Health Consultation

For TPWD Workers with Potential
Occupational Exposures to PCDDs/PCDFs in
Sediments from the San Jacinto River,
Houston Ship Channel, and
Upper Galveston Bay

HARRIS and CHAMBERS COUNTIES, TEXAS

Prepared by
Texas Department of State Health Services

JUNE 17, 2010

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

A health consultation is a verbal or written response from ATSDR or ATSDR's Cooperative Agreement Partners to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Table of Contents

Summary

INTRODUCTION The Texas Department of State Health Services (DSHS) and the Agency for Toxic Substances and Disease Registry (ATSDR) were asked to evaluate the potential risks from exposure to dioxin-contaminated sediments for TPWD staff who routinely collect fish and other aquatic life samples from the San Jacinto River (SJR), the Houston Ship Channel (HSC), and Upper Galveston Bay (UGB) [1]. For this health consultation, DSHS and ATSDR reviewed the sampling results that were collected and submitted as part of the Texas Commission on Environmental Quality (TCEQ) Hazard Ranking System Documentation Record for the San Jacinto River Waste Pits NPL site [2] as well as samples collected by the University of Houston as part of the Dioxin Total Maximum Daily Loads (TMDL) Project [3].

The most frequently noted health effect in people exposed to very high levels of dioxins is chloracne, a severe acne-like skin rash affecting the face and upper body. Other effects include other skin rashes, skin discoloration, excessive body hair, hepatotoxicity (liver damage), and peripheral neuropathy (a form of peripheral nerve damage). Lower level exposures in animals have caused impaired resistance to infection, decreased thymus weight, and altered social behavior in the offspring of mothers exposed to dioxin during pregnancy. These effects represent the critical effects for acute, intermediate, and chronic duration exposures, respectively. Since TCDD is a carcinogen, longer term exposures present a theoretical cancer risk for exposed individuals.

Individual oral and dermal exposure levels for TPWD staff could not be determined from the description of their activities; thus, we made a number of health-protective assumptions about possible oral and skin exposures and created three scenarios to describe a range of possible exposures.

The first scenario is that of **routine daily exposure** for technicians who may collect samples from a particular location 5 days per week, 50 weeks per year, for 30 years. The second scenario is that of **frequent periodic exposure** for technicians who may collect samples from a particular location 1 day per week, 26 weeks per year, for 30 years. The third scenario is that of **sporadic exposure** for technicians who may collect samples from a particular location 5 times per year, for 15 years. All scenarios assume that, on visiting the site, technicians would get contaminated sediments on their hands and forearms, leading to exposures by mouth as well as through skin contact. The first two scenarios very likely over-estimate exposure frequencies and theoretical risks; the third scenario may be somewhat more realistic but still probably over-estimates real-life exposures for most TPWD employees.

For this public health consultation (PHC), the ATSDR used a risk-based approach for evaluating the public health significance of exposures to the various SJR-HSC-UGB sediment samples under each of the three exposure scenarios described above. As explained in the paragraphs above, it is considered unlikely that any TPWD technicians have been exposed to sufficient dioxins levels in sediments to expect to see any observable adverse health effects.

CONCLUSIONS	After review of the available data, ATSDR has reached the following four conclusions with regard to sediments from the SJRWP site, the SJR, the HSC, and UGB:
Conclusion 1	ATSDR concludes that routine daily exposures by mouth and/or through skin contact with sediments from the SJRWP site for periods of 5.2 years or longer could harm TPWD technicians' health by increasing theoretical risks for cancer.
Basis for Conclusion	PCDDs/PCDFs have been detected in sediments at the SJRWP site at levels that would cause unacceptably high theoretical risks for cancer (greater than 10^{-4}) for TPWD technicians under the routine daily exposure scenario (250 times per year for 30 years) for either oral and/or dermal exposures.
Next Steps	The following actions have been taken: • The SJRWP site was proposed to the EPA's National Priorities List on September 19, 2007 and was officially added to the NPL by final rule in 40 CFR Part 300 as published in the Federal Register on March 19, 2008. • An ATSDR Health Assessment for the SJRWP site is currently in progress. While we are waiting for the Remedial Investigation/Feasibility Study and cleanup activities at the SJRWP site, here are some steps that TPWD technicians can take to protect their health: • Avoid collecting any biota samples near the SJRWP site that could potentially result in skin contact (and/or subsequent contact by mouth) with contaminated sediments from that immediate area.
Conclusion 2	ATSDR concludes that routine daily exposures by mouth or through skin contact with sediments from the SJRWP site for periods of one year or longer could harm TPWD technicians' health by increasing theoretical risks for non-cancer effects.
Basis for Conclusion	PCDDs/PCDFs have been detected in SJRWP site sediments at levels that would produce hazard quotients of 2.3 and 2.7 for oral and dermal routine daily exposures, respectively. These exposures are only factors of 44 and 37, respectively, below levels that have been associated with non-cancer adverse health effects (i.e., altered social behavior in children of mothers exposed during pregnancy) for individuals under chronic duration exposures.
Next Steps	The following actions have been taken: • The SJRWP site was proposed to the EPA's National Priorities List on September 19, 2007 and was officially added to the NPL by final rule in 40 CFR Part 300 as published in the Federal Register on March 19, 2008. • An ATSDR Health Assessment for the SJRWP site is currently in progress. While we are waiting for the Remedial Investigation/Feasibility Study and cleanup activities at the SJRWP site, here are some steps that TPWD technicians can take to protect their health: • Avoid routine daily collections of biota samples from near the SJRWP site that could potentially result in skin contact with highly contaminated sediments from that immediate area.

Conclusion 3	ATSDR concludes that routine daily exposures to off-site sediments at any of the sampling locations in the SJR-HSC-UGB waterway system thus-far tested for dioxins are not expected to harm TPWD technicians' health.
Basis for Conclusion	None of the sediment sampling locations thus-far tested (outside the SJRWP site) have been found to have high enough PCDD/PCDF concentrations to pose an unacceptable cancer risk (greater than or equal to 10^{-4}) or an unacceptable non-cancer hazard quotient (greater than or equal to 1.00) for routine daily exposures as defined under this health consultation (250 times a year for 30 years).
Next Steps	Although routine daily exposures to sediments in the SJR-HSC-UGB waterway system (outside the SJRWP site) are not a significant health concern for TPWD technicians, here are some general steps that they can take to further protect their health: • Refrain from eating, drinking, or smoking while collecting biota samples. • Wash their hands thoroughly before eating, drinking, or smoking after collecting biota samples that may involve contact with sediments.
Conclusion 4	ATSDR concludes that sporadic exposures to on- or off-site sediments at any of the sampling locations in the SJR-HSC-UGB waterway system thus-far tested for dioxins are not expected to harm TPWD technicians' health.
Basis for Conclusion	None of the sediment sampling locations thus-far tested (on- or off- site) have been found to have high enough PCDD/PCDF concentrations to pose an unacceptable cancer risk (greater than or equal to 10^{-4}) or an unacceptable non-cancer hazard quotient (greater than or equal to1.0) for acute, intermediate, or chronic duration sporadic exposures as defined under this health consultation (5 times a year for 15 years).
Next Steps	Although sporadic exposures to sediments in the SJR-HSC-UGB waterway system are not a significant health concern for TPWD technicians, here are some general steps that they can take to further protect their health: • Refrain from eating, drinking, or smoking while collecting biota samples. • Wash their hands thoroughly before eating, drinking, or smoking after collecting biota samples that may involve contact with sediments.
FOR MORE INFORMATION	If you have any questions or concerns about this Health Consultation or about theoretical dioxin risks from exposures to sediments from the SJR-HSC-UGB, you should contact Richard A. Beauchamp, M.D., from Texas DSHS at 1-512-458-7269. A copy of this Health Consultation will be available on the DSHS website at http://www.dshs.state.tx.us/epitox/assess.shtm You can also call ATSDR at 1-800-CDC-INFO and ask for information on dioxins. The ATSDR's toxicological profile on dioxins is available on ATSDR's website (under Chlorinated Dibenzo-p-Dioxins) at http://www.atsdr.cdc.gov/toxpro2.html.

Purpose and Health Issues

In February 2008, the TPWD asked Texas DSHS and the ATSDR to evaluate potential risks from exposure to dioxin-contaminated[1] sediments for TPWD staff who routinely collect fish and other aquatic life samples from the San Jacinto River (SJR), the Houston Ship Channel (HSC), and Upper Galveston Bay (UGB) [1]. The proposal of the San Jacinto River Waste Pits (SJRWP) to the National Priorities List (NPL) heightened TPWD staff concerns about exposure to these compounds throughout the above bodies of water. While TPWD staff do not specifically collect sediment samples, their activities potentially expose them to sediments. Exposure to sediments could come from one or more of the following activities:

- Bag Seines – staff must wade through the water pulling a 60-foot (ft) seine. Waders are worn in the winter but staff will usually wear shorts in the summer. Shoes/wading boots are worn; the seine is dragged through mud but is washed out in order to collect specimens.
- Trawls – nets and other gear are pulled by a boat, but retrieval is accomplished by hand; the 20-ft flat trawl skims across bottom, and mud is often deposited in the bag.
- Gill Nets – deployed from shoreline out 600 ft; lead line holds net to the bottom; does not bring up much sediment but there is some associated with lead line.

TPWD asked DSHS to review the sampling results that were collected and submitted as part of the Texas Commission on Environmental Quality (TCEQ) Hazard Ranking System (HRS) Documentation Record for the San Jacinto River Waste Pits NPL site [2] as well as samples collected by the University of Houston as part of the Dioxin Total Maximum Daily Loads (TMDL) Project [3]. Based on the results of this analysis, TPWD will evaluate whether they should temporarily remove some of the sampling grids from their sampling plan in order to reduce staff exposures to excessive amounts of dioxins [1]. [Note: Appendix A provides a list of abbreviations and acronyms used in this report.]

Background

The Seafood and Aquatic Life Group (SALG) at DSHS, routinely collects and analyzes fish, crabs, and other aquatic life samples from bodies of water across the state for contaminants of potential public health concern, such as mercury, polychlorinated biphenyls (PCBs), pesticides, and, occasionally, dioxins. As part of this monitoring program, the Texas Department of Health (TDH – the predecessor agency for DSHS) collected fish and crab samples from the HSC and UGB. In September 1990, they found excessive concentrations of dioxin in some of these samples and issued a seafood consumption advisory for catfish and blue crabs caught from these waters. The advisory recommended that men should consume no more than one 8-ounce meal of

[1] In this document, "dioxin" or "dioxins" refer to polychlorinated dibenzo-p-dioxins (PCDDs) and/or polychlorinated dibenzofurans (PCDFs).

catfish or blue crabs from this area per month and, further, that women of child-bearing age and children should not consume any catfish or blue crabs from the HSC or the UGB [4].

In July 1995, the Houston Ship Channel Toxicity Study reported unexplained high concentration of dioxins in sediment samples in the vicinity of the San Jacinto River (SJR) where it flows under the IH-10 Bridge [5]. Approximately 10 years later, the TPWD became aware of the presence of what appeared to be a number of waste pits located in a sandbar in the SJR immediately north of the IH-10 Bridge. TPWD contacted the TCEQ in April of 2005 and asked that the area be evaluated as an apparent threat to aquatic resources and human health. In the summer of 2005, TCEQ began sampling from the waste pits site under their Preliminary Assessment/Site Inspection (PASI) program [6,7].

Since 1990, TDH has conducted five additional health consultations/risk characterizations for the consumption of seafood from the HSC and UGB, all of which have recommended the continuance of the consumption advisory [8,9,10,11,12]. The two most recent health consultations/risk characterizations [11,12] have lifted the advisory on blue crabs but added an advisory on spotted seatrout from the UGB and lower Galveston Bay (LGB).

Section 303(d) of the Clean Water Act requires all states to identify waters that do not meet, or are not expected to meet, applicable water quality standards. For each listed water body that does not meet a standard, states must develop a total maximum daily load (TMDL) for each pollutant that has been identified as contributing to the impairment of water quality in that water body. In Texas, the TCEQ is responsible for ensuring that TMDLs are developed for impaired surface waters. The ultimate goal of the TMDL initiative is to restore the quality of the impaired water bodies across the country [3]. Because of the elevated levels of dioxins found in fish and crabs, the HSC system was placed on the §303(d) list, and a TMDL study was initiated by the TCEQ [3]. In carrying out the Dioxin TMDL Project, the University of Houston has collected hundreds of sediment, water, fish, and other aquatic life samples and analyzed them for various PCDD/PCDF congeners [3]. These data are available from TCEQ's website in pdf format [13].

In their Third Quarterly Report, the University of Houston reported evidence of a sand mining operation in the area immediately northwest of the SJRWP site [3]. (See the circled area in Figure 1, Appendix B). Both the PASI study and the Dioxin TMDL Project have shown very high levels of dioxin in the area of the waste pits on the SJRWP site, and the Dioxin TMDL Project has shown scattered moderately elevated levels of dioxin over a much larger area in the SJR, HSC, and UGB [3,6].

The TCEQ's site inspection report, including sampling data analysis and other background information, was completed by early 2007, and the HRS Documentation Record for the SJRWP site was completed in September 2007 [2,6]. Figure 2, Appendix B, shows the approximate locations where the site sediment samples were obtained, and Figure 3, Appendix B shows the approximate locations where background sediment samples were collected. The SJRWP site was proposed to the Environmental Protection Agency's National Priorities List (NPL) on September 19, 2007 [14] and was officially added to the NPL by Final Rule in 40 CFR Part 300 as published in the Federal Register on March 19, 2008 [15].

Methods Used in this Consultation

Quality Assurance/Quality Control (QA/QC)

In preparing this report, DSHS and ATSDR relied on the data provided to us by the TCEQ in the HRS Documentation Record for the San Jacinto River Waste Pits NPL site (sediment samples) [2]. The TCEQ states in their HRS Documentation Record for the SJRWP site that:

> "All source and background samples are comparable in terms of collection date (Ref. 37, pp. 008, 010, 012, 014, 018, 020, 022, 024, 026, 042, 044), type of analysis (Ref. 38, pp. 010-018, 052-119, 135-136), and sample type (Ref. 36, pp. 014, 045). All samples were collected from a depth no greater than 30 inches below the surface of the sediment (Ref. 7). All samples were collected according to the EPA approved, FY 2004-2005 TCEQ Quality Assurance Project Plan (Refs. 36, p. 14; 39, p. 032)".

The University of Houston carefully follows what appear to be appropriate QA/QC methods in their conduct of their TMDL Project for the evaluation of dioxins in the HSC [3]:

> "PCDDs and PCDFs in sediment samples were quantified by high-resolution gas chromatography/high resolution mass spectrometry (HRGC/HRMS) using EPA Method 1613B at Pace Analytical. Sediment samples were homogenized, spiked with fifteen $^{13}C_{12}$-labeled PCDD/PCDF internal standards and extracted using Soxhlet extraction apparatus. The extracts were then spiked with 2378-TCDD-$^{37}Cl_4$ enrichment efficiency standard and subjected to acid/base washes, multilayer silica, alumina, and carbon column cleanup procedures to remove interferences from the extracts. After cleanup, the extracts were concentrated to near dryness and spiked with recovery standards (1234-TCDD-$^{13}C_{12}$ and 123789-HxCDD-$^{13}C_{12}$) immediately prior to injection. Chromatographic separation was achieved with a DB-5, capillary chromatography column (60 m, 0.25 mm i.d., 0.25 µm film thickness). A second column DB-225 (30 m, 0.25 mm i.d., 0.25 µm film thickness) was used for confirmation of TCDF identification. Physical properties of sediment samples were analyzed at North Water District Laboratory Services (NWDLS) using standard methods (U.S. Environmental Protection Agency, 1983) as follow: organic content of sediments (TOC) Lloyd Kahn, total solids content EPA 160.3, and volatile solids EPA 160.4.
>
> **"**Field duplicates and blanks were collected at a frequency of 6% or higher and 3% or higher, respectively, and processed in an identical manner to samples. In addition, laboratory duplicates and blanks were run at a frequency of 5%. Overall, when detected, both field and laboratory blanks showed levels below 5% of the levels in the samples. Results obtained from the duplicate samples were consistent and in agreement with the method requirements for the different congeners. Recoveries for 2378-substituted congeners ranged from 72 to 92% with an average of 81%... Non-detects were assumed to be equal to half of the detection limit for total equivalence quotient (TEQ) calculations and summary statistics" [3].

After reviewing these reports, we have assumed adequate quality assurance/quality control (QA/QC) procedures were followed with regard to data collection, chain of custody, laboratory procedures, and data reporting.

Children's Health Considerations

ATSDR and DSHS recognize that fetuses, infants, and children may be uniquely susceptible to adverse effects from exposure to toxic chemicals and that exceptional susceptibilities demand special attention [16,17]. Windows of vulnerability or "critical periods" exist during development – particularly during early gestation (weeks 0 through 8) – but can occur at any time during pregnancy, infancy, childhood, or adolescence. A growing body of evidence demonstrates that children may suffer disproportionately from environmental health risks. Indeed, there are numerous times during development when toxicants can impair or alter the structure or function of susceptible systems [18].

