED / (BW x AT)
	EF	Exposure Frequency	day/yr	4	BPJ (3)	
	ED	Exposure Duration	yr	10	U.S. EPA 1997	
	BW	Body Weight	kg	45	U.S. EPA 1997	
	AT-NC	Averaging time-Noncancer	days	3,650	U.S. EPA 1989	
	AT-C	Averaging Time - Cancer	days	25,550	U.S. EPA 1989	
Dermal	CW	Concentration in Surface Water	mg/L	Chemical-Specific	Chemical-Specific	CDI (mg/kg/day) =
	SA	Surface Area for Contact	cm^2	13,350	U.S. EPA 2011 (1)	CW x SA x PC x ET x EF x ED x CF / (BW x AT)
	PC	Permeability Coefficient	cm/hr	Chemical-Specific	Chemical-Specific	
	ET	Exposure Time	hr/day	2	BPJ (2)	For organic compounds
	EF	Exposure Frequency	day/yr	4	BPJ (3)	CDI (mg/kg/day) =
	ED	Exposure Duration	yr	10	U.S. EPA 1997	DA_{event} x SA x EF x ED / (BW x AT)
	BW	Body Weight	kg	45	U.S. EPA 1997	
	AT-NC	Averaging Time - Noncancer	days	3,650	U.S. EPA 1989	
	AT-C	Averaging Time - Cancer	days	25,550	U.S. EPA 1989	
	CF	Conversion Factor	L/cm^3	0.001	U.S. EPA 1989	

NOTES:
BPJ = Best Professional Judgement
CDI = chronic daily intake
DA_{event} = Dermal Absorbed Dose per event, Example calculated in Appendix F
(1) The surface body area is averaged for two age ranges: 12 to 16 years and 6 to 11 years.
(2) Swimming is estimate to occur during a 2 hour time during boating.
(3) Swimming will occur only on a limited basis, 4 days/year because this is an intercoastal waterway with barge traffic.

TABLE 9
VALUES USED FOR WATERMAN DAILY SURFACE WATER INTAKE EQUATIONS
AOC-5, FALCON REFINERY
INGLESIDE, SAN PATRICIO COUNTY, TEXAS

Scenario Timeframe: Current
Medium: Surface Water
Exposure Medium: Surface Water
Exposure Point: AOC 5
Receptor Population: Watermen
Receptor Age: Adult - Fishing

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/Reference	Intake Equation
Dermal	CW	Concentration in Surface Water	mg/L	Chemical-Specific	Chemical-Specific	CDI (mg/kg/day) =
	SA	Surface Area for Contact	cm^2	3,900	U.S. EPA 2011 (1)	CW x SA x PC x ET x EF x ED x CF / (BW x AT)
	PC	Permeability Coefficient	cm/hr	Chemical-Specific	Chemical-Specific	
	ET	Exposure Time	hr/day	2	BPJ (2)	For organic compounds
	EF	Exposure Frequency	day/yr	52	BPJ (3)	CDI (mg/kg/day) =
	ED	Exposure Duration	yr	30	U.S. EPA 1989	DA_{event} x SA x EF x ED / (BW x AT)
	BW	Body Weight	kg	70	U.S. EPA 1997	
	AT-NC	Averaging Time - Noncancer	days	10,950	U.S. EPA 1989	
	AT-C	Averaging Time - Cancer	days	25,550	U.S. EPA 1989	
	CF	Conversion Factor	L/cm^3	0.001	U.S. EPA 1989	

NOTES:
BPJ = Best Professional Judgement
CDI = chronic daily intake
DA_{event} = Dermal Absorbed Dose per event, Example calculated in Appendix F
(1) The watermen contact would be limited to the hands and forearms arms since contact to surface water is primarily while hauling fishing nets into boat.
The arm SA at 2,910 cm^2 and hands at 990 cm^2. This results in an SA of 3,900 cm^2.
(2) Overall exposure time for water contact
(3) Fishing is expected to occur year-round, for a total of 12 months or 52 weeks. It is expected that a watermen would not fish exclusively in the intercoastal wat
near the Falcon Refinery Superfund Site. The watermen fishes near the site 1 day/week for a total of 52 days/year.

TABLE 10
VALUES USED FOR ADULT RECREATIONAL USER DAILY SEDIMENT INTAKE EQUATIONS
AOC-5, FALCON REFINERY
INGLESIDE, SAN PATRICIO COUNTY, TEXAS

Scenario Timeframe: Current
Medium: Sediment
Exposure Medium: Sediment
Exposure Point: AOC 5
Receptor Population: Recreational User
Receptor Age: Adult

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/Reference	Intake Equation
Dermal	CS	Chemical Concentration in Sediment	mg/kg	Chemical-Specific	Chemical-Specific	CDI (mg/kg/day) =
	SA	Surface Area for Contact	cm^2/event	3,870	BPJ (1)	CS x SA x AF x ABS x EF x ED x CF / (BW x AT)
	AF	Adherence Factor	mg/cm^2	0.07	U.S. EPA 2004 (2)	
	ABS	Dermal Absorption Fraction	Unitless	Chemical-Specific	U.S. EPA 2004	
	EF	Exposure Frequency	event/yr	4	BPJ (3)	
	ED-C	Exposure Duration - Cancer	yr	30	U.S. EPA 1989	
	BW	Body Weight	kg	70	U.S. EPA 1997	
	AT-NC	Averaging Time - Noncancer	days	10,950	U.S. EPA 1989	
	AT-C	Averaging Time - Cancer	days	25,550	U.S. EPA 1989	
	CF	Conversion Factor	kg/mg	1.0E-06	U.S. EPA 1989	

NOTES:
BPJ = Best Professional Judgement
CDI = chronic daily intake
(1) Contact with sediment will be with the feet and lower legs. For the adult, the lower legs are 2,560 cm^2 and the feet are 1,310 cm^2, with a total of 3,870 cm^2.
(2) The adherence factor is conservatively equal to the recommended factor for resident adult exposure to soil
(3) Swimming will occur only on a limited basis, 4 days/year because this is an intercoastal waterway with barge traffic.

TABLE 11
VALUES USED FOR ADOLESCENT RECREATIONAL USER DAILY SEDIMENT INTAKE EQUATIONS
AOC-5, FALCON REFINERY
INGLESIDE, SAN PATRICIO COUNTY, TEXAS

Scenario Timeframe: Current
Medium: Sediment
Exposure Medium: Sediment
Exposure Point: AOC 5
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/Reference	Intake Equation
Dermal	CS	Chemical Concentration in Sediment	mg/kg	Chemical-Specific	Chemical-Specific	CDI (mg/kg/day) =
	SA	Surface Area for Contact	cm^2/event	3,870	U.S. EPA 1997b (1)	CS x SA x AF x ABS x EF x ED x CF / (BW x AT)
	AF	Adherence Factor	mg/cm^2	0.2	U.S. EPA 2004 (2)	
	ABS	Dermal Absorption Fraction	Unitless	Chemical-Specific	U.S. EPA 2004	
	EF	Exposure Frequency	event/yr	4	BPJ (3)	
	ED-C	Exposure Duration - Cancer	yr	10	BPJ	
	BW	Body Weight	kg	45	U.S. EPA 1997	
	AT-NC	Averaging Time - Noncancer	days	3,650	U.S. EPA 1989	
	AT-C	Averaging Time - Cancer	days	25,550	U.S. EPA 1989	
	CF	Conversion Factor	kg/mg	1.0E-06	U.S. EPA 1989	

NOTES:
BPJ = Best Professional Judgement
CDI = chronic daily intake
(1) Contact with sediment will be with the feet and lower legs. For the adolescent, the surface area for the adult lower legs are 2,560 cm^2 and the feet are 1,310 cm^2, with a total of 3,870 cm^2.
(2) The adherence factor is conservatively equal to the recommended factor for resident child exposure to soil.
(3) Swimming will occur only on a limited basis, 4 days/year because this is an intercoastal waterway with barge traffic.