Children exposed to toxicants in various environmental media (food, water, air, soil, etc.) may receive higher exposure doses than adults exposed to the same media, because children eat more food, drink more fluids, and breathe more air in proportion to their body weights than do adults. Also, children are likely to ingest higher quantities of soil or sediment from the environment, because they have a greater tendency to handle contaminated objects and to put their hands or said objects in their mouths. Children tend to absorb a higher percentage of many toxicants from the GI tract than do adults. A child's smaller body and organ size and weight, combined with a higher exposure dose, results in a higher concentration of toxicant at the target organ. Children may also experience toxicity at lower exposure doses than adults because a child's organs may be more sensitive to the effects of toxicants, and their systems could respond more extensively, or with greater severity, to a given dose than would an adult organ exposed to an equivalent toxicant dose [19].

Infants can ingest toxicants passed on from the mother through breast milk – an exposure pathway that may go unrecognized. Nonetheless, the advantages of breastfeeding generally outweigh the probability of significant exposure to infants through breast milk, so women are encouraged to continue breastfeeding while limiting exposure of their infants through limitation of their intake of contaminated foodstuffs.

In any case, if a chemical appears more toxic to fetuses, infants, or children than to adults, federal risk assessors adjust Reference Doses (RfDs), Minimal Risk Levels (MRLs), or other non-cancer Health Assessment Comparison (HAC) values to assure protection of the immature system [20]. This comes in the form of an additional uncertainty factor (typically 10) being applied during the development of the comparison value. Although the HAC values used for assessing the probability of cancer from a given exposure do not contain uncertainty factors as such, these probability calculations do contain substantial margins of safety by virtue of the conservative models used to derive the cancer slope factors (CSFs) and by the small probability values that are still considered to be unacceptable risks. Furthermore, in their *Supplemental Guidance for Assessing Cancer Susceptibility from Early-Life Exposure to Carcinogens* [21], the EPA recommends applying a 10-fold adjustment factor to the published CSF, for exposures before 2 years of age, when the carcinogen has been determined to have a mutagenic mode of action. For exposures during ages 2 through 15 years, the adjustment factor is reduced to 3, and for exposures after age 15 (or for carcinogens not having a mutagenic mode of action), no

adjustment is applied. Additionally, in accordance with the ATSDR's *Child Health Initiative* [22] and the EPA's *National Agenda to Protect Children's Health from Environmental Threats* [23], the DSHS further seeks to protect children from the possible negative effects of toxicants in fish by suggesting that this potentially sensitive subgroup consume smaller quantities of contaminated fish or shellfish than adults ordinarily consume.

In making recommendations regarding the maximum quantity of a potentially contaminated fish species a person should consume, the DSHS SALG calculates a HAC value representing a fish-tissue concentration for each contaminant of concern (usually expressed as milligrams contaminant per kilogram fish). This HAC value amounts to an environmental media evaluation guide (EMEG) for the contaminant in fish tissues. For carcinogenic contaminants, a fish tissue concentration is calculated which would produce a theoretical cancer risk of 10^{-4}, assuming an individual eats an average of 30 grams of the contaminated fish per day for a period of 30 years and that the individual's average body weight over the exposure period is 70 kg. For non-carcinogenic effects, the fish tissue concentration is calculated which would result in an exposure dose (in mg/kg/day) that would just equal the RfD or MRL for that contaminant, assuming a 70 kg adult, eating an average of 30 grams of contaminated fish per day (approximately one 8 oz. meal per week) for a period of longer than a year. To account for the lower body weights of children (and correspondingly higher exposure dose per unit of fish consumed), the DSHS SALG recommends that children weighing 35 kg or less and/or who are 11 years of age or younger limit their exposure to the contaminated species of fish or shellfish by eating no more than 15 grams per day of the contaminated species (i.e., no more than approximately one 4-ounce meal per week). DSHS also recommends that consumers spread these meals over time [8,9,10,11,12].

TPWD Dioxin Exposure Scenarios

Since this PHC addresses exposures to sediments in an occupational setting, no childhood exposure scenarios were considered, and since TPWD staff are not expected to be eating their catch, no fish consumption exposure scenarios were evaluated. Both of these issues are thoroughly addressed in the Public Health Assessment for the San Jacinto River Waste Pits Superfund site.

Because of the nature of the contaminants, their low volatility, and their affinity for soil or sediments, the airborne route was not considered a significant pathway of exposure for this PHC. For individuals coming in contact with contaminated sediments, the major routes of exposure would be through 1) oral contact with sediments as a result of eating, drinking, smoking, or other oral contact with sediment-contaminated hands or fingers and 2) direct dermal absorption of contaminants through the skin as a result of contaminated sediments adhering to skin surfaces. Individual oral and dermal exposure levels for TPWD staff could not be determined from the description of their activities; thus, we made a number of assumptions about possible oral and dermal exposures and used three scenarios to describe a range of possible exposures.

The first scenario is that of **routine daily exposure** for technicians who may collect samples from a particular location 5 days per week, 50 weeks per year, for 30 years and who may, in the process, get contaminated sediments on his or her hands and forearms, leading to dermal and potential oral exposures. This scenario is intended to represent a worst-case situation and almost certainly grossly over-estimates any real-life exposures because few TPWD employees will work at the same job for 30 years or collect samples from a specific location 250 times per year.

The second scenario is that of **frequent periodic exposure** for technicians who may collect samples from a particular location 1 day per week, 26 weeks per year, for 30 years and who may, in the process, get contaminated sediments on his or her hands and forearms, leading to dermal and potential oral exposures. This scenario also very likely over-estimates real-life risks because few TPWD employees will work at the same job for 30 years or sample from the same location 26 times per year.

The third scenario is that of **sporadic exposure** for technicians who may collect samples from a particular location 5 times per year, for 15 years and who may, in the process, get contaminated sediments on his or her hands and forearms, leading to dermal and potential oral exposures. This scenario may be somewhat more realistic but still probably over-estimates real-life exposures for most TPWD employees.

The ATSDR used a risk-based approach for evaluating the public health significance of exposures to the various dioxin-contaminated SJR-HSC-UGB sediment samples under each of the three exposure scenarios described above. Sediment sample results reported as "ND" or "non-detects" were assumed to be equal to half of the detection limit for the specific congener for the purposes of calculating the TCDD TEQ for the sample.

Risk and Hazard Quotient Calculations

Risk and hazard quotient calculations involve the determination of a daily exposure dose [in milligrams per kilogram per day (mg/kg/day)] for each exposure scenario and TCDD TEQ concentration. Daily exposure doses together with exposure duration factors, oral or dermal cancer slope factors, and oral or dermal minimal risk levels (MRLs) are used to calculate theoretical cancer risks and/or hazard quotients for the various exposure routes and scenarios. (See Appendix C for the detailed TCDD TEQ calculation, exposure dose calculation, risk calculation, and hazard quotient calculation methods used in this PHC).

Results and Discussion

Toxicologic Evaluation of PCDDs/PCDFs

Sources and Production

Dioxins and dioxin-like compounds inadvertently released into the environment generally originate as minor by-products of various industrial processes, such as metal smelting and refining, manufacture of chlorinated chemicals, and paper bleaching. They are also generated through various natural or man-made combustion activities such as forest fires, brush fires, house fires, and medical or municipal waste incineration. Dioxins also can enter the environment through natural biological and photochemical processes, or can transfer from one medium to another through mobilization from environmental reservoirs (e.g., stirred sediments mobilized to the water column). Dioxins can be found throughout the world at low levels in air, soil, water, sediment, and in foods such as meat, dairy products, fish, and shellfish. Dioxins are found at their highest levels in soil, sediment, and in the fatty tissues of animals. When dioxins are released into surface waters, some are broken down by sunlight while others (primarily those with 1, 2, or 3 chlorines, i.e., the mono-, di-, or trichlorodibenzo-p-dioxins) may evaporate into

the air. The more highly chlorinated congeners, however, are less volatile, and most will attach to suspended organic particulate matter in the water which gradually settles to the bottom; thus dioxins tend to accumulate in the sediments [24,25].

Exposure Sources and Pathways

Possible routes of human exposure to dioxins and dioxin-like compounds include but are not limited to exposure through food, ambient air, drinking water, and contact with contaminated soil or sediment. Occasionally, exposures may occur through occupational contacts or through exposure at hazardous waste sites [24,25].

For the general population, consumption of food containing low levels of dioxins and dioxin-like compounds is by far the most important pathway for exposure, accounting for more than 95% of the intake of dioxins in the human population [which generally averages 120 picograms (pg) TEQ/day][2]. Foods that contribute most to the total daily dietary intake of dioxins include pork, beef, chicken, and eggs (66.1 pg TEQ/day); dairy products (42 pg TEQ/day); and fish (7.8 pg TEQ/day). However, for certain subpopulations (e.g., recreational and subsistence fishermen), fish consumption may be the single most important source of dioxin exposure. For example, residents of the Great Lakes region, who regularly consume fish from the Great Lakes, may have dioxin intakes that range from 390 to 8,400 pg TEQ/day. Other minor sources of exposure for the general population would include breathing ambient air containing low levels of dioxins (2.2 pg TEQ/day), ingesting small amounts of soil containing low levels of dioxins (0.8 pg TEQ/day), and drinking water containing low levels of dioxins (0.008 pg TEQ/day). For some individuals, additional exposures to dioxins may occur through skin contact with herbicides and pesticides (e.g., 2,4,5-T and 2,4-D); living near a hazardous waste site containing dioxins; and occupational exposure at paper and pulp mills, municipal or hazardous waste incinerators, or wood treatment facilities using pentachlorophenol (PCP) [24].

Absorption, Distribution, and Elimination

Dioxins present in food items are generally almost completely absorbed (up to 95%). However, the absorption of TCDD from oily soil at Times Beach, Missouri, was found to be approximately 50% and the absorption from non-oily New Jersey soil was measured at less than 1% [26]. Once dioxins are absorbed into the bloodstream, they will be distributed to various organs based on the organ's lipid content, and over time, dioxins will accumulate in an individual's body fat. Seventy-six percent of adipose tissue samples collected from the general population in the U.S. contained measurable quantities of 2,3,7,8-TCDD that averaged 6.2±3.3 pg TEQ/g. The median concentration of PCDDs/PCDFs in adipose tissues of the general population was 31.3 pg TEQ/g adipose tissue (range, 6.01-75.0 pg TEQ/g adipose tissue) [24].

In many animal species, the metabolism of dioxins has been found to take place in the liver through various detoxification processes, including oxidation and reductive dechlorination and/or oxygen bridge cleavage. Once dioxin is broken down into its various metabolites, it will be excreted in the bile and urine. Bile is then excreted in the feces, thus eliminating the toxicant

[2] Note: see "Calculation of the Toxic Equivalency (TEQ) for Mixed Dioxins" in Appendix C for the definition and method of calculating the TCDD TEQ (frequently abbreviated to TEQ) used extensively in this PHC.

from the body. Women who are breastfeeding infants also have the ability to excrete dioxins in their breast milk. Dioxin has been found to have a half-life of approximately 8.7 years in the human body (range, 7 to 12 years).

Toxicological Effects of Exposure

The most frequently noted health effect in people exposed to excessive amounts of the most toxic member of the dioxin family [2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD)] is chloracne, a severe skin rash characterized by acne-like lesions that occur mainly on the face and upper body. Other skin effects noted in people exposed to high doses of 2,3,7,8-TCDD include other skin rashes, skin discoloration, and excessive body hair. Another non-cancer health effect caused by dioxin exposure is transient mild hepatotoxicity (liver damage). Peripheral neuropathy (a form of peripheral nerve damage) has been reported in some individuals exposed to elevated levels of dioxins. Lastly, exposure to high concentrations of PCDDs may induce long-term alterations in glucose metabolism and subtle changes in hormonal levels [24].

In certain animal species, such as the Hartley guinea pig, 2,3,7,8-TCDD is especially harmful and can cause death after a single, relatively low-dose exposure (i.e., LD_{50} doses of 0.6 to 2.1 µg/kg). Other animal species, such as Syrian hamsters (with LD_{50} doses of 1,157 to 5,051 µg/kg), appear to be far more resistant to the acute toxic effects of 2,3,7,8-TCDD. Most other animal species fall between these extremes, with LD_{50} doses ranging from 22 to 360 µg/kg. Exposure to sub-lethal levels can cause a variety of effects in animals, such as weight loss, liver damage, and disruption of the endocrine system. Some animals exposed to dioxins at doses of 0.5 to 10 µg/kg/day during pregnancy had higher rates of miscarriages, and the offspring of animals exposed to 2,3,7,8-TCDD during pregnancy often had severe birth defects including skeletal deformities and kidney defects. In some species, a single dose of 2,3,7,8-TCDD at 0.01 µg/kg has been found to weaken the immune system, causing a decrease in the animal's ability to fight viral infections. Other studies have shown an adverse effect on the development of the thymus in animals exposed for 90 days to diets containing 2,3,7,8-TCDD at 0.005 µg/kg/day. Chronic exposure (for periods of over 16 months) to diets containing 2,3,7,8-TCDD at 0.00012 µg/kg/day has caused altered social behavior in the offspring of exposed mothers [24].

Dioxin toxicity can be seen at the cellular level by its effect on the growth regulation of cells. Dioxins are known to be able to block cell death (apoptosis) as well as to induce cell death. These two processes may lead to the underdevelopment of tissue (hypoplasia), the overgrowth of tissue (hyperplasia), the transformation of tissue (metaplasia), or the formation of tumors (neoplasia) [24].

Other non-cancer health effects that are suspected, but not yet confirmed, to be associated with dioxin exposures, include porphyria cutanea tarda (characterized by liver dysfunction and photosensitive skin lesions), type 2 diabetes, and neurobehavioral development effects in infants. Also, men in populations that are highly exposed to dioxins appear to be less likely to father boys [24].

Carcinogenicity

Several studies in humans have been performed, evaluating 2,3,7,8-TCDD exposures and potential cancer effects. These studies suggest that exposure to 2,3,7,8-TCDD increases the risk of several types of cancer in humans. Cancer health effects that are suspected, but not yet confirmed to be associated with dioxin exposures in humans include respiratory cancers, prostate

cancer, and multiple myeloma (malignant tumor of the bone marrow). Numerous animal studies have also suggested that exposure to 2,3,7,8-TCDD increases the risk of cancer in animals.

The Department of Health and Human Services (DHHS) and the National Toxicology Program (NTP) have determined that 2,3,7,8-TCDD may reasonably be anticipated to cause cancer in humans and thus have listed it as a Class 1 carcinogen (known human carcinogen).

The International Agency for Research on Cancer (IARC) concluded that there is limited evidence in humans for the carcinogenicity of 2,3,7,8-TCDD; however, data from studies involving experimental animals provided sufficient evidence of carcinogenicity. Thus, IARC and the World Health Organization (WHO) currently list 2,3,7,8-TCDD as a Class 1 carcinogen [i.e., carcinogenic to humans (sufficient human evidence)].

The US EPA concludes that there is sufficient evidence that 2,3,7,8-TCDD is an animal carcinogen but inadequate evidence that it is a human carcinogen and thus classifies it as a B2 carcinogen [24].

Health Assessment Comparison Values for Dioxins

The following HAC values have been established (or calculated) for oral and/or dermal exposures to 2,3,7,8-TCDD:

- Soil/Sed CREG (calculated) 4.67×10^{-6} ppm = 4.67 pg_{TEQ}/g_{Sed}
- Chronic Soil/Sed $EMEG_{Adult}$ 8.4×10^{-4} ppm = 840 pg_{TEQ}/g_{Sed}
- Intermediate Soil/Sed $EMEG_{Adult}$ 1.63×10^{-2} ppm = 16,300 pg_{TEQ}/g_{Sed}
- Acute Soil/Sed $EMEG_{Adult}$ 1.17×10^{-1} ppm = 117,000 pg_{TEQ}/g_{Sed}
- ATSDR's Chronic Oral MRL 1.2×10^{-9} $mg_{TEQ}/kg_{BW}/day$
- ATSDR's Intermediate Oral MRL 2.33×10^{-8} $mg_{TEQ}/kg_{BW}/day$
- ATSDR's Acute Oral MRL 1.67×10^{-7} $mg_{TEQ}/kg_{BW}/day$
- (Est.) Chronic Dermal MRL 1.2×10^{-9} $mg_{TEQ}/kg_{BW}/day$
- (Est.) Intermediate Dermal MRL 2.33×10^{-8} $mg_{TEQ}/kg_{BW}/day$
- (Est.) Acute Dermal MRL 1.67×10^{-7} $mg_{TEQ}/kg_{BW}/day$
- RAIS's Oral Slope Factor 150,000 $(mg_{TEQ}/kg_{BW}/day)^{-1}$
- RAIS's Dermal Slope Factor 300,000 $(mg_{TEQ}/kg_{BW}/day)^{-1}$

Environmental Samples Collected

TCEQ HRS Samples

On July 12-13, 2005, seven sediment samples were collected just below the sediment surface layer (1 to 8 feet below the surface of the water for submerged locations) from the San Jacinto River Waste Pits site by the TCEQ as reported in the HRS Documentation Record [2]. Each TCEQ sediment sample was measured for 15 of the 17 PCDD/PCDF congeners thought to have 2,3,7,8-TCDD-like toxicity or carcinogenicity [octachlorodibenzo-p-dioxin (OCDD) & octachlorodibenzofuran (OCDF) concentrations were not reported].

University of Houston TMDL Samples

As part of the TMDL study of dioxins in the SJR, HSC, and UGB, the University of Houston has collected 210 sediment samples from 84 different locations throughout the SJR, HSC, and UGB

from 2002 through 2005. Two of these samples (00015 and 00015-dup) were collected on the SJRWP site between pits B and C and close to the northwest extreme of pit B (See Figure 1, Appendix B). The remaining 208 sediment samples were collected throughout the SJR, HSC, and UGB waterway system. The 210 TMDL samples were measured for all 17 of the PCDD/PCDF congeners having TCDD-like toxicity [3].

Grouping of Samples for Analysis

For the purpose of this analysis, samples were grouped into 5 geographical categories: 1) those that were collected on the SJRWP site (the 2 TMDL samples were grouped with the 7 TCEQ samples from above); 2) those that are down-stream from the SJRWP site in the SJR, HSC, or UGB (59 samples); 3) those that are in the SJR in the immediate vicinity of the SJRWP site (31 samples); 4) those that are in the HSC above (west) of its confluence with the SJR (62 samples); and 5) those that are up-stream from the SJRWP site or are up various tributaries to the SJR, HSC, or UGB (56 samples) (See Figures 1, 4, 5, and 6, Appendix B).

TCDD TEQ Concentrations

Of the 9 samples collected on the SJRWP site, only one sample (SE-07) had a TCDD TEQ concentration of less than 1,000 picograms per gram (pg/g). The average TCDD TEQ concentration for the nine samples from the site was 15,594 pg/g (range: 80.9 – 34,028 pg/g) (See Table 4, Appendix D). Downstream TMDL samples were found to have an average TCDD TEQ concentration of 13.8 pg/g (range: 0.739 – 86.2 pg/g) (See Table 5, Appendix D), site vicinity TMDL samples averaged 82.2 pg/g (range: 2.00 – 573 pg/g) (See Table 6, Appendix D), HSC TMDL samples averaged 65.7 pg/g (range: 4.90 – 857 pg/g) (See Table 7, Appendix D), and upstream or tributary TMDL samples averaged 16.0 pg/g (range: 0.759 – 103 pg/g) (See Tables 8 & 9, Appendix D)

Public Health Implications

Details of the cancer and non-cancer risk assessment calculations employed in this section can be found in Appendix C. The assumptions employed in calculating the various risk estimates for this health consultation should be considered to range from “conservative” to “extremely conservative” and should not be construed to represent actual or likely risks for casual visitors to the site. Since theoretical risks are directly proportional to the lifetime average daily exposure dose, cutting the average exposure dose in half (by halving the sediment intake rate, halving the number of days per year a person visits the site, or halving the number of years a person is exposed) will cut the resulting theoretical risk in half as well.

Carcinogenic Health Effects Evaluation

a. Oral Exposures

The oral slope factor for 2,3,7,8-TCDD is generally taken to be 150,000 $(mg/kg/day)^{-1}$ [27]. Using parameters for the oral sediment exposure scenarios shown in Table 2, Appendix D, we calculated the theoretical increased lifetime cancer risks for oral ingestion exposures to the average and maximum values for each of the five groupings of sediment samples and each of the three exposure scenarios. Regular oral exposure to sediments from the SJRWP site was found to pose unacceptably high theoretical risks for cancer under the routine daily exposure scenario.

The highest theoretical risk (3.55×10^{-4}) would be for an individual with routine daily exposure to on-site sediments (having a TCDD TEQ concentration equal to the maximum value of 34,028 pg/g). The theoretical risk for routine daily exposure to the site average concentration (15,594 pg/g) was found to be 1.63×10^{-4}. This means that if 6,151 people were exposed to the levels of TCDD TEQ found at the SJRWP site, 250 days per year, for 30-years (starting at age 20), theoretically, we would predict that one additional person might get cancer as a result of that exposure. Qualitatively, we would describe oral exposures to sediments with this degree of TCDD TEQ contamination as posing a **moderately increased lifetime risk** for cancer (See Tables 4 through 9, Appendix D, and Figure 7, Appendix B, for risk estimates and odds for other off-site oral sediment exposures).

None of the off-site sediment samples were high enough to produce theoretical lifetime cancer risk estimates for routine daily oral exposures of greater than 10^{-4} (average risk, all samples, 4.17×10^{-7}, range 7.71×10^{-9} – 8.93×10^{-6}). Sediment samples 00011 and 00011-dup from the Dioxin TMDL Project (taken in the area of a former sand mining operation) had TCDD TEQ concentrations of 523 and 572 pg/g, producing cancer risk estimates of 5.45×10^{-6} and 5.97×10^{-6}, respectively for any individuals having routine daily exposure. The highest off-site concentration (857 pg/g at Station ID 11280) was found in the HSC approximately 7 miles upstream from its confluence with the SJR. Regular daily oral exposure to these sediments would produce a theoretical cancer risk of 8.93×10^{-6}. This means that if 111,944 people were exposed to the levels of TCDD TEQ found at this location in the HSC, 250 days per year, for 30-years (starting at age 20), theoretically, we would predict that one additional person might get cancer as a result of that exposure. Qualitatively, we would describe oral exposures to sediments with this degree of TCDD TEQ contamination as posing **no apparent increased lifetime risk** for cancer. (See Tables 5 through 9, Appendix D, and Figure 7, Appendix B, for risk estimates and odds for other off-site oral sediment exposures).

Under the sporadic exposure scenario (the scenario most likely to represent realistic oral exposures for TPWD technicians), exposures to maximum and average on-site concentrations would be expected to result in theoretical cancer risks of 3.63×10^{-6} and 1.66×10^{-6}, respectively. Qualitatively, we would describe oral exposures to sediments with this degree of TCDD TEQ contamination as posing **no apparent increased lifetime risk** for cancer. (See Tables 5 through 9, Appendix D, and Figure 7, Appendix B, for risk estimates and odds for other off-site oral sediment exposures).

b. Dermal Exposures

The dermal slope factor for 2,3,7,8-TCDD is generally taken to be 300,000 $(mg/kg/day)^{-1}$ [27]. Using parameters for the dermal sediment exposure scenarios shown in Table 3, Appendix D, we calculated the theoretical increased cancer risks for dermal contact exposures for each sediment sample and for the average and maximum values for each of the five groupings of sediment samples and each of the three exposure scenarios (See Tables 10 through 15, Appendix D and Figure 8, Appendix B).

Regular dermal exposure to sediments from the SJRWP site was found to pose unacceptably high theoretical risks for cancer under the routine daily exposure scenario. The highest risk (8.76×10^{-4}) would be for individuals with routine daily exposures to on-site sediments (having a TCDD TEQ concentration equal to the maximum value of 34,028 pg/g). Routine daily dermal exposure to sediments containing TCDD TEQ at the average concentration for all the on-site

samples (15,594 pg/g) would result in a theoretical lifetime cancer risk of 4.01×10^{-4}. This means that if 2,492 people were dermally exposed to the levels of TCDD TEQ found at the SJRWP site, 250 days per year, for 30-years (starting at age 20), theoretically, we would predict that one additional person might get cancer as a result of that exposure. Qualitatively, we would describe dermal exposures to sediments with this degree of TCDD TEQ contamination as posing a **moderate increased lifetime risk** for cancer. (See Tables 10 through 15, Appendix D, and Figure 8, Appendix B, for risk estimates and odds for other off-site dermal sediment exposures).

Under the frequent periodic dermal exposure scenario, the theoretical lifetime cancer risk estimates for exposure to sediments at the maximum and average on-site concentrations were 9.11×10^{-5} and 4.17×10^{-5}, respectively. Qualitatively, we would describe dermal exposures to sediments with this degree of TCDD TEQ contamination as posing a **low increased lifetime risk** for cancer. (See Tables 10 through 15, Appendix D, and Figure 8, Appendix B, for risk estimates and odds for other off-site dermal sediment exposures).

None of the sediment samples from off-site locations were high enough to produce theoretical cancer risks from dermal exposures of greater than 10^{-4}. The five off-site locations with the highest sediment TCDD TEQ levels (Station IDs 00011 × 2, 11280 × 2, and 15979 × 1) had concentrations of 523, 572, 458, 857, and 441 pg/g, respectively. Routine daily exposures to sediments from these sites would produce theoretical cancer risks for dermal exposures ranging from $1.13\times10^{-5} – 2.20\times10^{-5}$). Qualitatively, we would describe dermal exposures to sediments with this degree of TCDD TEQ contamination as posing a **low increased lifetime risk** for cancer (Note: these risk estimates apply only if technicians have routine daily exposures 250 days per year for 30 years at one of these five locations). (See Tables 10 through 15, Appendix D, and Figure 8, Appendix B, for risk estimates and odds for other off-site dermal sediment exposures).

The average risk for routine daily exposures at all 208 off-site sampling locations was 1.03×10^{-6} (range, $1.90\times10^{-8} – 2.20\times10^{-5}$). Qualitatively, we would describe dermal exposures to sediments with this degree of TCDD TEQ contamination as posing **no apparent increased lifetime risk** for cancer. (See Tables 10 through 15, Appendix D, and Figure 8, Appendix B, for risk estimates and odds for individual off-site dermal sediment exposures).

Under the sporadic exposure scenario (the scenario most likely to represent realistic dermal exposures for TPWD technicians), exposures to maximum and average on-site concentrations would be expected to result in theoretical cancer risks of 8.88×10^{-6} and 4.07×10^{-6}, respectively. Qualitatively, we would describe dermal exposures to sediments with this degree of TCDD TEQ contamination as posing **no apparent increased lifetime risk** for cancer. (See Tables 5 through 9, Appendix D, and Figure 8, Appendix B, for risk estimates and odds for other off-site dermal sediment exposures).

c. Oral plus Dermal Exposures

For the cumulative risk for both exposure routes combined, we added the risks for oral exposures to the risks for dermal exposures. The maximum theoretical cancer risk for both exposure routes combined (1.23×10^{-3}) was seen in individuals with routine daily exposure to on-site sediments (having a maximum TCDD TEQ concentration of 34,028 pg/g). The theoretical risk for routine daily exposure to the site-average concentration of 15,594 pg/g was found to be 5.64×10^{-4}. This means that if 1,774 people were routinely exposed to the average TCDD TEQ level found at the

SJRWP site, 250 days per year, for 30-years (starting at age 20), theoretically, we would predict that one additional person might get cancer as a result of that exposure. Qualitatively, we would describe combined oral and dermal exposures to sediments with this degree of TCDD TEQ contamination as posing a **moderate increased lifetime risk** for cancer. (See Table 16, Appendix D, and Figure 9, Appendix B, for risk estimates and odds for other off-site oral + dermal sediment exposures).

For off-site sediment exposures, the maximum theoretical cancer risk for both exposure routes combined (3.10×10^{-5}) would be seen in individuals with routine daily exposure to sediments from Station ID 11280 (having a maximum TCDD TEQ concentration of 857 pg/g). This means that if 32,282 people were routinely exposed to sediments from this Station, 250 days per year, for 30-years (starting at age 20), theoretically, we would predict that one additional person might get cancer as a result of that exposure. Qualitatively, we would describe combined oral and dermal exposures to sediments with this degree of TCDD TEQ contamination as posing a **low increased lifetime risk** for cancer. (See Table 16, Appendix D, and Figure 9, Appendix B, for risk estimates and odds for other off-site oral + dermal sediment exposures).

The theoretical risk for routine daily exposure to the off-site average concentration of 40.0 pg/g was found to be 1.45×10^{-6}. This means that if 690,784 people were routinely exposed to the average TCDD TEQ level found at the various off-site locations, 250 days per year, for 30-years (starting at age 20), theoretically, we would predict that one additional person might get cancer as a result of that exposure. Qualitatively, we would describe combined oral and dermal exposures to sediments with this degree of TCDD TEQ contamination as posing **no apparent increased lifetime risk** for cancer. (See Table 16, Appendix, D and Figure 9, Appendix B, for risk estimates and odds for oral + dermal exposures to sediments with average and maximum TCDD TEQ concentrations for each of the five groupings of sediment samples).

Under the sporadic exposure scenario (the scenario most likely to represent realistic oral + dermal exposures for TPWD technicians), exposures to maximum and average on-site concentrations would be expected to result in theoretical cancer risks of 1.25×10^{-5} and 5.73×10^{-6}, respectively. Qualitatively, we would describe oral + dermal exposures to sediments with this degree of TCDD TEQ contamination as posing a **low** to **no apparent increased lifetime risk** for cancer. (See Table 16, Appendix D, and Figure 9, Appendix B, for risk estimates and odds for other off-site oral + dermal sediment exposures).

Non-carcinogenic Health Effects Evaluation

a. Acute Duration Exposures

The acute oral MRL for 2,3,7,8-TCDD is based on an animal study in which there was a statistically significant increase in mortality in the influenza-A-infected female B6C3F1 mice exposed to a single gavage dose of 0.01 (or higher) µg/kg 2,3,7,8-TCDD in corn oil. No significant effects were observed at lower doses (0.001 or 0.005 µg/kg). Thus 0.005 and 0.01 µg/kg are the NOAEL and LOAEL, respectively, for impaired resistance to influenza A infection in female B6C3F1 mice. The acute oral MRL of 1.67×10^{-7} mg/kg/day was derived by dividing the NOAEL of 5.0×10^{-6} mg/kg by an uncertainty factor of 30 (3 for extrapolation from animals to humans and 10 for human variability) [24].

For the SJRWP site, the SJR, the HSC, and UGB, the hazard quotients (HQs) for acute duration exposures to average and maximum TCDD TEQ concentrations through oral ingestion of

soil/sediments, dermal absorption from skin contact with soil/sediment, and oral plus dermal exposures were all less than 1.00 under all three exposure scenarios (range, 3.26×10^{-4} to 7.79×10^{-2}. Qualitatively, we would describe acute duration oral and/or dermal exposures to sediments with this degree of TCDD TEQ contamination as posing **no increased risk** for impaired resistance to infection (See Tables 17 through 19, Appendix D and Figures 10 through 12, Appendix B, for risk estimates and odds for various on- and off-site oral and/or dermal sediment exposures).

Under the sporadic exposure scenario (the scenario most likely to represent realistic oral and/or dermal exposures for TPWD technicians), exposures to maximum and average on-site concentrations would be expected to result in hazard quotients ranging from 3.26×10^{-4} to 1.56×10^{-3}. Qualitatively, we would describe oral and/or dermal exposures to sediments with this degree of TCDD TEQ contamination as posing **no increased risk** for impaired resistance to infection. (See Tables 17 through 19, Appendix D, and Figures 10 through 12, Appendix B, for hazard quotients for other acute duration on- and off-site oral and/or dermal sediment exposures).

b. Intermediate Duration Exposures

The intermediate oral MRL for 2,3,7,8-TCDD is based on an animal study in which there was a statistically significant decrease in thymus weight in weanling Hartley guinea pigs fed a diet containing 76 parts per trillion (ppt) (or higher) of 2,3,7,8-TCDD for 90 days (for the animals in the study, this was equivalent to a dose of 0.005 µg/kg/day). No significant effects were observed at the lower doses (i.e., 0.0001 or 0.0007 µg/kg/day). Thus 0.0007 and 0.005 µg/kg/day are the NOAEL and LOAEL, respectively, for decreased thymus weight in weanling Hartley guinea pigs. The intermediate oral MRL of 2.33×10^{-8} mg/kg/day was derived by dividing the NOAEL of 7.0×10^{-7} mg/kg/day by an uncertainty factor of 30 (3 for extrapolation from animals to humans and 10 for human variability) [24].

For the SJRWP site, the hazard quotient for intermediate duration oral exposures through soil/sediment ingestion in individuals with routine daily exposures to site maximum concentrations was 0.254. Qualitatively, we would describe intermediate duration oral exposures to sediments with this degree of TCDD TEQ contamination as posing **no apparent increased risk** for altered development of the thymus. For off-site sediments, the maximum hazard quotient for intermediate duration oral exposures was 6.93×10^{-3}. Qualitatively, we would describe intermediate duration oral exposures to sediments with this degree of TCDD TEQ contamination as posing **no increased risk** for altered development of the thymus. (See Table 20, Appendix D, and Figure 13, Appendix B, for hazard quotients for intermediate duration oral exposures to the average and maximum concentrations in the five groupings of sediment samples).

For the SJRWP site, the hazard quotient for intermediate duration dermal exposures to soil/sediments in individuals with routine daily exposures to site maximum concentrations was 0.303. Qualitatively, we would describe intermediate duration dermal exposures to sediments with this degree of TCDD TEQ contamination as posing **no apparent increased risk** for altered development of the thymus. For off-site sediments, the maximum hazard quotient for intermediate duration dermal exposures was 7.62×10^{-3}. Qualitatively, we would describe intermediate duration dermal exposures to sediments with this degree of TCDD TEQ contamination as posing **no increased risk** for altered development of the thymus. (See Table 21, Appendix D, and Figure 14, Appendix B, for hazard quotients for intermediate duration

dermal exposures to the average and maximum concentrations in the five groupings of sediment samples).