TABLE 12
VALUES USED FOR WATERMEN DAILY SEDIMENT INTAKE EQUATIONS
AOC-5, FALCON REFINERY
INGLESIDE, SAN PATRICIO COUNTY, TEXAS

Scenario Timeframe: Current
Medium: Sediment
Exposure Medium: Sediment
Exposure Point: AOC 5
Receptor Population: Watermen
Receptor Age: Adult

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/Reference	Intake Equation
Dermal	CS	Chemical Concentration in Sediment	mg/kg	Chemical-Specific	Chemical-Specific	CDI (mg/kg/day) =
	SA	Surface Area for Contact	cm^2/event	3,900	U.S. EPA 2011 (1)	CS x SA x AF x ABS x EF x ED x CF / (BW x AT)
	AF	Adherence Factor	mg/cm^2	0.2	U.S. EPA 2004 (2)	
	ABS	Dermal Absorption Fraction	Unitless	Chemical-Specific	U.S. EPA 2004	
	EF	Exposure Frequency	event/yr	52	BPJ (3)	
	ED-C	Exposure Duration - Cancer	yr	30	U.S. EPA 1989	
	BW	Body Weight	kg	70	U.S. EPA 1997	
	AT-NC	Averaging Time - Noncancer	days	10,950	U.S. EPA 1989	
	AT-C	Averaging Time - Cancer	days	25,550	U.S. EPA 1989	
	CF	Conversion Factor	kg/mg	1.0E-06	U.S. EPA 1989	

NOTES:
BPJ = Best Professional Judgement
CDI = chronic daily intake
(1) The watermen contact would be limited to the hands and forearms arms since contact to sediment is primarily while hauling fishing nets into boat. The arm SA at 2,910 cm^2 and hands at 990 cm^2. This results in an SA of 3,900 cm^2.
(2) The adherence factor is conservatively equal to the recommended factor for commercial/industrial worker exposure to soil
(3) Fishing is expected to occur year-round, for a total of 12 months or 52 weeks. It is expected that a watermen would not fish exclusively in the intercoastal water near the Falcon Refinery Superfund Site. The watermen fishes near the site 1 day/week for a total of 52 days/year.

TABLE 13
VALUES USED FOR ADULT RECREATIONAL USER DAILY FINFISH/CRAB INTAKE EQUATIONS
AOC-5, FALCON REFINERY
INGLESIDE, SAN PATRICIO COUNTY, TEXAS

Scenario Timeframe: Current
Medium: Surface Water/Sediment
Exposure Medium: Fish/Crab
Exposure Point: AOC 5
Receptor Population: Recreational User
Receptor Age: Adult

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/Reference	Intake Equation
Ingestion	CS	Chemical Concentration in Fish Tissue/Crab Meat	mg/kg	Chemical-Specific	Chemical-Specific	CDI (mg/kg/day) =
	CR	Ingestion Rate	kg/meal	0.232	U.S EPA 2011 (1)	CS x CR x EF x ED / (BW x AT)
	EF	Exposure Frequency	meals/yr	42	U.S EPA 2011 (1)	
	ED	Exposure Duration	yr	30	U.S. EPA 1989	
	BW	Body Weight	kg	70	U.S. EPA 1997	
	AT-NC	Averaging time - Noncancer	days	10,950	U.S. EPA 1989	
	AT-C	Averaging Time - Cancer	days	25,550	U.S. EPA 1989	

NOTES:
BPJ = Best Professional Judgement
CDI = chronic daily intake
(1) The weight of fish ingested by an adult is taken from Table 10-62 of USEPA 2011 EFH. Portion size is the 95 UCL for the adult male, which is 8.2 ounces or 0.232 kg.
The number of meals is the 95UCL of the adult male, which is 3.5 meals per month for 12 months.

TABLE 14
VALUES USED FOR ADOLESCENT RECREATIONAL USER DAILY FINFISH/CRAB INTAKE EQUATIONS
AOC-5, FALCON REFINERY
INGLESIDE, SAN PATRICIO COUNTY, TEXAS

Scenario Timeframe: Current
Medium: Surface Water/Sediment
Exposure Medium: Fish/Crab
Exposure Point: AOC 5
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/Reference	Intake Equation
Ingestion	CS	Chemical Concentration in Fish Tissue/Crab Meat	mg/kg	Chemical-Specific	Chemical-Specific	CDI (mg/kg/day) =
	CR	Ingestion Rate	kg/meal	0.196	U.S. EPA 2011 (1)	CS x CR x EF x ED / (BW x AT)
	EF	Exposure Frequency	meals/yr	32	U.S. EPA 2011 (1)	
	ED	Exposure Duration	yr	10	BPJ	
	BW	Body Weight	kg	45	U.S. EPA 1997	
	AT-NC	Averaging time - Noncancer	days	3,650	U.S. EPA 1989	
	AT-C	Averaging Time - Cancer	days	25,550	U.S. EPA 1989	

NOTES:
BPJ = Best Professional Judgement
CDI = chronic daily intake
(1) The weight of fish ingested by an adult is taken from Table 10-62 of USEPA 2011 EFH. Portion size is the 95 UCL for the youth (6 to 19 years), which is 6.9 ounces or 0.196 kg. The number of meals is the 95UCL of the youth, which is 2.7 meals per month for 12 months.

TABLE 15
VALUES USED FOR WATERMEN DAILY FINFISH/CRAB INTAKE EQUATIONS
AOC-5, FALCON REFINERY
INGLESIDE, SAN PATRICIO COUNTY, TEXAS

Scenario Timeframe: Current
Medium: Surface Water/Sediment
Exposure Medium: Fish/Crab
Exposure Point: AOC 5
Receptor Population: Watermen
Receptor Age: Adult

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/Reference	Intake Equation / Model Name
Ingestion	CS	Chemical Concentration in Fish Tissue/Crab Meat	mg/kg	Chemical-Specific	Chemical-Specific	CDI (mg/kg/day) =
	CR	Ingestion Rate	kg/meal	0.232	U.S. EPA 2011 (1)	CS x CR x EF x ED / (BW x AT)
	EF	Exposure Frequency	meals/yr	52	BPJ (2)	
	ED	Exposure Duration	yr	30	BPJ	
	BW	Body Weight	kg	70	U.S. EPA 1997	
	AT-NC	Averaging time - Noncancer	days	10,950	U.S. EPA 1989	
	AT-C	Averaging Time - Cancer	days	25,550	U.S. EPA 1989	

NOTES:
Note : BPJ = Best Professional Judgement
CDI = chronic daily intake
(1) The weight of fish ingested by an adult is taken from Table 10-62 of USEPA 2011 EFH. Portion size is the 95 UCL for the adult male, which is 8.2 ounces or 0.232 kg.
The number of meals is the 95UCL of the adult male, which is 3.5 meals per month for 12 months.
(2) It is assumed that the recreational user will fish from the waterway 1 days per week during the year (52 Days).