For intermediate duration exposures through the oral and dermal routes combined and in individuals with routine daily exposures to site-maximum concentrations, the hazard index was found to be 0.556. Qualitatively, we would describe intermediate duration oral plus dermal exposures to sediments with this degree of TCDD TEQ contamination as posing **no apparent increased risk** for altered development of the thymus. For off-site sediments, the maximum hazard quotient for intermediate duration oral plus dermal exposures was 0.0140. Qualitatively, we would describe intermediate duration oral exposures to sediments with this degree of TCDD TEQ contamination as posing **no increased risk** for altered development of the thymus. (See Table 22, Appendix D, and Figure 15, Appendix B, for hazard quotients for intermediate duration oral plus dermal exposures to the average and maximum concentrations in the five groupings of sediment samples).

Under the sporadic exposure scenario (the scenario most likely to represent realistic oral and/or dermal exposures for TPWD technicians), exposures to maximum and average on-site concentrations would be expected to result in hazard quotients ranging from 2.33×10^{-3} to 1.11×10^{-2}. Qualitatively, we would describe oral and/or dermal exposures to sediments with this degree of TCDD TEQ contamination as posing **no increased risk** for altered development of the thymus. (See Table 20 through 22, Appendix D, and Figures 13 through 15, Appendix B, for hazard quotients for other intermediate duration on- and off-site oral and/or dermal sediment exposures).

c. Chronic Duration Exposures

The chronic oral MRL for 2,3,7,8-TCDD is based on an animal study involving rhesus monkeys in which there was altered social behavior in the offspring of mothers fed diets containing 5 ppt 2,3,7,8-TCDD for 16.2 months (for the animals in the study, this was equivalent to an oral dose of 1.2×10^{-4} µg/kg/day of 2,3,7,8-TCDD). Thus 1.2×10^{-4} µg/kg/day was the LOAEL for altered social behavior in rhesus monkeys whose mothers were fed diets containing 2,3,7,8-TCDD. The chronic oral MRL of 1.2×10^{-9} mg/kg/day was derived by dividing the LOAEL of 1.2×10^{-7} mg/kg/day by an uncertainty factor of 100 (3 for the use of a minimal LOAEL, 3 for extrapolation from animals to humans, and 10 for human variability) [24].

For the SJRWP site, the hazard quotients for chronic duration oral exposures to soil/sediments exceeded 1.00 only for the routine daily exposure scenario. The maximum HQ of 4.93 occurred in individuals with routine daily exposure to SJRWP sediments (having the maximum TCDD TEQ concentration of 34,028 pg/g). Chronic duration oral exposure to the SJRWP site average TCDD TEQ concentration of 15,594 pg/g produced a hazard quotient of 2.26. Qualitatively, we would describe chronic duration oral exposures to sediments with this degree of TCDD TEQ contamination as posing a **low increased risk** for altered social behavior in the children of mothers exposed to site sediments during their pregnancy. For off-site sediments, the maximum hazard quotient for chronic duration oral exposures to TCDD TEQ was 0.124. Qualitatively, we would describe chronic duration oral exposures to sediments with this degree of TCDD TEQ contamination as posing **no apparent increased risk** for altered social behavior in the children of mothers exposed to site sediments during their pregnancy. (See Table 23, Appendix D, and Figure 16, Appendix B, for hazard quotients for chronic duration oral exposures to the average and maximum concentrations in the five groupings of on- and off-site sediment samples).

For the SJRWP site, the hazard quotients for chronic duration dermal exposures to soil/sediments exceeded 1.00 only for the routine daily exposure scenario. The maximum HQ of 5.88 occurred in individuals with routine daily exposure to SJRWP sediments (having the maximum TCDD TEQ concentration of 34,028 pg/g). Dermal exposure to the site average concentration of 15,594 pg/g produced a hazard quotient of 2.70. Qualitatively, we would describe chronic duration dermal exposures to sediments with this degree of TCDD TEQ contamination as posing a **low increased risk** for altered social behavior in the children of mothers exposed to site sediments during their pregnancy. For off-site sediments, the maximum hazard quotient for chronic duration dermal exposures to TCDD TEQ was 0.148. Qualitatively, we would describe chronic duration dermal exposures to sediments with this degree of TCDD TEQ contamination as posing **no apparent increased risk** for altered social behavior in the children of mothers exposed to site sediments during their pregnancy. (See Table 24, Appendix D, and Figure 17, Appendix B, for hazard quotients for chronic duration dermal exposures to the average and maximum concentrations in the five groupings of on- and off-site sediment samples).

For the SJRWP site, the hazard index (HI) for chronic duration exposures to site maximum TCDD TEQ levels, both exposure routes combined, was greater than 1.00 in individuals with routine daily exposures and frequent periodic exposures (HIs = 10.8 and 1.13, respectively). For chronic duration oral plus dermal exposures to site average TCDD TEQ concentrations, the hazard index was found to be 4.96. Qualitatively, we would describe combined oral and dermal chronic duration exposures to sediments with this degree of TCDD TEQ contamination as posing a **low increased risk** for altered social behavior in the children of mothers exposed to site sediments during their pregnancy. The maximum HI for routine daily exposures to off-site soil/sediments was 0.272. Qualitatively, we would describe combined oral and dermal chronic duration exposures to sediments with this degree of TCDD TEQ contamination as posing **no apparent increased risk** for altered social behavior in the children of mothers exposed to off-site sediments during their pregnancy. (See Table 25, Appendix D, and Figure 18, Appendix B, for hazard quotients for chronic duration oral plus dermal exposures to the average and maximum concentrations in the five groupings of on- and off-site sediment samples).

Under the sporadic exposure scenario (the scenario most likely to represent realistic oral and/or dermal exposures for TPWD technicians), chronic duration exposures to average and maximum on-site concentrations would be expected to result in hazard quotients ranging from 4.52×10^{-2} to 2.16×10^{-1}. Qualitatively, we would describe oral and/or dermal chronic duration exposures to sediments with this degree of TCDD TEQ contamination as posing **no apparent increased risk** for altered social behavior in the children of mothers exposed to site sediments during their pregnancy. (See Table 23 through 25, Appendix D, and Figures 16 through 18, Appendix B, for hazard quotients for other chronic duration on- and off-site oral and/or dermal sediment exposures).

Childhood Health Effects Evaluation

Since this PHC addresses exposures to sediments in an occupational setting, no childhood exposure scenarios were considered or evaluated. Most of the TMDL sediment samples collected by the University of Houston were of submerged sediments from numerous locations throughout the SJR, HSC, and UGB waterway system and, as such, would not be accessible to children. Childhood exposures to sediments at the San Jacinto River Waste Pits Superfund site are thoroughly addressed in the Public Health Assessment for the SJRWP site.

Conclusions

ATSDR has reached the following 4 conclusions with regard to sediments from the SJRWP site, the SJR, the HSC, and UGB:

1. PCDDs and PCDFs have been detected in SJRWP site sediments at concentrations that would cause unacceptably high theoretical risks for cancer for TPWD technicians under the routine daily oral and/or dermal exposure scenarios. Therefore, ATSDR concludes that routine daily oral and/or dermal exposures to sediments from the SJRWP site for periods of 5.15 years or longer could harm TPWD technicians' health.
2. PCDDs and PCDFs have been detected in SJRWP site sediments at concentrations that have been associated with non-cancer adverse health effects (i.e., altered social behavior in children of mothers exposed during pregnancy) for individuals with routine daily exposures for periods of 1 year or longer. Therefore, ATSDR concludes that routine daily oral and/or dermal exposures to sediments from the SJRWP site for periods of one year or longer could harm TPWD technicians' health.
3. None of the sediment sampling locations thus-far identified (outside the SJRWP site) have been found to have high enough PCDD/PCDF concentrations to pose an unacceptable cancer risk for routine daily oral and/or dermal exposures, as defined under this health consultation (250 times a year for 30 years). Therefore, ATSDR concludes that routine daily exposures to off-site sediments at any of the sampling locations thus-far tested for dioxins are not expected to harm TPWD technicians' health.
4. None of the sediment sampling locations thus-far identified (on- or off-site) have been found to have high enough PCDD/PCDF concentrations to pose an unacceptable cancer risk for sporadic oral and/or dermal exposures, as defined under this health consultation (5 times a year for 15 years). Therefore, ATSDR concludes that sporadic exposures to on- or off-site sediments at any of the sampling locations thus-far tested for dioxins are not expected to harm TPWD technicians' health.

Recommendations

ATSDR makes the following recommendations with regard to sediments from the SJRWP site, the SJR, the HSC, and UGB:

1. TPWD technicians should avoid collecting biota samples on a routine daily basis from the SJRWP site for more than 364 days.
2. TPWD technicians should wear protective gloves and waders should it become necessary to collect biota samples from the SJRWP site.
3. TPWD technicians should avoid direct skin contact with sediments at the SJRWP site.
4. TPWD technicians should refrain from eating, drinking, or smoking while they are collecting samples from the SJRWP site.
5. TPWD technicians should wash their hands thoroughly before eating, drinking, or smoking after visiting the SJRWP site.

6. TPWD technicians need not take anything other than routine precautions when they are collecting biota samples from any of the other locations thus-far tested in the SJR-HSC-UGB waterway system.

Public Health Action Plan

Since the SJRWP site are on track for being evaluated and cleaned up under the EPA's superfund program, ongoing exposures to site sediments will not be a likely possibility. Also, since even the sporadic exposure scenario (biota samples collected from the SJRWP site 5 times a year for 15 years by one specific TPWD technician) is still likely to overestimate any real-life exposure scenario (for example once or twice a year sample collections at the SJRWP site for 10 or 15 years of employment collecting samples), real-life risks are expected to be less than the sporadic exposure scenario would predict.

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Appendices

Appendix A – Acronyms and Abbreviations

Appendix B – Figures

Appendix C – Risk Calculation Methods

Appendix D – Tables

Appendix A – Acronyms and Abbreviations

Acronyms and Abbreviations

ATSDR	Agency for Toxic Substances and Disease Registry
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CREG	Carcinogenic Risk Evaluation Guide
CRQL	Contract Required Quantitation Limit
CSF	Cancer Slope Factor
CSL	Contaminant Screening Levels
DHHS	US Department of Health and Human Services
DSHS	Texas Department of State Health Services
EDL	Estimated Detection Limit
EMEGs	Environmental Media Evaluation Guides
EPA	US Environmental Protection Agency
ESL	Effects Screening Level
ft^2	Square Feet
GI	Gastrointestinal
HAC Value	Health Assessment Comparison Value
HI	Hazard Index
HpCDD	Heptachlorodibenzo-p-dioxin
HpCDF	Heptachlorodibenzofuran
HQ	Hazard Quotient
HRS	Hazard Ranking System
HSC	Houston Ship Channel
HSDB	Hazardous Substance Data Bank
HxCDD	Hexachlorodibenzo-p-dioxin
HxCDF	Hexachlorodibenzofuran
IARC	International Agency for Research on Cancer
IDL	Instrument Detection Limit
IH-10	Interstate Highway 10
IRIS	U.S. EPA Integrated Risk Information System
IUR	Inhalation Unit Risk
J	Result is estimated.
kg	Kilogram
L	Reported concentration is between the IDL and the CRQL.
LD_{50}	Lethal dose for 50% of animals tested
LGB	Lower Galveston Bay
LOAEL	Lowest Observed Adverse Effects Level
mg/kg	Milligrams per kilogram
mg/kg/day	Milligrams per kilogram per day
MRL	Minimal Risk Level
ND	Non-Detect (any associated value represents ½ the detection limit)
NLM	National Library of Medicine
NOAEL	No Observed Adverse Effects Level
NPL	National Priorities List

OCDD	Octachlorodibenzo-p-dioxin
OCDF	Octachlorodibenzofuran
ORNL	Oak Ridge National Laboratories
OSF	Oral Slope Factor
PASI	Preliminary Assessment/Site Inspection
PCB	Polychlorinated biphenyl
PCDD	Polychlorinated dibenzodioxin
PCDF	Polychlorinated dibenzofuran
PCP	Pentachlorophenol
PeCDD	Pentachlorodibenzo-p-dioxin
PeCDF	Pentachlorodibenzofuran
pg/g	Picograms per gram
PHA	Public Health Assessment
PHC	Public Health Consultation
ppb	Parts per billion
ppm	Parts per million
ppt	Parts per trillion
PRPs	Potentially Responsible Parties
QA/QC	Quality Assurance/Quality Control
RAIS	Risk Assessment Information System
RBCs	Risk-Based Concentrations
RCRA	Resource Conservation Recovery Act
REGs	Risk Evaluation Guides
RELs	Reference Exposure Levels
RfC	Reference Concentration
RfD	Reference Dose
RMEGs	Reference Dose Media Evaluation Guides
SALG	Seafood and Aquatic Life Group
SARA	Superfund Amendments and Reauthorization Act
SJR	San Jacinto River
SJRWP	San Jacinto River Waste Pits
TCDD	Tetrachlorodibenzo-p-dioxin
TCDF	Tetrachlorodibenzofuran
TCEQ	Texas Commission on Environmental Quality
TDH	Texas Department of Health
TEF	Toxic Equivalency Factor
TEQ	Toxic Equivalency
TMDL	Total Maximum Daily Load
TPWD	Texas Parks and Wildlife Department
µg/kg	Micrograms per kilogram
$\mu g/m^3$	Micrograms per cubic meter
UGB	Upper Galveston Bay
WHO	World Health Organization

Appendix B – Figures

Figure 1. University of Houston Dioxin TMDL Project, Sample Locations 3.11

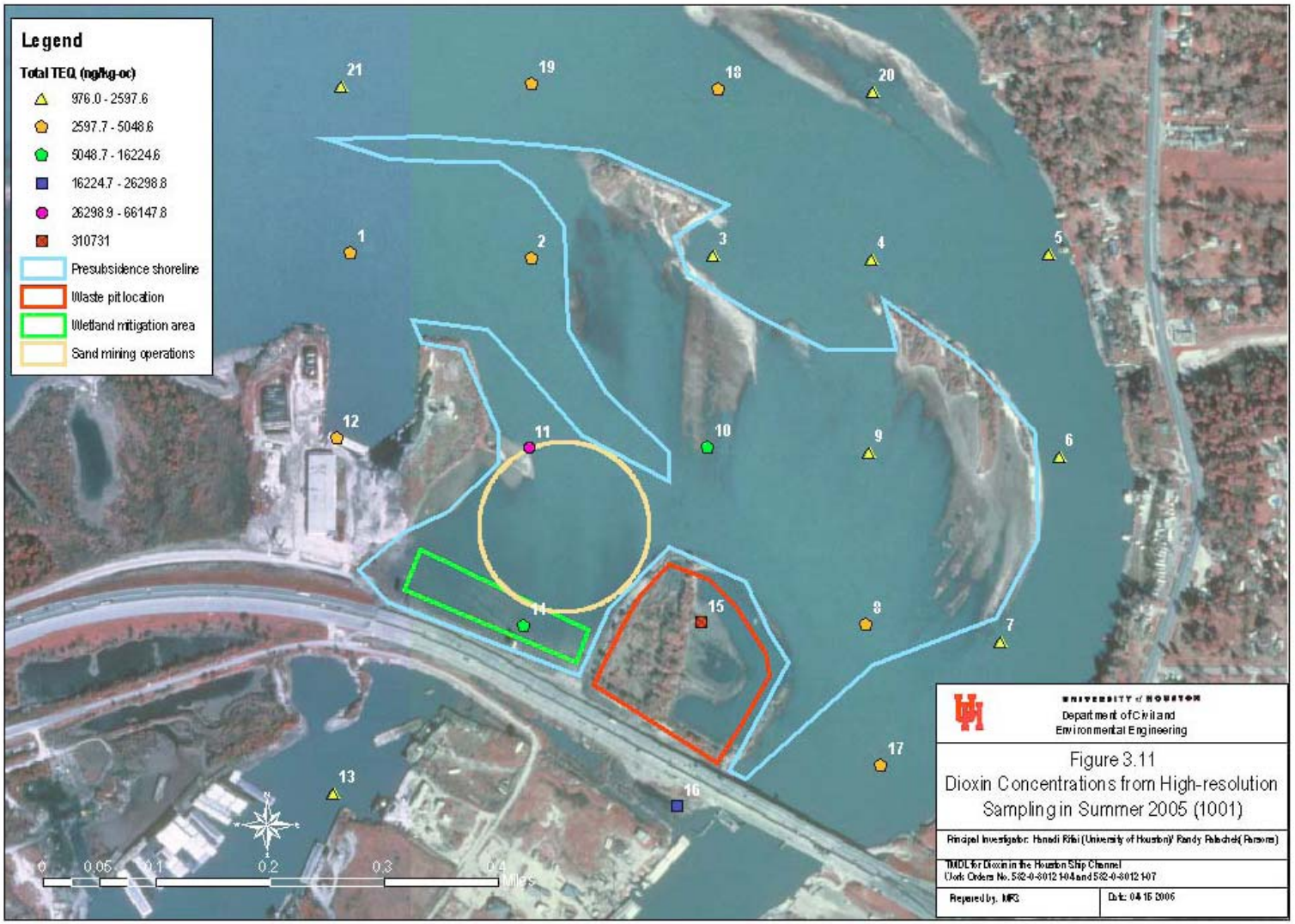


Figure 2. Aerial Photo of San Jacinto River Waste Pits, Sediment Sample Locations

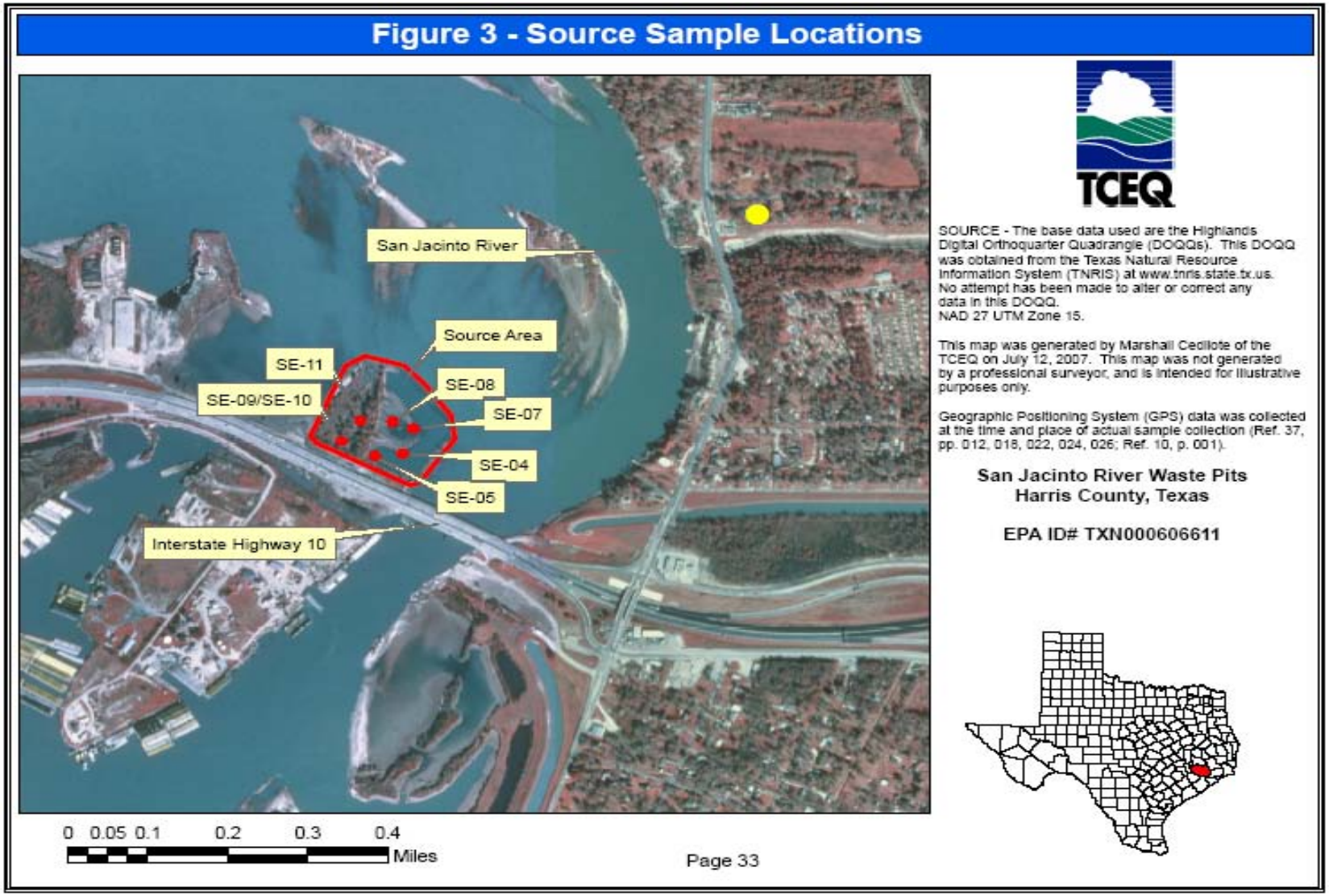


Figure 3. Aerial Photo, San Jacinto River Waste Pits, Background Sample Locations.