TABLE 16
NON-CANCER TOXICITY DATA - ORAL/DERMAL
AOC-5, FALCON REFINERY
INGLESIDE, SAN PATRICIO COUNTY, TEXAS

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD Value (mg/kg-day)	Oral to Dermal Adjustment Factor (GI ABS) (1)	Adjusted Dermal RfD (2) (mg/kg bw-day)	Primary Target Organ	Combined Uncertainty/ Modifying Factors	Sources of RfD: Target Organ	Dates of RfD: Target Organ (3) (mm/dd/yy)
METALS								
ARSENIC	Chronic	3.00E-04	1	3.00E-04	Skin	3/1	IRIS	3/10/2014
CHROMIUM VI	Chronic	3.00E-03	0.025	7.50E-05	None	300/1	IRIS	3/10/2014
COPPER	Chronic	4.00E-02	1	4.00E-02	Gastrointestinal System	NA/NA	HEAST	1997
SELENIUM	Chronic	5.00E-03	1	5.00E-03	Hair and Skin	3/1	IRIS	3/10/2014
THALLIUM	Chronic	1.00E-05	1	1.00E-05	Hair	3000/1	PPRTV	9/17/2012
PAHS								
BENZO(A)PYRENE	NA	NA	1	NA	NA	NA/NA	IRIS	3/10/2014
Semivolatiles								
BIS(2-ETHYLHEXYL)PHTHALATE	Chronic	2.00E-02	1	2.00E-02	Liver	1000/1	IRIS	3/10/2014

NOTES:

NA = Not Applicable

(1) Taken from USEPA 2004 Guidance.

(2) Dermal toxicological values adjusted from oral values using USEPA 2004 recommended chemical-specific gastrointestinal absorption factors (GI ABS). RfDs are multiplied by the GI ABS.

(3) IRIS - Integrated Risk Information System. For IRIS values, the date IRIS was searched is provided.
HEAST - Health Effects Assessment Summary Tables. For HEAST values, the date of HEAST is provided.
EPA-NCEA - National Center for Environmental Assessment. For EPA-NCEA values, the date of the article provided by EPA-NCEA is provided.
PPRTV - Provisional Peer-Reviewed Toxicity Value. For PPRTV values, the date of the issue paper is provided.
CalEPA - Calfornia Environmental Protection Agency. For CalEPA values, the date searched is provided.
ATSDR - Agency for Toxic Substances and Disease Registry, Minimal Risk Level (MRL).

TABLE 17
NON-CANCER TOXICITY DATA - INHALATION
AOC-5, FALCON REFINERY
INGLESIDE, SAN PATRICIO COUNTY, TEXAS

Chemical of Potential Concern	Chronic/ Subchronic	Value Inhalation (RfC) (mg/m^3)	Primary Target Organ	Combined Uncertainty/Modifying Factors	Sources of RfC:RfD: Target Organ	Dates [1] (mm/dd/yy)
Inorganics						
ARSENIC	Chronic	1.50E-05	Developmental System	30/1	CalEPA	3/10/2014
CHROMIUM VI	Chronic	1.00E-04	Lungs and Blood	300/1	IRIS	3/10/2014
COPPER	NA	NA	NA	NA	IRIS	3/10/2014
SELENIUM	NA	2.00E-02	Liver	NA	CalEPA	3/10/2014
THALLIUM	NA	NA	NA	NA	PPRTV	9/17/2012
PAHs						
BENZO(A)PYRENE	NA	NA	NA	NA	IRIS	3/10/2014
Semivolatiles						
BIS(2-ETHYLHEXYL)PHTHALATE	NA	NA	NA	NA	IRIS	3/10/2014

NOTES:

NA = Not Applicable

(1) IRIS - Integrated Risk Information System. For IRIS values, the date IRIS was searched is provided.
CalEPA - Calfornia Environmental Protection Agency. For CalEPA values, the date searched is provided.
PPRTV - Provisional Peer-Reviewed Toxicity Value. For PPRTV values, the date of the issue paper is provided.

TABLE 18
CHEMICAL-SPECIFIC PARAMETERS
AOC-5, FALCON REFINERY
INGLESIDE, SAN PATRICIO COUNTY, TEXAS

Chemical of Potential Concern	Absorption Factor	Reference	GI ABS	Reference	Permeability Constant (cm/hr)	Reference
Inorganics						
ARSENIC	0.03	U.S. EPA, 2004	1	U.S. EPA, 2004	1.00E-03	U.S. EPA 2004
CHROMIUM VI	0.01	U.S. EPA, 2004	0.025	U.S. EPA, 2004	2.00E-03	U.S. EPA 2004
COPPER	0.01	U.S. EPA, 2003c	1	U.S. EPA, 2004	1.00E-03	U.S. EPA 2004
SELENIUM	0.01	U.S. EPA, 2003c	1	U.S. EPA, 2004	9.03E-04	U.S. EPA 2004
THALLIUM	0.01	U.S. EPA, 2003c	1	U.S. EPA, 2004	1.00E-03	U.S. EPA 2004
PAHs						
BENZO(A)PYRENE	0.13	U.S. EPA, 2004	1	U.S. EPA, 2004	7.00E-01	U.S. EPA 2004
Semivolatiles						
BIS(2-ETHYLHEXYL)PHTHALATE	0.1	U.S. EPA, 2004	1	U.S. EPA, 2004	1.97E+00	On-line Database(1)

NOTES:

NA = Data not available.
GI ABS = Gastrointestional Absorption factors
(1) Toxicity and Chemical-Specific Factors Database. Http://risk.lsd.ornl.gov/cgi-bin/tox. May 2010.
U.S. EPA, 2004 = U.S. Environmental Protection Agency, 2004. *Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment)*. Final Guidance.
U.S. EPA, 2003c = U.S. Environmental Protection Agency, 2003. Region 3, Updated Deraml Exposure Assessment Guidance. Mid-Atlantic Risk Assessment. June. Available at: http://www.epa.gov/reg3hwmd/risk/human/info/dermalag.htm.

TABLE 19
CANCER TOXICITY DATA - ORAL/DERMAL
AOC-5, FALCON REFINERY
INGLESIDE, SAN PATRICIO COUNTY, TEXAS

Chemical of Potential Concern	Oral Cancer Slope Factor	Oral Absorption Efficiency for Dermal (GI ABS)(1)	Absorbed Cancer Slope Factor for Dermal (2)	Units	Weight of Evidence/Cancer Guideline Description	Mutagenic Compound	Source	Date (3) (mm/dd/yy)
Inorganics								
ARSENIC	1.50E+00	1	1.50E+00	per (mg/kg-day)	A		IRIS	3/10/2014
CHROMIUM VI	5.00E-01	0.025	2.00E+01	per (mg/kg-day)	B2		NJDEP	4/8/2009
COPPER	NA	1	NA	per (mg/kg-day)	D		IRIS	3/10/2014
SELENIUM	NA	1	NA	per (mg/kg-day)	D		IRIS	3/10/2014
THALLIUM	NA	1	NA	per (mg/kg-day)	NA		IRIS	3/10/2014
PAHs								
BENZO(A)PYRENE	7.30E+00	1	7.30E+00	per (mg/kg-day)	B2	M	IRIS	3/10/2014
Semivolatiles								
BIS(2-ETHYLHEXYL)PHTHALATE	1.40E-02	1	1.40E-02	per (mg/kg-day)	B2		IRIS	3/10/2014

NOTES:

M = Chemical has a mutagenic mode of action
mg/kg-day = Milligram per kilogram-day
NA = Not Applicable

(1) Taken from USEPA 2004 Guidance.
(2) Dermal Toxicological values adjusted from oral values using USEPA 2004 recommended chemical-specific gastrointestinal absorption factors (GI ABS). CSFs are divided by the GI ABS.
(3) IRIS - Integrated Risk Information System. For IRIS values, the date IRIS was searched is
EPA-NCEA - National Center for Environmental Assessment. For EPA-NCEA values, the date of the article is provided .
PPRTV - Provisional Peer-Reviewed Toxicity Value. For PPRTV values, the date of the issue paper is provided.
CalEPA - Calfornia Environmental Protection Agency.
NJDEP - New Jersey Department of Environmental Protection.