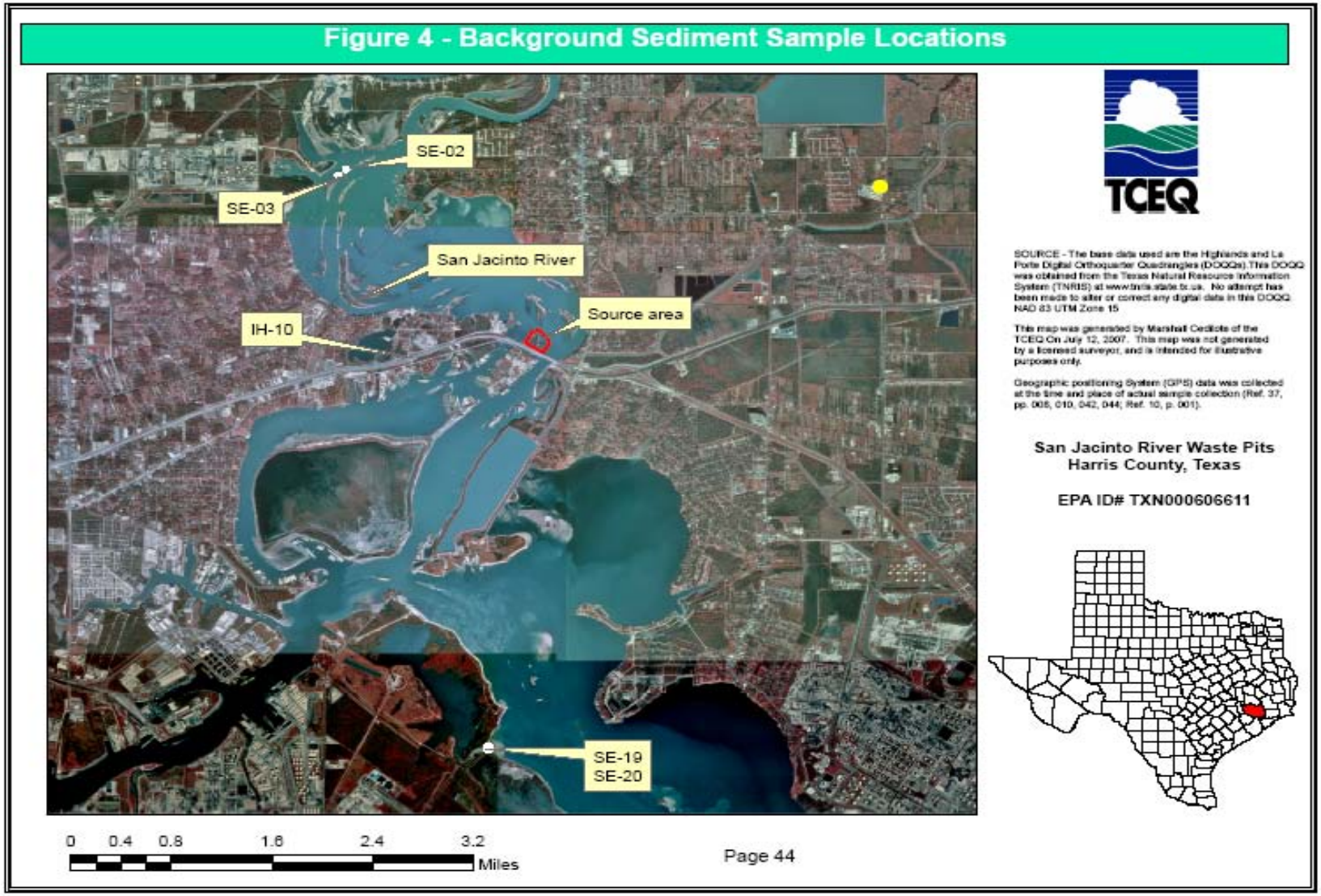


Figure 4. University of Houston Dioxin TMDL Project, Sample Locations 3.1

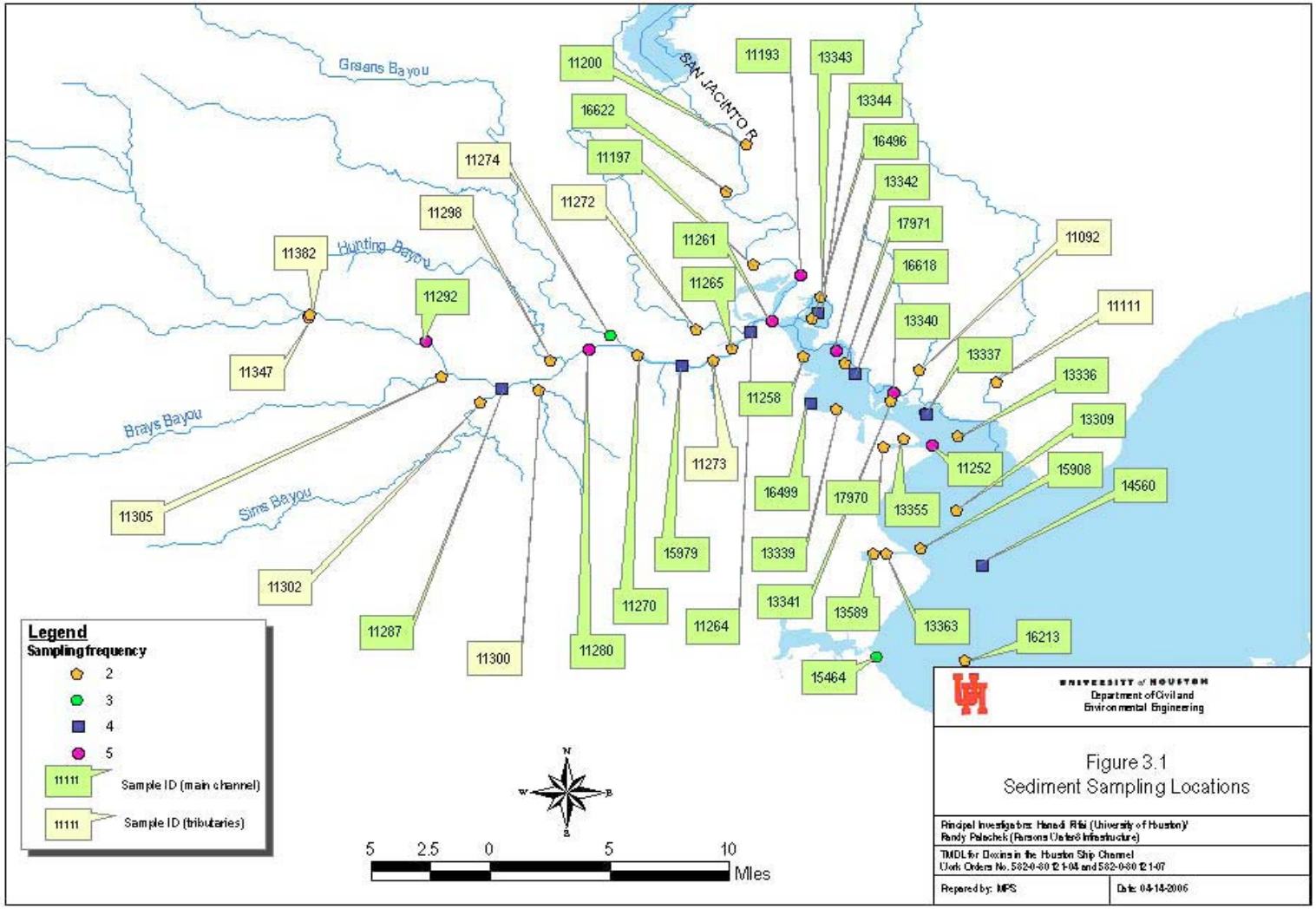


Figure 5. University of Houston Dioxin TMDL Project, Sample Locations 3.2

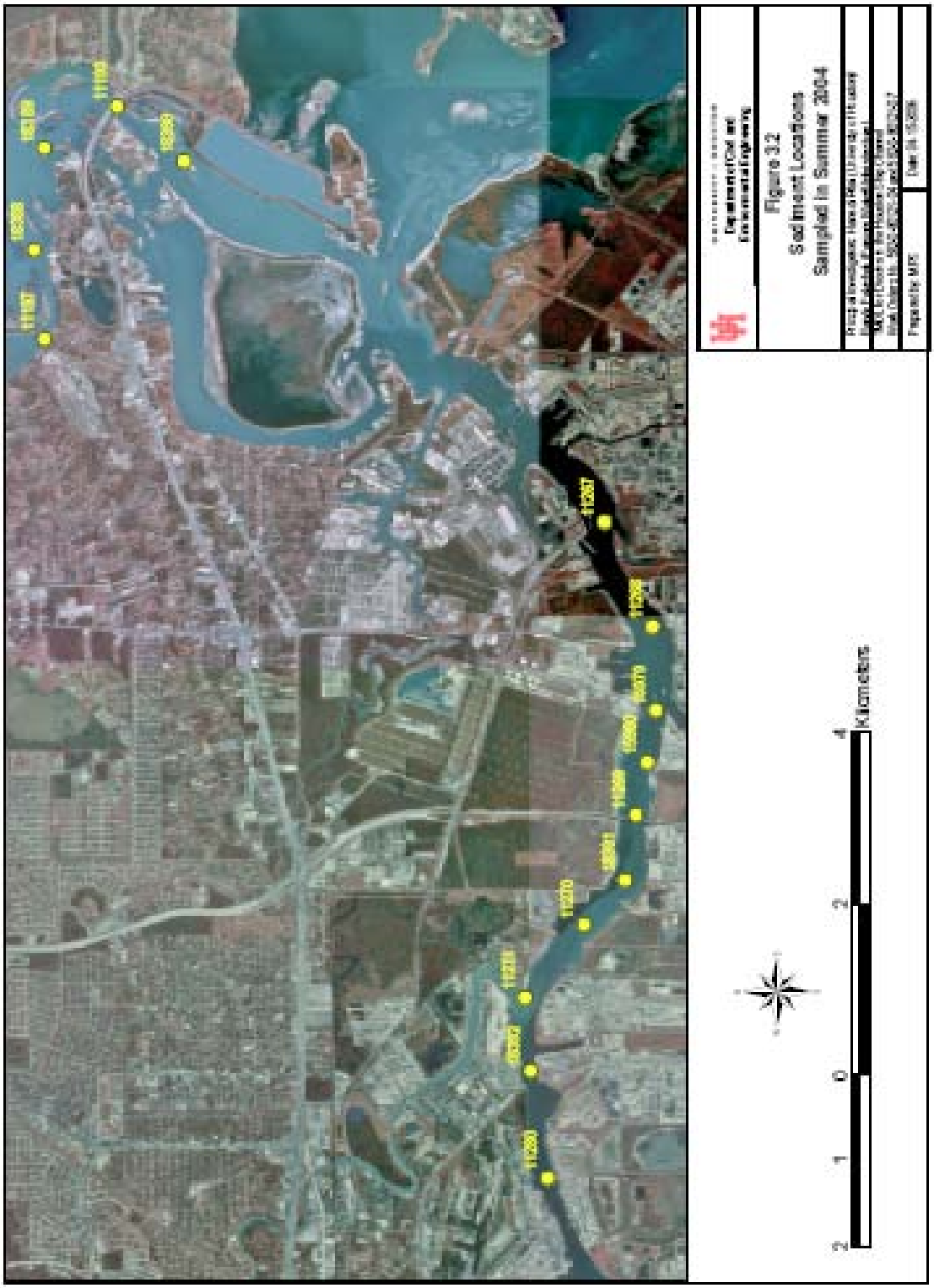


Figure 6. University of Houston Dioxin TMDL Project, Sample Locations 3.4

Figure 3.4a Sampled Locations in Segment 1007 in Summer 2005

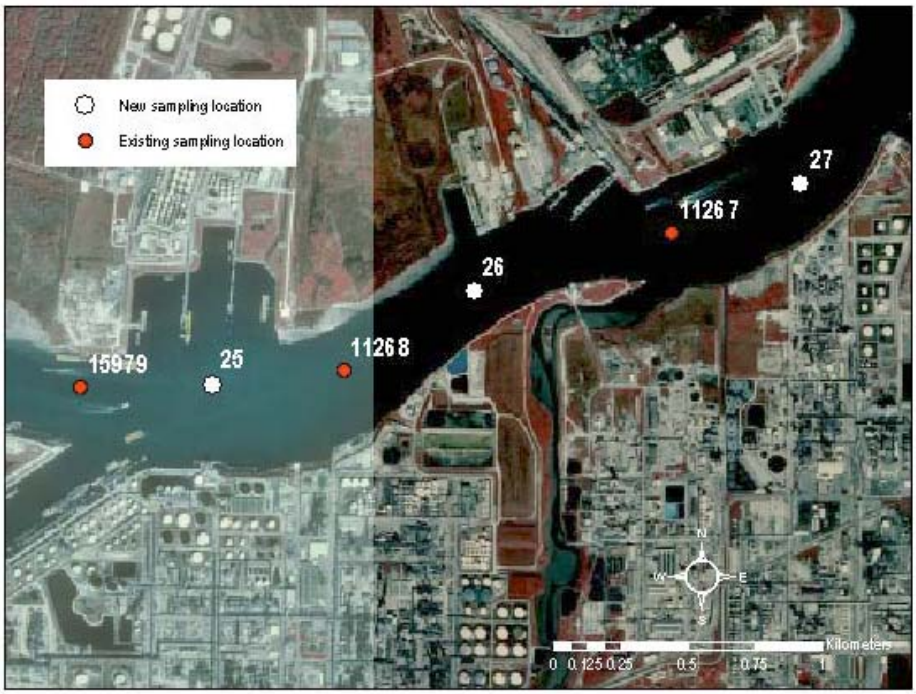


Figure 3.4b Sampled Locations in Segment 1006 in Summer 2005

Figure 7. Theoretical Cancer Risks for Oral Exposure to TCDD TEQ

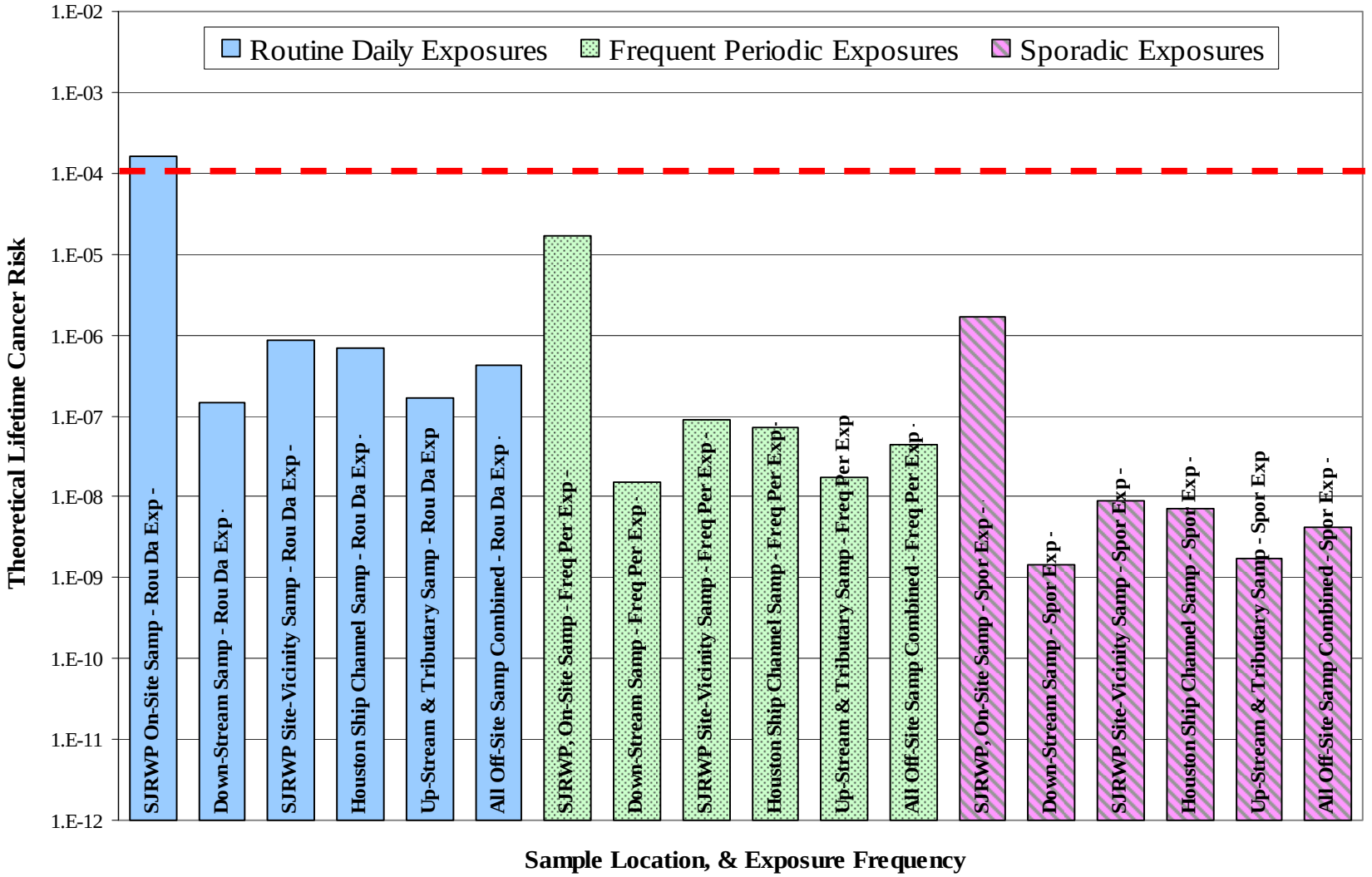


Figure 8. Theoretical Cancer Risks for Dermal Exposure to TCDD TEQ

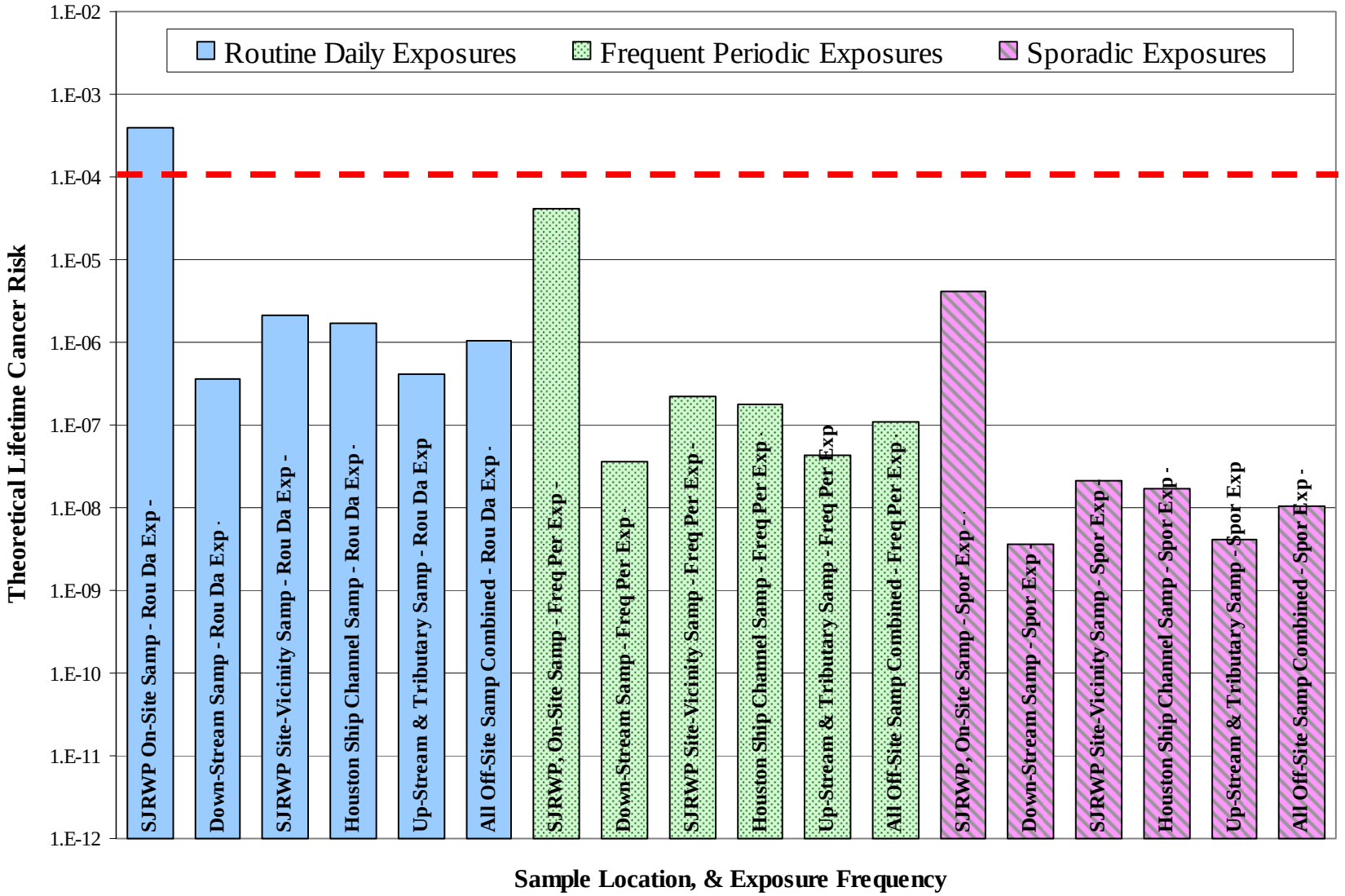