Weight of Evidence: A - Human carcinogen
B1 - Probable human carcinogen - indicate that limited human data are available
B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans
C - Possible human carcinogen
D - Not classifiable as a human carcinogen
E - Evidence of noncarcinogenicity

TABLE 20
CANCER TOXICITY DATA - INHALATION
AOC-5, FALCON REFINERY
INGLESIDE, SAN PATRICIO COUNTY, TEXAS

Chemical of Potential Concern	Unit Risk		Weight of Evidence/Cancer Guideline Description	Mutagenic Compound	Unit Risk - Inhalation CSF	
	Value	Units			Source	Date (1)
Inorganics						
ARSENIC	4.30E-03	per (ug/m^3)	A		IRIS	3/10/2014
CHROMIUM VI	8.40E-02	per (ug/m^3)	A		IRIS	3/10/2014
COPPER	NA	per (ug/m^3)	D		IRIS	3/10/2014
SELENIUM	NA	per (ug/m^3)	D		IRIS	3/10/2014
THALLIUM	NA	per (ug/m^3)	NA		IRIS	3/10/2014
PAHs						
BENZO(A)PYRENE	1.10E-03	per (ug/m^3)	B2		CalEPA	5/2009
Semivolatiles						
BIS(2-ETHYLHEXYL)PHTHALATE	2.40E-06	per (ug/m^3)	B2		CalEPA	5/2009

NOTES:

ug/m^3 = Microgram per cubic meter

NA = Not Applicable

(1) IRIS - Integrated Risk Information System. For IRIS values, the date IRIS was searched is provided.
EPA-NCEA - National Center for Environmental Assessment. For EPA-NCEA values, the date of the article is provided .
PPRTV - Provisional Peer-Reviewed Toxicity Value. For PPRTV values, the date of the issue paper is provided.

Weight of Evidence: A - Human carcinogen
B1 - Probable human carcinogen - indicate that limited human data are available
B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans
C - Possible human carcinogen
D - Not classifiable as a human carcinogen
E - Evidence of noncarcinogenicity

TABLE 21
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE - ADULT RECREATIONAL USER
AOC-5, FALCON REFINERY
INGLESIDE, SAN PATRICIO COUNTY, TEXAS

Scenario Timeframe: Current
Receptor Population: Recreational User
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC*		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake		CSF		Cancer Risk	Intake		RfD		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
	Sediment	AOC 5	Dermal[1]	**METALS**												
				ARSENIC	5.57E+00	(mg/kg)	3.04E-09	(mg/kg-day)	1.50E+00	per (mg/kg-day)	4.6E-09	7.09E-09	(mg/kg-day)	3.00E-04	(mg/kg-day)	2.4E-05
				CHROMIUM VI	5.70E+00	(mg/kg)	1.04E-09	(mg/kg-day)	2.00E+01	per (mg/kg-day)	2.1E-08	2.42E-09	(mg/kg-day)	7.50E-05	(mg/kg-day)	3.2E-05
				PAHS												
				BENZO(A)PYRENE	3.45E-01	(mg/kg)	8.15E-10	(mg/kg-day)	7.30E+00	per (mg/kg-day)	6.0E-09	1.90E-09	(mg/kg-day)	NA	(mg/kg-day)	--
			Exp. Route Total								**3.1E-08**					**5.6E-05**
		Exposure Point Total									**3.1E-08**					**5.6E-05**
	Exposure Medium Total										**3.1E-08**					**5.6E-05**
Sediment Total											**3.1E-08**					**5.6E-05**
Surface Water	Surface Water	AOC 5	Ingestion	**METALS**												
				SELENIUM	8.40E-02	(mg/L)	1.13E-07	(mg/kg-day)	NA	per (mg/kg-day)	--	2.63E-07	(mg/kg-day)	5.00E-03	(mg/kg-day)	5.3E-05
			Exp. Route Total								**0.0E+00**					**5.3E-05**
			Dermal	**METALS**												
				SELENIUM	8.40E-02	(mg/L)	1.83E-07	(mg/kg-day)	NA	per (mg/kg-day)	--	4.27E-07	(mg/kg-day)	5.00E-03	(mg/kg-day)	8.5E-05
			Exp. Route Total								**0.0E+00**					**8.5E-05**
		Exposure Point Total									**0.0E+00**					**1.4E-04**
		Finfish	Ingestion	**METALS**												
				COPPER	3.47E+01	(mg/kg)	5.67E-03	(mg/kg-day)	NA	per (mg/kg-day)	--	1.32E-02	(mg/kg-day)	4.00E-02	(mg/kg-day)	3.3E-01
				SELENIUM	2.03E+01	(mg/kg)	3.32E-03	(mg/kg-day)	NA	per (mg/kg-day)	--	7.75E-03	(mg/kg-day)	5.00E-03	(mg/kg-day)	1.6E+00
				Semivolatiles												
				BIS(2-ETHYLHEXYL)PHTHALATE	1.41E+00	(mg/kg)	2.30E-04	(mg/kg-day)	1.40E-02	per (mg/kg-day)	3.2E-06	5.38E-04	(mg/kg-day)	2.00E-02	(mg/kg-day)	2.7E-02
			Exp. Route Total								**3.2E-06**					**1.9E+00**
		Exposure Point Total									**3.2E-06**					**1.9E+00**
	Exposure Medium Total										**3.2E-06**					**1.9E+00**
Surface Water Total											**3.2E-06**					**1.9E+00**
										Total of Receptor Risks Across All Media	**3.3E-06**			Total of Receptor Hazards Across All Media		**1.9E+00**

NOTES:
1) Dermal Intake is "NA" due to no reccomended Dermal Absorption Fractions (ABS) for this chemical. Table 5.5.2 presents dermal ABS values.
EPC = Exposure Point Concentration
CSF = Cancer Slope Factor
mg/kg = Milligram per kilogram
mg/kg-day = Milligram per kilogram-day
RfD = Reference Dose
RfC = Reference Concentration

TABLE 22
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE - ADOLESCENT RECREATIONAL USER
AOC-5, FALCON REFINERY
INGLESIDE, SAN PATRICIO COUNTY, TEXAS

Scenario Timeframe: Current
Receptor Population: Recreational User
Receptor Age: Adolescent

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC*		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake		CSF		Cancer Risk	Intake		RfD		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Sediment	Sediment	AOC 5	Dermal[1]	**METALS**												
				ARSENIC	5.57E+00	(mg/kg)	4.50E-09	(mg/kg-day)	1.50E+00	per (mg/kg-day)	6.7E-09	3.15E-08	(mg/kg-day)	3.00E-04	(mg/kg-day)	1.0E-04
				CHROMIUM VI	5.70E+00	(mg/kg)	1.53E-09	(mg/kg-day)	2.00E+01	per (mg/kg-day)	3.1E-08	1.07E-08	(mg/kg-day)	7.50E-05	(mg/kg-day)	1.4E-04
				PAHS												
				BENZO(A)PYRENE	3.45E-01	(mg/kg)	3.62E-09	(mg/kg-day)	7.30E+00	per (mg/kg-day)	2.6E-08	8.45E-09	(mg/kg-day)	NA	(mg/kg-day)	--
			Exp. Route Total								**6.4E-08**					**2.5E-04**
		Exposure Point Total									**6.4E-08**					**2.5E-04**
	Exposure Medium Total										**6.4E-08**					**2.5E-04**
Sediment Total											**6.4E-08**					**2.5E-04**
Surface Water	Surface Water	AOC 5	Ingestion	**METALS**												
				SELENIUM	8.40E-02	(mg/L)	2.92E-08	(mg/kg-day)	NA	per (mg/kg-day)	--	2.04E-07	(mg/kg-day)	5.00E-03	(mg/kg-day)	4.1E-05
			Exp. Route Total								**0.0E+00**					**4.1E-05**
			Dermal	**METALS**												
				SELENIUM	8.40E-02	(mg/L)	7.04E-08	(mg/kg-day)	NA	per (mg/kg-day)	--	4.93E-07	(mg/kg-day)	5.00E-03	(mg/kg-day)	9.9E-05
			Exp. Route Total								**0.0E+00**					**9.9E-05**
		Exposure Point Total									**0.0E+00**					**1.4E-04**
		Finfish	Ingestion	**METALS**												
				COPPER	3.47E+01	(mg/kg)	1.89E-03	(mg/kg-day)	NA	per (mg/kg-day)	--	1.32E-02	(mg/kg-day)	4.00E-02	(mg/kg-day)	3.3E-01
				SELENIUM	2.03E+01	(mg/kg)	1.11E-03	(mg/kg-day)	NA	per (mg/kg-day)	--	7.76E-03	(mg/kg-day)	5.00E-03	(mg/kg-day)	1.6E+00
				Semivolatiles												
				BIS(2-ETHYLHEXYL)PHTHALATE	1.41E+00	(mg/kg)	7.69E-05	(mg/kg-day)	1.40E-02	per (mg/kg-day)	1.1E-06	5.38E-04	(mg/kg-day)	2.00E-02	(mg/kg-day)	2.7E-02
			Exp. Route Total								**1.1E-06**					**1.9E+00**
		Exposure Point Total									**1.1E-06**					**1.9E+00**
	Exposure Medium Total										**1.1E-06**					**1.9E+00**
Surface Water Total											**1.1E-06**					**1.9E+00**
										Total of Receptor Risks Across All Media	**1.1E-06**	Total of Receptor Hazards Across All Media				**1.9E+00**

NOTES:
1) Dermal Intake is "NA" due to no reccomended Dermal Absorption Fractions (ABS) for this chemical. Table 5.5.2 presents dermal ABS values.
EPC = Exposure Point Concentration
CSF = Cancer Slope Factor
mg/kg = Milligram per kilogram
mg/kg-day = Milligram per kilogram-day
RfD = Reference Dose
RfC = Reference Concentration

TABLE 23
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE - WATERMEN
AOC-5, FALCON REFINERY
INGLESIDE, SAN PATRICIO COUNTY, TEXAS

Scenario Timeframe: Current
Receptor Population: Watermen
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC*		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake		CSF		Cancer Risk	Intake		RfD		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Sediment	Sediment	AOC 5	Dermal[1]	**METALS**												
				ARSENIC	5.57E+00	(mg/kg)	1.14E-07	(mg/kg-day)	1.50E+00	per (mg/kg-day)	1.7E-07	2.65E-07	(mg/kg-day)	3.00E-04	(mg/kg-day)	8.8E-04
				CHROMIUM VI	5.70E+00	(mg/kg)	3.88E-08	(mg/kg-day)	2.00E+01	per (mg/kg-day)	7.8E-07	9.05E-08	(mg/kg-day)	7.50E-05	(mg/kg-day)	1.2E-03
				PAHS												
				BENZO(A)PYRENE	3.45E-01	(mg/kg)	3.05E-08	(mg/kg-day)	7.30E+00	per (mg/kg-day)	2.2E-07	7.12E-08	(mg/kg-day)	NA	(mg/kg-day)	--
			Exp. Route Total								**1.2E-06**					**2.1E-03**
		Exposure Point Total									**1.2E-06**					**2.1E-03**
	Exposure Medium Total										**1.2E-06**					**2.1E-03**
Sediment Total											**1.2E-06**					**2.1E-03**
Surface Water	Surface Water	AOC 5	Dermal	**METALS**												
				SELENIUM	8.40E-02	(mg/L)	5.16E-07	(mg/kg-day)	NA	per (mg/kg-day)	--	1.20E-06	(mg/kg-day)	5.00E-03	(mg/kg-day)	2.4E-04
			Exp. Route Total								**0.0E+00**					**2.4E-04**
		Exposure Point Total									**0.0E+00**					**2.4E-04**
		Finfish	Ingestion	**METALS**												
				COPPER	3.47E+01	(mg/kg)	7.02E-03	(mg/kg-day)	NA	per (mg/kg-day)	--	1.64E-02	(mg/kg-day)	4.00E-02	(mg/kg-day)	4.1E-01
				SELENIUM	2.03E+01	(mg/kg)	4.11E-03	(mg/kg-day)	NA	per (mg/kg-day)	--	9.60E-03	(mg/kg-day)	5.00E-03	(mg/kg-day)	1.9E+00
				Semivolatiles												
				BIS(2-ETHYLHEXYL)PHTHALATE	1.41E+00	(mg/kg)	2.85E-04	(mg/kg-day)	1.40E-02	per (mg/kg-day)	4.0E-06	6.66E-04	(mg/kg-day)	2.00E-02	(mg/kg-day)	3.3E-02
			Exp. Route Total								**4.0E-06**					**2.4E+00**
		Exposure Point Total									**4.0E-06**					**2.4E+00**
	Exposure Medium Total										**4.0E-06**					**2.4E+00**
Surface Water Total											**4.0E-06**					**2.4E+00**
										Total of Receptor Risks Across All Media	**5.2E-06**	Total of Receptor Hazards Across All Media				**2.4E+00**

NOTES:
1) Dermal Intake is "NA" due to no reccomended Dermal Absorption Fractions (ABS) for this chemical. Table 5.5.2 presents dermal ABS values.
EPC = Exposure Point Concentration
CSF = Cancer Slope Factor
mg/kg = Milligram per kilogram
mg/kg-day = Milligram per kilogram-day
RfD = Reference Dose
RfC = Reference Concentration

TABLE 24
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE - ADULT RECREATIONAL USER
AOC-5, FALCON REFINERY
AOC 5, FALCON REFINERY SUPERFUND SITE