Figure 9. Theoretical Cancer Risks for Oral + Dermal Exposure to TCDD TEQ

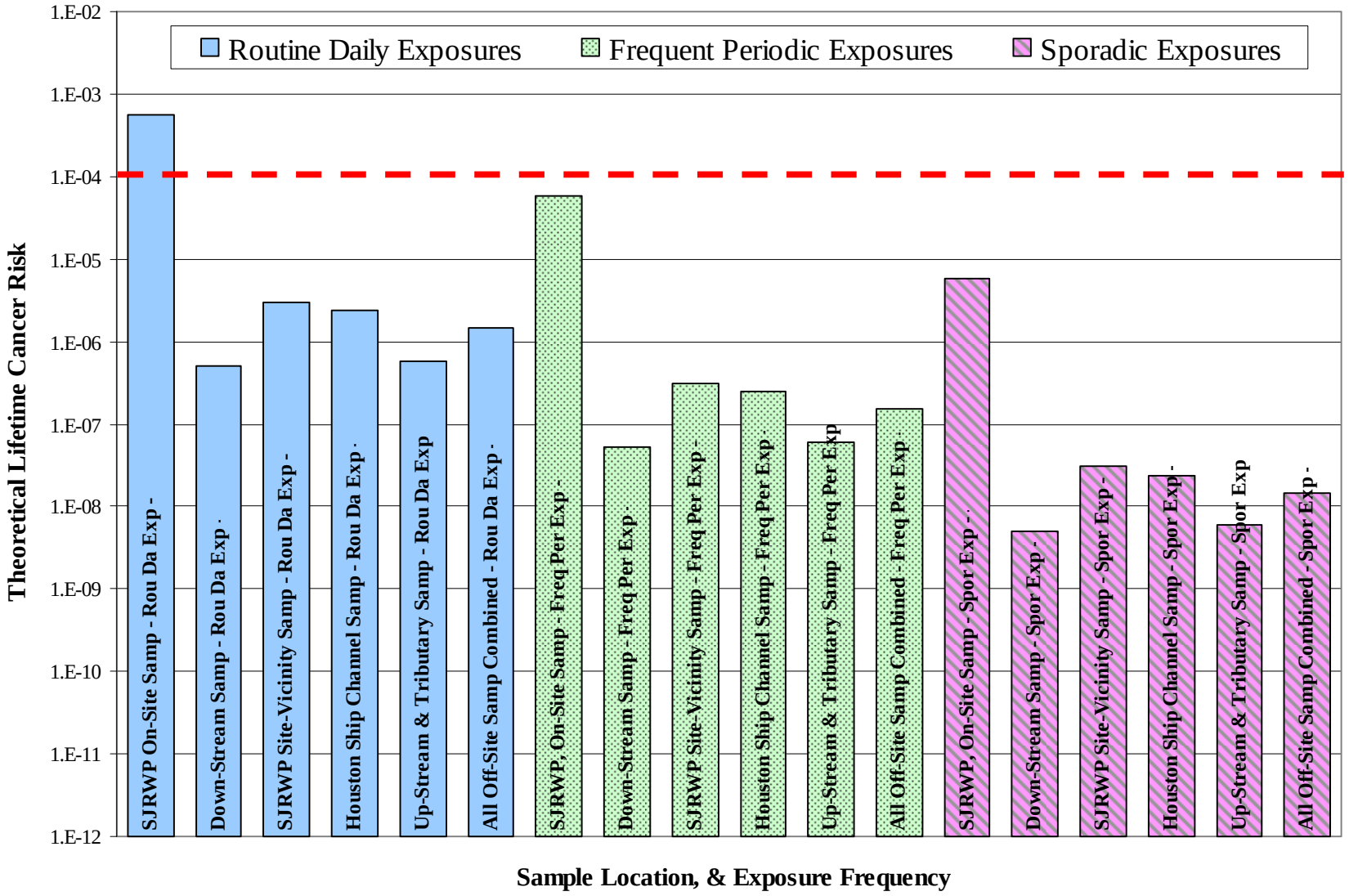


Figure 10. Hazard Quotients for Oral Route, Acute Exposures to TCDD TEQ

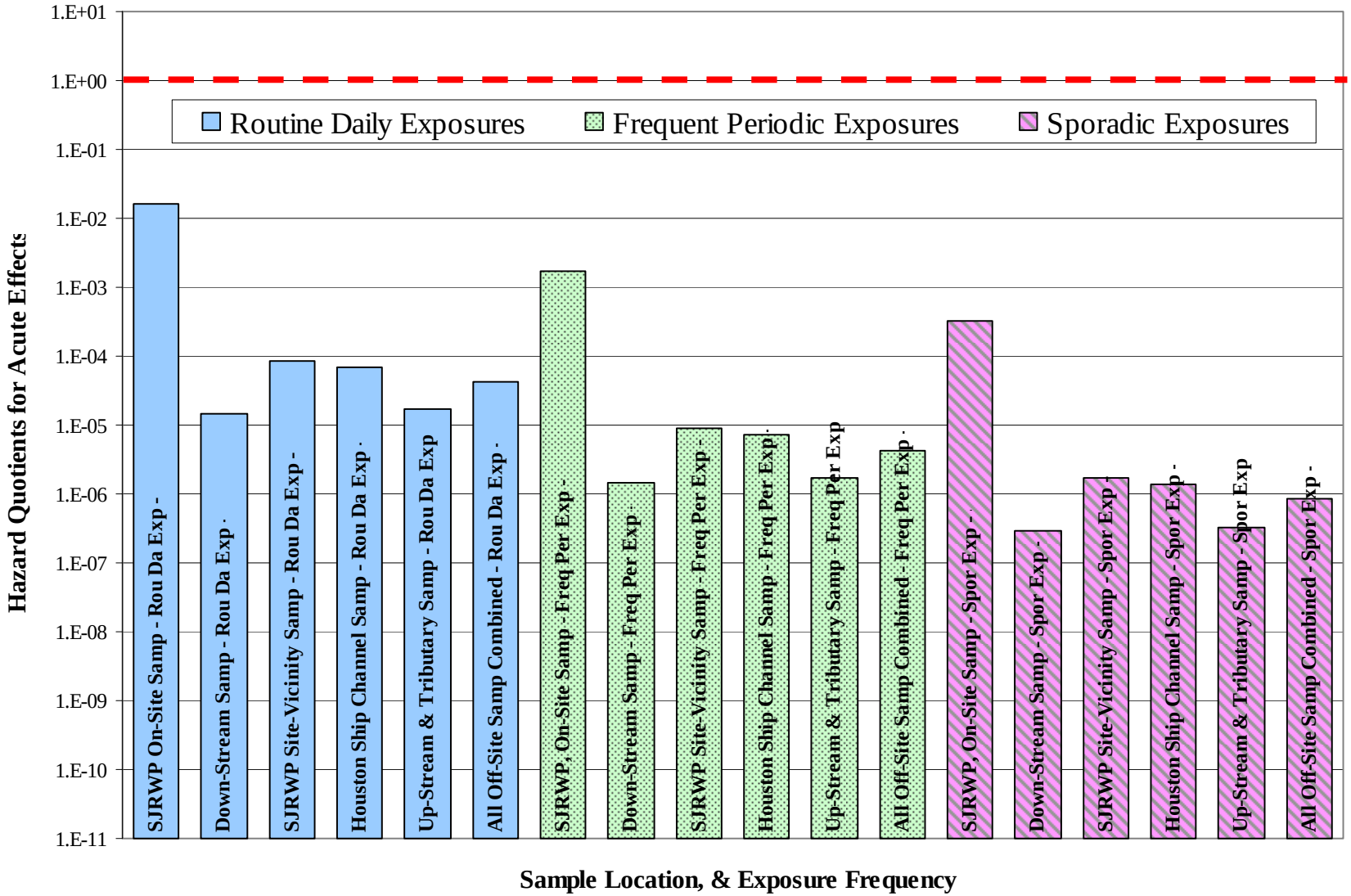


Figure 11. Hazard Quotients for Dermal Route, Acute Exposures to TCDD TEQ

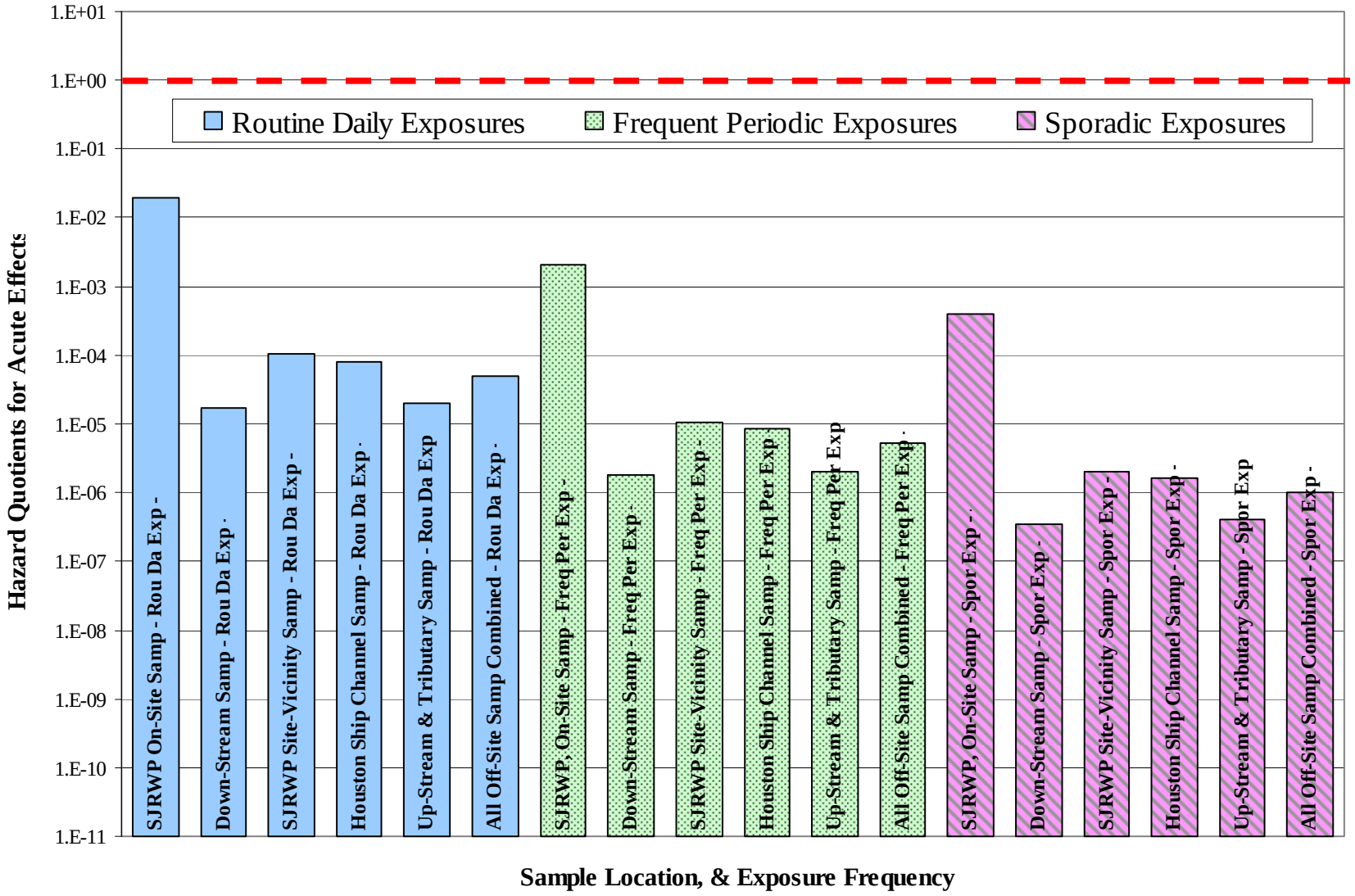


Figure 12. Hazard Quotients for Oral + Dermal Route, Acute Exposures to TCDD TEQ

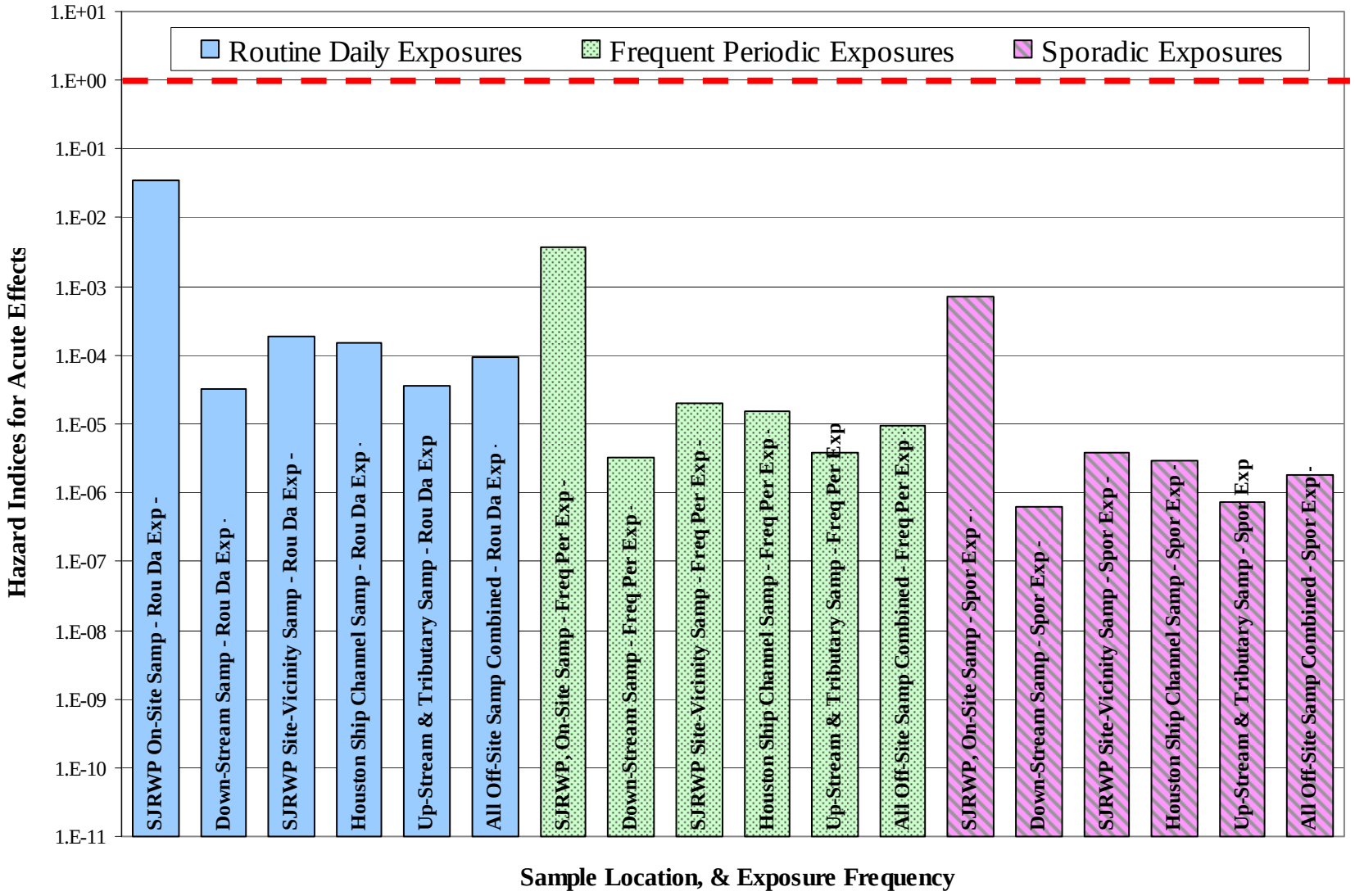


Figure 13. Hazard Quotients for Oral Route, Intermediate Exposures to TCDD TEQ

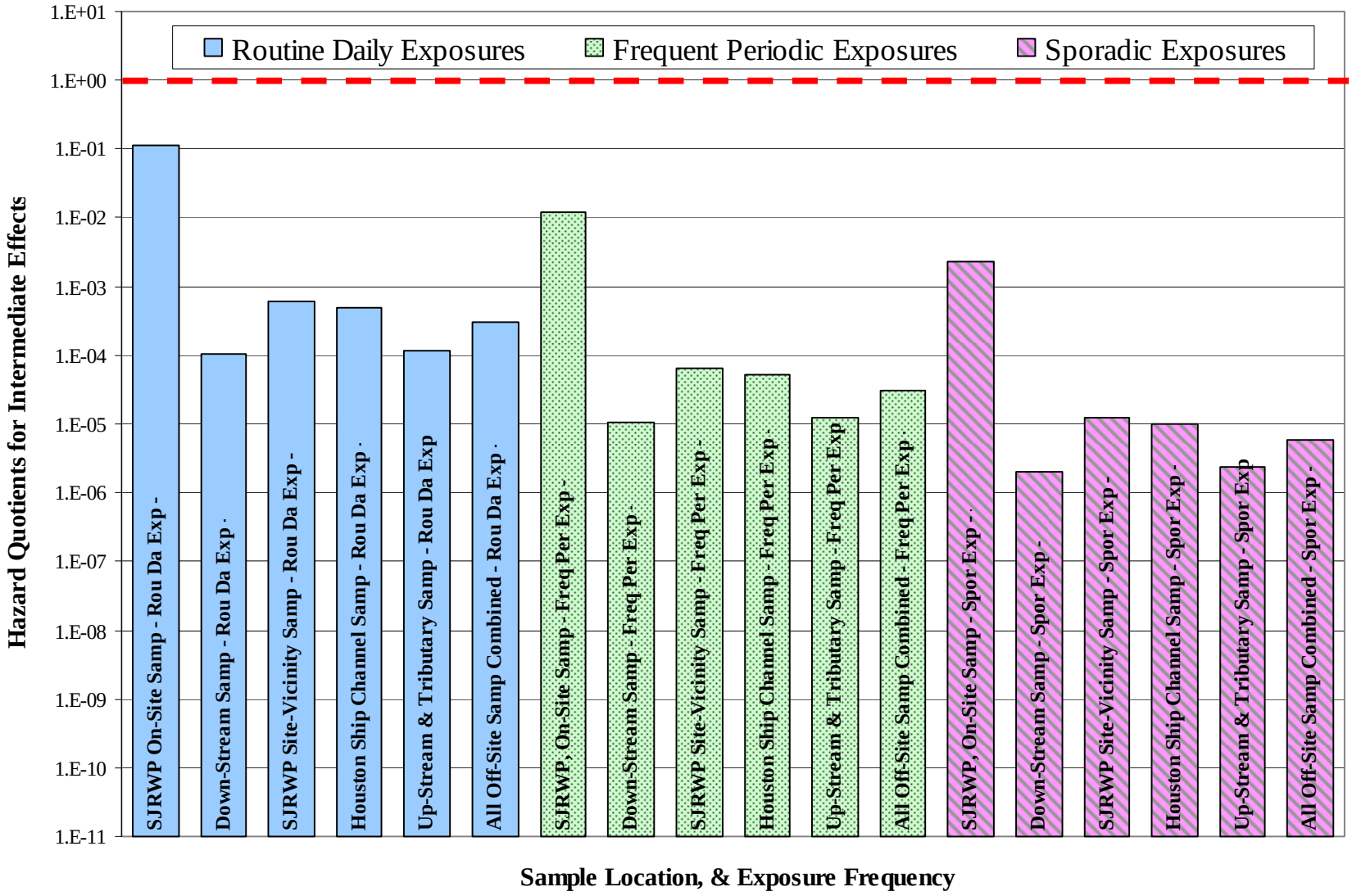


Figure 14. Hazard Quotients for Dermal Route, Intermediate Exposures to TCDD TEQ

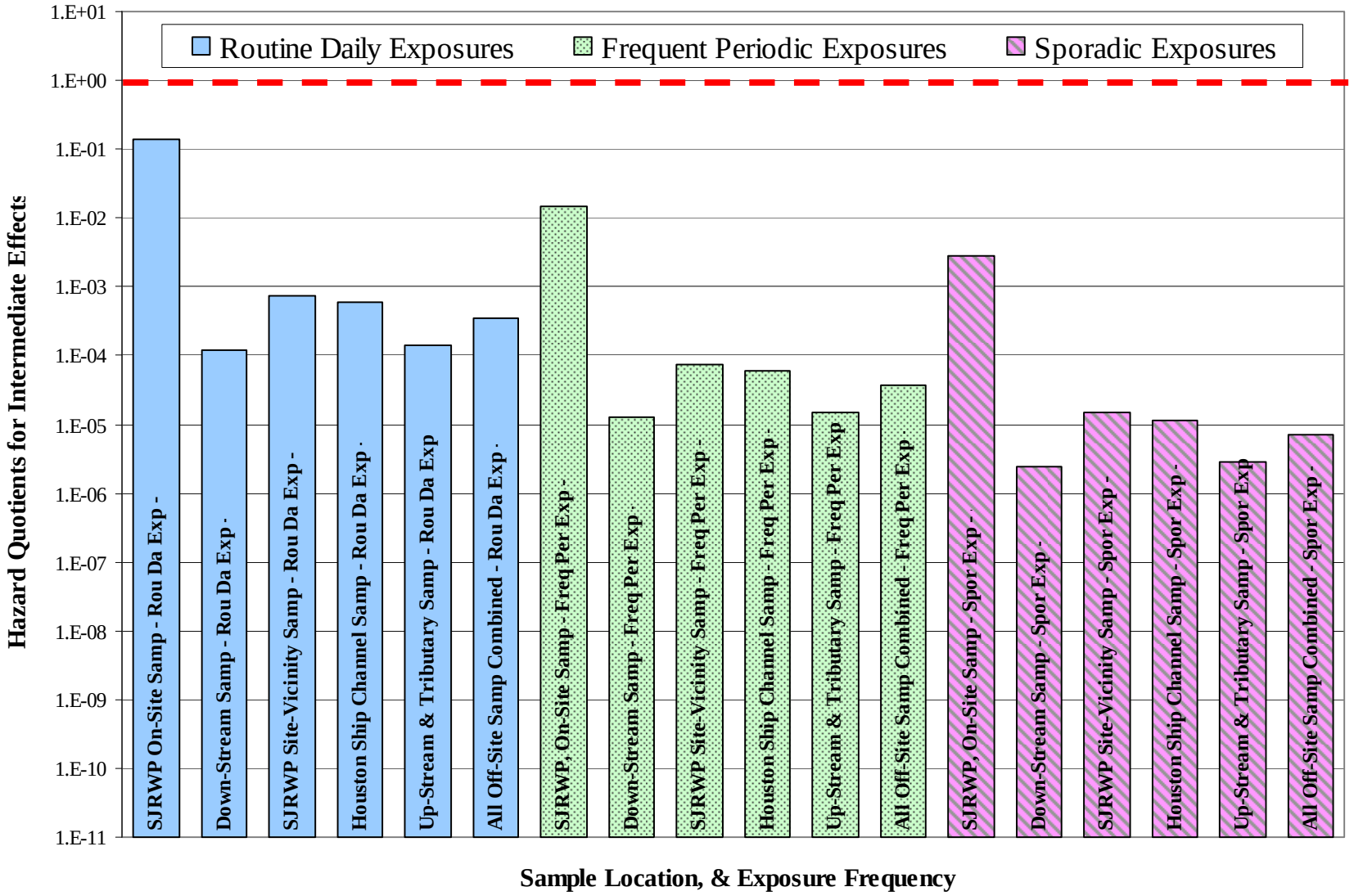


Figure 15. Hazard Quotients for Oral + Dermal, Intermediate Exposures to TCDD TEQ