Location: AOC 5

Scenario Timeframe: Current
Receptor Population: Recreational User
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Dermal	Inhalation	Exposure Routes Total		Primary Target Organ	Ingestion	Dermal	Inhalation	Exposure Routes Total
Surface Water	Surface Water	AOC 5	**METALS**					**METALS**					
			SELENIUM	--	--	--	NA	SELENIUM	Hair and Skin	5.3E-05	8.5E-05	--	1.4E-04
			(Total)	---	---	---	---		(Total)	5.3E-05	8.5E-05	---	1.4E-04
	Finfish	AOC 5	**METALS**					**METALS**					
			COPPER	--	--	--	NA	COPPER	Gastrointestinal System	3.3E-01	--	--	3.3E-01
			SELENIUM	--	--	--	NA	SELENIUM	Hair and Skin	1.6E+00	--	--	1.6E+00
			Semivolatiles					**Semivolatiles**					
			BIS(2-ETHYLHEXYL)PHTHALATE	3.2E-06	--	--	3.2E-06	BIS(2-ETHYLHEXYL)PHTHALATE	Liver	2.7E-02	--	--	2.7E-02
			(Total for Finfish)	3.2E-06	---	---	3.2E-06		(Total for Finfish)	1.9E+00	---	---	1.9E+00
						Total Risk Across Surface Water	**3.2E-06**					**Total Hazard Index Across Surface Water**	**1.9E+00**
Sediment	Sediment	AOC 5	**METALS**					**METALS**					
			ARSENIC	--	4.6E-09	--	4.6E-09	ARSENIC	Skin	--	2.4E-05	--	2.4E-05
			CHROMIUM VI	--	2.1E-08	--	2.1E-08	CHROMIUM VI	None	--	3.2E-05	--	3.2E-05
			PAHS					**PAHS**					
			BENZO(A)PYRENE	--	6.0E-09	--	6.0E-09	BENZO(A)PYRENE	NA	--	--	--	NA
			(Total)	---	3.1E-08	---	3.1E-08		(Total)	---	5.6E-05	---	5.6E-05
						Total Risk Across Sediment	**3.1E-08**					**Total Hazard Index Across Sediment**	**5.6E-05**
						Total Risk Across All Media and All Exposure Routes	**3E-06**					**Total Hazard Index Across All Media and All Exposure Routes**	**2**

NOTE:
-- = exposure pathway not complete and evaluated.

TABLE 25
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE - ADOLESCENT RECREATIONAL USER
AOC-5, FALCON REFINERY
AOC 5, FALCON REFINERY SUPERFUND SITE

Location: AOC 5
Scenario Timeframe: Current
Receptor Population: Recreational User
Receptor Age: Adolescent

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Dermal	Inhalation	Exposure Routes Total		Primary Target Organ	Ingestion	Dermal	Inhalation	Exposure Routes Total
Surface Water	Surface Water	AOC 5	**METALS**					**METALS**					
			SELENIUM	--	--	--	NA	SELENIUM	Hair and Skin	4.1E-05	9.9E-05	--	1.4E-04
			(Total)	---	---	---	---		(Total)	4.1E-05	9.9E-05	---	1.4E-04
	Finfish	AOC 5	**METALS**					**METALS**					
			COPPER	--	--	--	NA	COPPER	Gastrointestinal System	3.3E-01	--	--	3.3E-01
			SELENIUM	--	--	--	NA	SELENIUM	Hair and Skin	1.6E+00	--	--	1.6E+00
			Semivolatiles					**Semivolatiles**					
			BIS(2-ETHYLHEXYL)PHTHALATE	1.1E-06	--	--	1.1E-06	BIS(2-ETHYLHEXYL)PHTHALATE	Liver	2.7E-02	--	--	2.7E-02
			(Total for Finfish)	1.1E-06	---	---	1.1E-06		(Total for Finfish)	1.9E+00	---	---	1.9E+00
						Total Risk Across Surface Water	**1.1E-06**					**Total Hazard Index Across Surface Water**	**1.9E+00**
Sediment	Sediment	AOC 5	**METALS**					**METALS**					
			ARSENIC	--	6.7E-09	--	6.7E-09	ARSENIC	Skin	--	1.0E-04	--	1.0E-04
			CHROMIUM VI	--	3.1E-08	--	3.1E-08	CHROMIUM VI	None	--	1.4E-04	--	1.4E-04
			PAHS					**PAHS**					
			BENZO(A)PYRENE	--	2.6E-08	--	2.6E-08	BENZO(A)PYRENE	NA	--	--	--	NA
			(Total)	---	6.4E-08	---	6.4E-08		(Total)	---	2.5E-04	---	2.5E-04
						Total Risk Across Sediment	**6.4E-08**					**Total Hazard Index Across Sediment**	**2.5E-04**
						Total Risk Across All Media and All Exposure Routes	**1E-06**					**Total Hazard Index Across All Media and All Exposure Routes**	**2**

NOTE:
-- = exposure pathway not complete and evaluated.

TABLE 26
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE - WATERMEN
AOC-5, FALCON REFINERY
AOC 5, FALCON REFINERY SUPERFUND SITE

Location: AOC 5
Scenario Timeframe: Current
Receptor Population: Watermen
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Dermal	Inhalation	Exposure Routes Total		Primary Target Organ	Ingestion	Dermal	Inhalation	Exposure Routes Total
Surface Water	Surface Water	AOC 5	**METALS**					**METALS**					
			SELENIUM	--	--	--	NA	SELENIUM	Hair and Skin	--	2.4E-04	--	2.4E-04
			(Total)	---	---	---	---		(Total)	---	2.4E-04	---	2.4E-04
	Finfish	AOC 5	**METALS**					**METALS**					
			COPPER	--	--	--	NA	COPPER	Gastrointestinal System	4.1E-01	--	--	4.1E-01
			SELENIUM	--	--	--	NA	SELENIUM	Hair and Skin	1.9E+00	--	--	1.9E+00
			Semivolatiles					**Semivolatiles**					
			BIS(2-ETHYLHEXYL)PHTHALATE	4.0E-06	--	--	4.0E-06	BIS(2-ETHYLHEXYL)PHTHALATE	Liver	3.3E-02	--	--	3.3E-02
			(Total for Finfish)	4.0E-06	---	---	4.0E-06		(Total for Finfish)	2.4E+00	---	---	2.4E+00
							Total Risk Across Surface Water	**4.0E-06**				**Total Hazard Index Across Surface Water**	**2.4E+00**
Sediment	Sediment	AOC 5	**METALS**					**METALS**					
			ARSENIC	--	1.7E-07	--	1.7E-07	ARSENIC	Skin	--	8.8E-04	--	8.8E-04
			CHROMIUM VI	--	7.8E-07	--	7.8E-07	CHROMIUM VI	None	--	1.2E-03	--	1.2E-03
			PAHS					**PAHS**					
			BENZO(A)PYRENE	--	2.2E-07	--	2.2E-07	BENZO(A)PYRENE	NA	--	--	--	NA
			(Total)	---	1.2E-06	---	1.2E-06		(Total)	---	2.1E-03	---	2.1E-03
							Total Risk Across Sediment	**1.2E-06**				**Total Hazard Index Across Sediment**	**2.1E-03**
							Total Risk Across All Media and All Exposure Routes	**5E-06**				**Total Hazard Index Across All Media and All Exposure Routes**	**2**

NOTE:
-- = exposure pathway not complete and evaluated.

TABLE 27
HUMAN HEALTH RISK ASSESSMENT SUMMARY OF RESULTS
AOC-5, FALCON REFINERY
INGLESIDE, SAN PATRICIO COUNTY, TEXAS

Receptor	Media	Carcinogenic Risks[1]	Non-Carcinogenic Hazards	COPC Contributing Significantly to Results
AOC-5				
Adult Recreational User	Sediment	3×10^{-8}	0.00006	Not Applicable
	Surface Water	NA	0.0001	Not Applicable
	Fish Tissue	3×10^{-6}	2	Selenium
	Cumulative Result	**3×10^{-6}**	**2**	
Adolescent Recreational User	Sediment	6×10^{-8}	0.0003	Not Applicable
	Surface Water	NA	0.0001	Not Applicable
	Fish Tissue	1×10^{-6}	2	Selenium
	Cumulative Result	**1×10^{-6}**	**2**	
Watermen	Sediment	1×10^{-6}	0.002	Not Applicable
	Surface Water	NA	0.0002	Not Applicable
	Fish Tissue	4×10^{-6}	2	Selenium
	Cumulative Result	**5×10^{-6}**	**2**	

NOTE:
NA = Not Applicable

APPENDIX A

SAMPLES USED IN THE HUMAN HEALTH RISK ASSESSMENT

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APPENDIX A - SAMPLES EVALUATED IN THE HHRA
FALCON REFINERY SUPERFUND SITE
INGLESIDE, SAN PATRICIO COUNTY, TEXAS

Media	Sample Location	Parent Sample	Final Sample Location	Sample Date
		AOC-5		
SD	FR-222		FR-222	1/11/2008
SD	FR-224		FR-224	1/11/2008
SD	FR-226		FR-226	1/11/2008
SD	SD5-01-0.0-0.5		SD5-01-0.0-0.5	9/11/2013
SD	SD5-01-0.0-0.5 Dup	SD5-01-0.0-0.5	SD5-01-0.0-0.5	9/11/2013
SD	SD5-02-0.0-0.5		SD5-02-0.0-0.5	9/11/2013
SD	SD5-03-0.0-0.5		SD5-03-0.0-0.5	9/11/2013
SD	SD5-04-0.0-0.5		SD5-04-0.0-0.5	9/12/2013
SD	SD5-05-0.0-0.5		SD5-05-0.0-0.5	9/12/2013
SD	SD5-06-0.0-0.5		SD5-06-0.0-0.5	9/12/2013
SD	SD5-07-0.0-0.5		SD5-07-0.0-0.5	9/12/2013
SD	SD5-08-0.0-0.5		SD5-08-0.0-0.5	9/12/2013
SD	SD5-09-0.0-0.5		SD5-09-0.0-0.5	9/12/2013
SD	SD5-10-0.0-0.5		SD5-10-0.0-0.5	9/12/2013
WS	FR-220A		FR-220A	1/11/2008
WS	FR-223		FR-223	1/11/2008
WS	FR-225		FR-225	1/11/2008
WS	SW5-01		SW5-01	9/11/2013
WS	SW5-01 Dup	SW5-01	SW5-01	9/11/2013
WS	SW5-02		SW5-02	9/11/2013
WS	SW5-03		SW5-03	9/11/2013
WS	SW5-04		SW5-04	9/12/2013
WS	SW5-05		SW5-05	9/12/2013
WS	SW5-06		SW5-06	9/12/2013
WS	SW5-07		SW5-07	9/12/2013
WS	SW5-08		SW5-08	9/12/2013
WS	SW5-09		SW5-09	9/12/2013
WS	SW5-10		SW5-10	9/12/2013

NOTES:
SB = Subsurface Soil
SS = Surface Soil
WG = Groundwater
SD = Sediment
WS = Surface water

APPENDIX B

ProUCL OUTPUTS

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General UCL Statistics for Data Sets with Non-Detects

User Selected Options

From File	Sheet1.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	10000

SD_Arsenic

General Statistics

Number of Valid Observations	6	Number of Distinct Observations	6

Raw Statistics		**Log-transformed Statistics**	
Minimum	1.7	Minimum of Log Data	0.531
Maximum	7.1	Maximum of Log Data	1.96
Mean	4.017	Mean of log Data	1.293
Geometric Mean	3.643	SD of log Data	0.496
Median	3.9		
SD	1.888		
Std. Error of Mean	0.771		
Coefficient of Variation	0.47		
Skewness	0.671		

Warning: A sample size of 'n' = 6 may not adequate enough to compute meaningful and reliable test statistics and estimates!

It is suggested to collect at least 8 to 10 observations using these statistical methods!
If possible compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

Warning: There are only 6 Values in this data
Note: It should be noted that even though bootstrap methods may be performed on this data set,
the resulting calculations may not be reliable enough to draw conclusions

The literature suggests to use bootstrap methods on data sets having more than 10-15 observations.

Relevant UCL Statistics

Normal Distribution Test		**Lognormal Distribution Test**	
Shapiro Wilk Test Statistic	0.956	Shapiro Wilk Test Statistic	0.976
Shapiro Wilk Critical Value	0.788	Shapiro Wilk Critical Value	0.788
Data appear Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	

Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	5.57	95% H-UCL	7.386
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	7.586
95% Adjusted-CLT UCL (Chen-1995)	5.51	97.5% Chebyshev (MVUE) UCL	9.125
95% Modified-t UCL (Johnson-1978)	5.605	99% Chebyshev (MVUE) UCL	12.15

Gamma Distribution Test		**Data Distribution**
k star (bias corrected)	2.753	**Data appear Normal at 5% Significance Level**
Theta Star	1.459	
MLE of Mean	4.017	
MLE of Standard Deviation	2.421	
nu star	33.04	
Approximate Chi Square Value (.05)	20.9	**Nonparametric Statistics**
Adjusted Level of Significance	0.0122	95% CLT UCL 5.285
Adjusted Chi Square Value	17.5	95% Jackknife UCL 5.57
		95% Standard Bootstrap UCL 5.181
Anderson-Darling Test Statistic	0.204	95% Bootstrap-t UCL 6.007
Anderson-Darling 5% Critical Value	0.698	95% Hall's Bootstrap UCL 5.845
Kolmogorov-Smirnov Test Statistic	0.178	95% Percentile Bootstrap UCL 5.233
Kolmogorov-Smirnov 5% Critical Value	0.333	95% BCA Bootstrap UCL 5.25
Data appear Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL 7.377
		97.5% Chebyshev(Mean, Sd) UCL 8.831
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL 11.69
95% Approximate Gamma UCL (Use when n >= 40)	6.35	
95% Adjusted Gamma UCL (Use when n < 40)	7.583	

Potential UCL to Use	Use 95% Student's-t UCL 5.57

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)
and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

General UCL Statistics for Data Sets with Non-Detects

User Selected Options

From File	Sheet1.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	10000

SD_Benzo(a)pyrene

General Statistics

Number of Valid Data	11	Number of Detected Data	10
Number of Distinct Detected Data	10	Number of Non-Detect Data	1
		Percent Non-Detects	9.09%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.0077	Minimum Detected	-4.867
Maximum Detected	0.511	Maximum Detected	-0.671
Mean of Detected	0.0677	Mean of Detected	-3.849
SD of Detected	0.156	SD of Detected	1.274
Minimum Non-Detect	0.047	Minimum Non-Detect	-3.058
Maximum Non-Detect	0.047	Maximum Non-Detect	-3.058

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.433	Shapiro Wilk Test Statistic	0.778
5% Shapiro Wilk Critical Value	0.842	5% Shapiro Wilk Critical Value	0.842
Data not Normal at 5% Significance Level		**Data not Lognormal at 5% Significance Level**	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	0.0637	Mean	-3.84
SD	0.149	SD	1.209
95% DL/2 (t) UCL	0.145	95% H-Stat (DL/2) UCL	0.165
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		Mean in Log Scale	-3.881
		SD in Log Scale	1.214
		Mean in Original Scale	0.0629
		SD in Original Scale	0.149
		95% t UCL	0.144
		95% Percentile Bootstrap UCL	0.151
		95% BCA Bootstrap UCL	0.198
		95% H-UCL	0.16

Gamma Distribution Test with Detected Values Only		Data Distribution Test with Detected Values Only	
k star (bias corrected)	0.446	**Data do not follow a Discernable Distribution (0.05)**	
Theta Star	0.152		
nu star	8.929		
A-D Test Statistic	1.655	**Nonparametric Statistics**	
5% A-D Critical Value	0.774	Kaplan-Meier (KM) Method	
K-S Test Statistic	0.774	Mean	0.0628
5% K-S Critical Value	0.28	SD	0.142
Data not Gamma Distributed at 5% Significance Level		SE of Mean	0.0452
		95% KM (t) UCL	0.145
Assuming Gamma Distribution		95% KM (z) UCL	0.137
Gamma ROS Statistics using Extrapolated Data		95% KM (jackknife) UCL	0.144
Minimum	0.00542	95% KM (bootstrap t) UCL	1.056
Maximum	0.511	95% KM (BCA) UCL	0.153
Mean	0.062	95% KM (Percentile Bootstrap) UCL	0.151
Median	0.015	95% KM (Chebyshev) UCL	0.26
SD	0.149	97.5% KM (Chebyshev) UCL	0.345
k star	0.445	99% KM (Chebyshev) UCL	0.513
Theta star	0.14		
Nu star	9.78	**Potential UCLs to Use**	
AppChi2	3.805	97.5% KM (Chebyshev) UCL	0.345
95% Gamma Approximate UCL (Use when n >= 40)	0.159		
95% Adjusted Gamma UCL (Use when n < 40)	0.188		

Note: DL/2 is not a recommended method.

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

General UCL Statistics for Data Sets with Non-Detects

User Selected Options

From File	Sheet1.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	10000

WS_Copper

General Statistics

Number of Valid Data	10	Number of Detected Data	7
Number of Distinct Detected Data	7	Number of Non-Detect Data	3
		Percent Non-Detects	30.00%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	44.4	Minimum Detected	3.793
Maximum Detected	112	Maximum Detected	4.718
Mean of Detected	58.07	Mean of Detected	4.01
SD of Detected	23.94	SD of Detected	0.318
Minimum Non-Detect	200	Minimum Non-Detect	5.298
Maximum Non-Detect	200	Maximum Non-Detect	5.298

Warning: There are only 7 Detected Values in this data
Note: It should be noted that even though bootstrap may be performed on this data set
the resulting calculations may not be reliable enough to draw conclusions

It is recommended to have 10-15 or more distinct observations for accurate and meaningful results.

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.568	Shapiro Wilk Test Statistic	0.631
5% Shapiro Wilk Critical Value	0.803	5% Shapiro Wilk Critical Value	0.803
Data not Normal at 5% Significance Level		**Data not Lognormal at 5% Significance Level**	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	70.65	Mean	4.189
SD	28.15	SD	0.387
95% DL/2 (t) UCL	86.97	95% H-Stat (DL/2) UCL	92.86
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		Mean in Log Scale	4.01
		SD in Log Scale	0.277
		Mean in Original Scale	57.43
		SD in Original Scale	20.31
		95% t UCL	69.21
		95% Percentile Bootstrap UCL	68.86
		95% BCA Bootstrap UCL	75.68
		95% H-UCL	68.64

Gamma Distribution Test with Detected Values Only		Data Distribution Test with Detected Values Only	
k star (bias corrected)	5.719	**Data do not follow a Discernable Distribution (0.05)**	
Theta Star	10.15		
nu star	80.06		
A-D Test Statistic	1.411	**Nonparametric Statistics**	
5% A-D Critical Value	0.709	Kaplan-Meier (KM) Method	
K-S Test Statistic	0.709	Mean	58.07
5% K-S Critical Value	0.312	SD	22.16
Data not Gamma Distributed at 5% Significance Level		SE of Mean	9.048
		95% KM (t) UCL	74.66
Assuming Gamma Distribution		95% KM (z) UCL	72.95
Gamma ROS Statistics using Extrapolated Data		95% KM (jackknife) UCL	75.07
Minimum	44.4	95% KM (bootstrap t) UCL	166.6
Maximum	112	95% KM (BCA) UCL	75.4
Mean	58.36	95% KM (Percentile Bootstrap) UCL	73.62
Median	50.65	95% KM (Chebyshev) UCL	97.51
SD	20.47	97.5% KM (Chebyshev) UCL	114.6
k star	8.68	99% KM (Chebyshev) UCL	148.1
Theta star	6.723		
Nu star	173.6	**Potential UCLs to Use**	
AppChi2	144.1	95% KM (BCA) UCL	75.4
95% Gamma Approximate UCL (Use when n >= 40)	70.29		
95% Adjusted Gamma UCL (Use when n < 40)	72.64		

Note: DL/2 is not a recommended method.

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

General UCL Statistics for Data Sets with Non-Detects

User Selected Options

From File	Sheet1.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	10000

WS_Selenium

General Statistics

Number of Valid Data	10	Number of Detected Data	7
Number of Distinct Detected Data	7	Number of Non-Detect Data	3
		Percent Non-Detects	30.00%

Raw Statistics		**Log-transformed Statistics**	
Minimum Detected	73.7	Minimum Detected	4.3
Maximum Detected	91.3	Maximum Detected	4.514
Mean of Detected	79.64	Mean of Detected	4.375
SD of Detected	6.234	SD of Detected	0.0759
Minimum Non-Detect	500	Minimum Non-Detect	6.215
Maximum Non-Detect	500	Maximum Non-Detect	6.215

Warning: There are only 7 Detected Values in this data
Note: It should be noted that even though bootstrap may be performed on this data set
the resulting calculations may not be reliable enough to draw conclusions

It is recommended to have 10-15 or more distinct observations for accurate and meaningful results.

UCL Statistics

Normal Distribution Test with Detected Values Only		**Lognormal Distribution Test with Detected Values Only**	
Shapiro Wilk Test Statistic	0.871	Shapiro Wilk Test Statistic	0.884
5% Shapiro Wilk Critical Value	0.803	5% Shapiro Wilk Critical Value	0.803
Data appear Normal at 5% Significance Level		**Data appear Lognormal at 5% Significance Level**	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	130.8	Mean	4.719
SD	82.45	SD	0.557
95% DL/2 (t) UCL	178.5	95% H-Stat (DL/2) UCL	200.7
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		Mean in Log Scale	4.375
		SD in Log Scale	0.0683
		Mean in Original Scale	79.61
		SD in Original Scale	5.577
		95% t UCL	82.84
		95% Percentile Bootstrap UCL	82.49
		95% BCA Bootstrap UCL	82.89
		95% H-UCL	N/A

Gamma Distribution Test with Detected Values Only		**Data Distribution Test with Detected Values Only**	
k star (bias corrected)	113.6	**Data appear Normal at 5% Significance Level**	
Theta Star	0.701		
nu star	1591		
A-D Test Statistic	0.465	**Nonparametric Statistics**	
5% A-D Critical Value	0.708	Kaplan-Meier (KM) Method	
K-S Test Statistic	0.708	Mean	79.64
5% K-S Critical Value	0.311	SD	5.772
Data appear Gamma Distributed at 5% Significance Level		SE of Mean	2.356
		95% KM (t) UCL	83.96
Assuming Gamma Distribution		95% KM (z) UCL	83.52
Gamma ROS Statistics using Extrapolated Data		95% KM (jackknife) UCL	84.07
Minimum	73.7	95% KM (bootstrap t) UCL	88.43
Maximum	91.3	95% KM (BCA) UCL	83.56
Mean	79.77	95% KM (Percentile Bootstrap) UCL	83.52
Median	78.55	95% KM (Chebyshev) UCL	89.91
SD	5.506	97.5% KM (Chebyshev) UCL	94.36
k star	168.8	99% KM (Chebyshev) UCL	103.1
Theta star	0.473		
Nu star	3376	**Potential UCLs to Use**	
AppChi2	3242	95% KM (t) UCL	83.96
95% Gamma Approximate UCL (Use when n >= 40)	83.07	95% KM (Percentile Bootstrap) UCL	83.52
95% Adjusted Gamma UCL (Use when n < 40)	83.66		

Note: DL/2 is not a recommended method.

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.