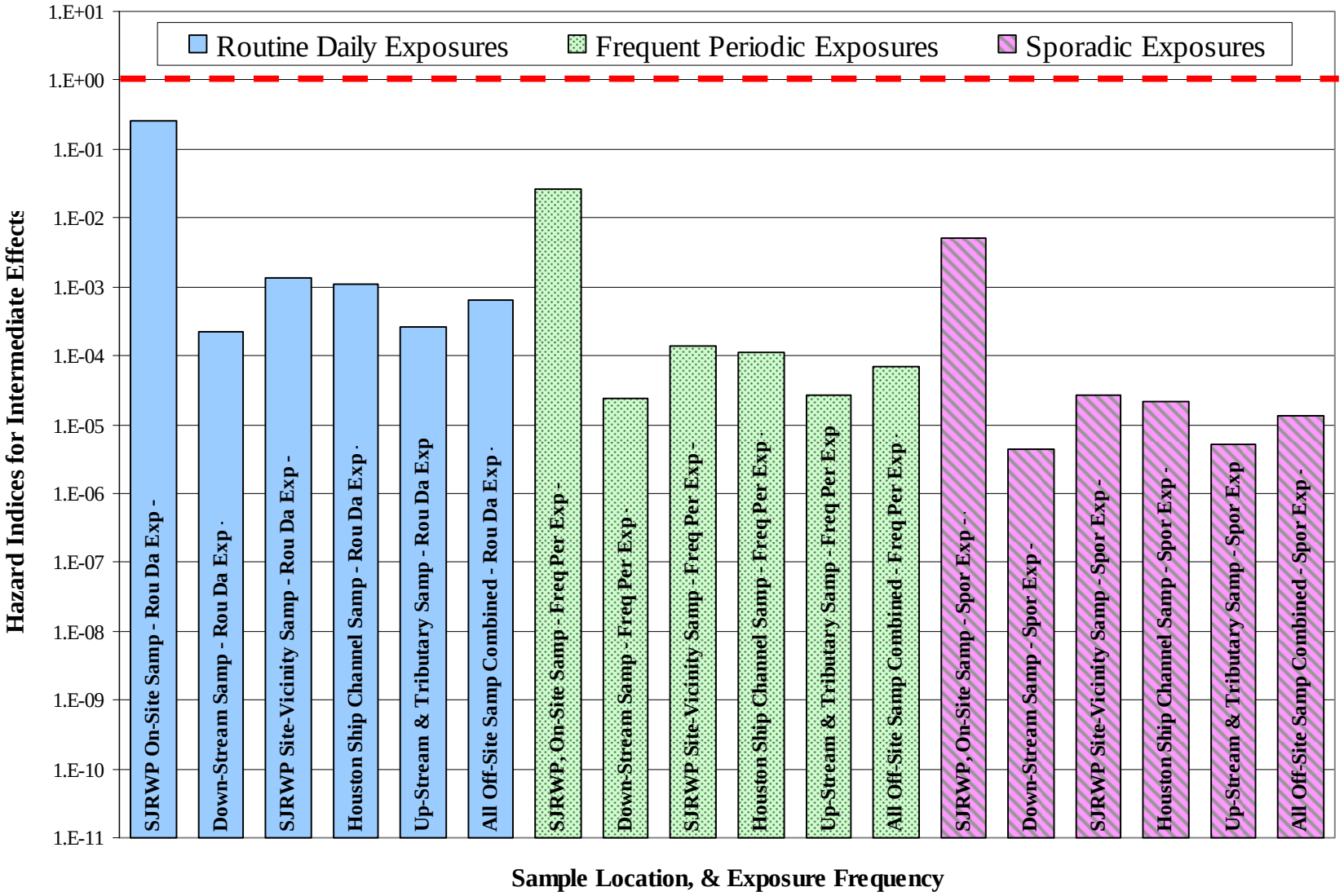


Figure 16. Hazard Quotients for Oral Route, Chronic Exposures to TCDD TEQ

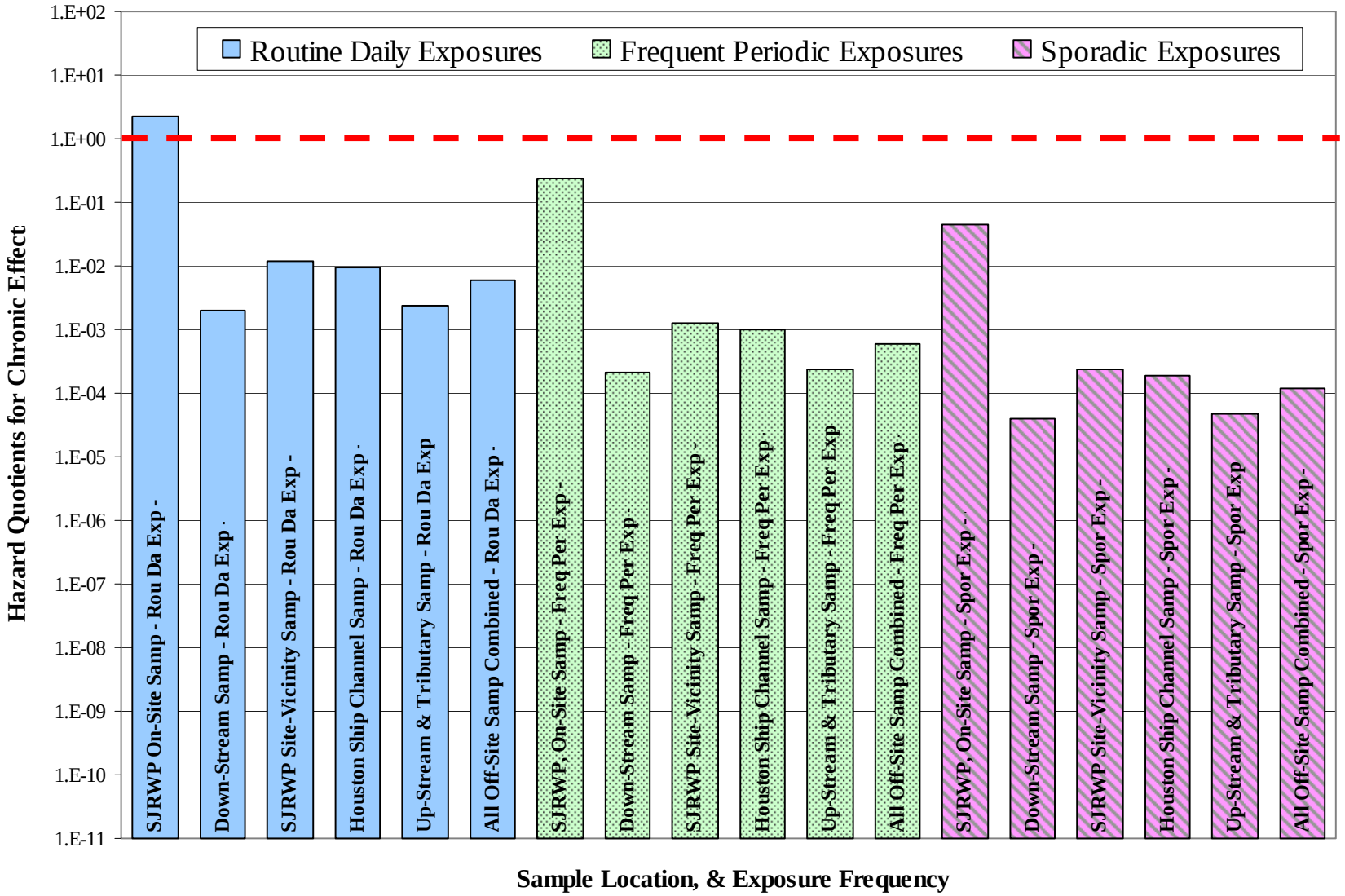


Figure 17. Hazard Quotients for Dermal Route, Chronic Exposures to TCDD TEQ

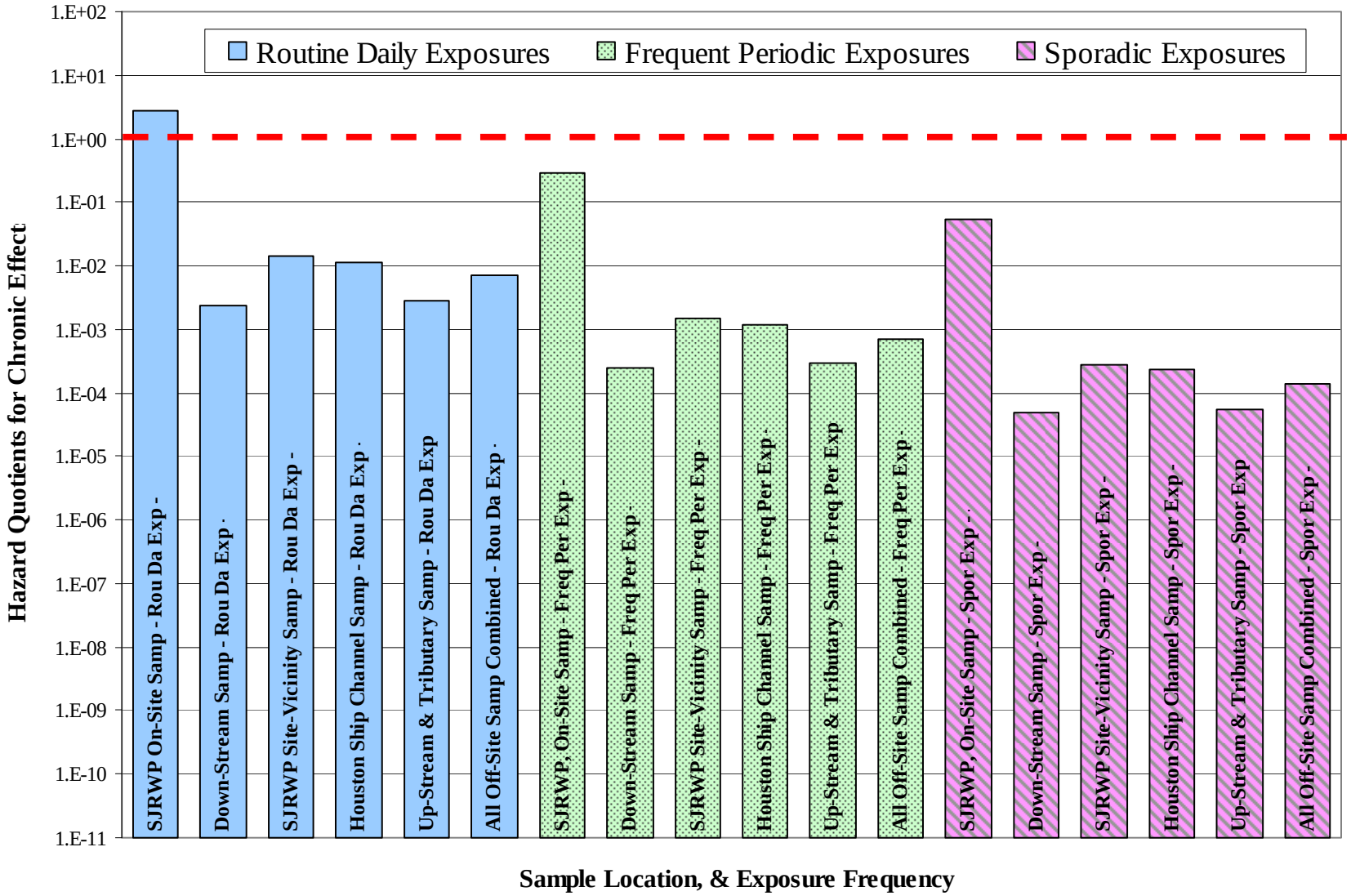
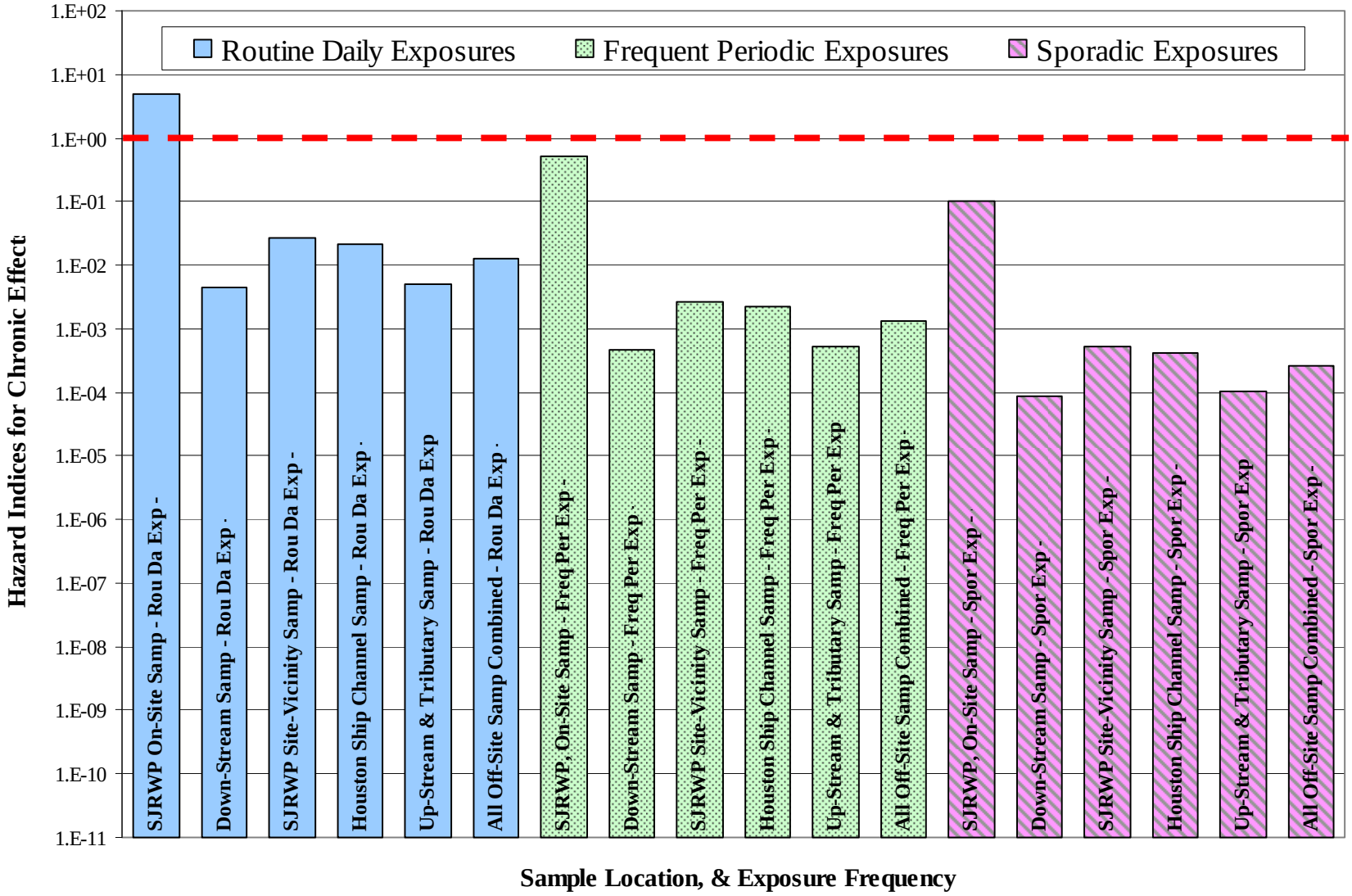


Figure 18. Hazard Indices for Oral + Dermal, Chronic Exposures to TCDD TEQ

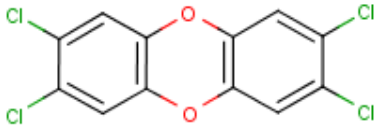


Appendix C – Risk Calculation Methods

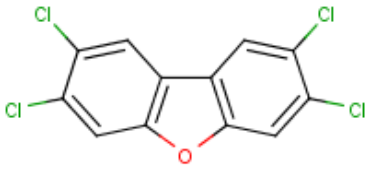
Calculation of the Toxic Equivalency (TEQ) for Mixed Dioxins

PCDDs and PCDFs are chlorinated tricyclic compounds that are extremely persistent in the environment. They are also highly toxic and can adversely affect human or animal health at very low concentrations. These families of compounds can contain from 1-8 chlorine atoms replacing the hydrogen atoms at any one or more of the 8 bonding locations around the molecules. The PCDD family includes 75 possible unique congeners, and PCDF family includes 135 possible unique congeners. However, only 7 out of the 75 PCDD congeners and 10 out of the 135 PCDF congeners are thought to have dioxin-like toxicity [3].

Toxicity generally increases with the number of chlorine atoms present on the molecule (up to four chlorines) but decreases thereafter as the number of chlorines increases to eight. Those congeners of PCDDs and PCDFs having chlorine atoms in the 2, 3, 7, and 8 positions appear to be more toxic than other PCDD/PCDF congeners. The most toxic of all PCDDs is 2,3,7,8-tetrachlorodibenzo-p-dioxin [28] (see structure for 2,3,7,8-TCDD below). Consequently, 2,3,7,8-TCDD has been designated the standard against which the toxicity of other congeners is measured.



2,3,7,8-TCDD



2,3,7,8-TCDF

The 17 PCDD/PCDF congeners with dioxin-like toxicity are often found in complex mixtures. For risk assessment purposes, scientists from the World Health Organization (WHO) have developed a toxicity equivalency procedure to describe the combined toxicity of these mixtures [28]. This procedure involves assigning individual toxicity equivalency factors (TEFs) to the various congeners with dioxin-like toxicity. Under this scheme, the most toxic congener (2,3,7,8-TCDD) is assigned a TEF of 1.0, and the other 16 congeners have been assigned TEFs from 0.5 down to 0.0001 (with the exception of 1,2,3,7,8-PeCDD which also was assigned a TEF of 1.0) (See Table 1, Appendix D).

To calculate the toxic equivalency (TEQ) of a mixture, the concentrations of individual congeners are multiplied by their respective TEFs, and the sum of the individual TEQs is defined as the TCDD TEQ concentration for the mixture. This process, in effect, converts the concentrations of the various congeners into concentrations of 2,3,7,8-TCDD that would have an equivalent toxicity (and that can therefore be summed to arrive at the overall toxicity of the mixture). This is described mathematically as follows:

$$\text{Total TCDD TEQ} = \sum_{i=1}^{n} (C_i \times TEF_i)$$

Where

C_i = Concentration of the i'th congener,

TEF_i = Toxicity equivalency factor for the i'th congener,

n = Number of congeners with dioxin-like toxicity, and

i = Term-counting integer that goes from 1 through n.

In the Dioxin TMDL Project, the University of Houston used the "Texas" TEFs (often employed by the TCEQ) for calculating the total TEQs for the various sediment samples [3]. However, for this health consultation, we used the updated World Health Organization (2005) TEFs to calculate the total TEQs [28]. Consequently, our TEQ numbers vary slightly from those reported in Tables 3.3 and 3.4 of the Dioxin TMDL Project, 3rd Quarterly Report [3].

Calculation of Oral Exposure Doses from Sediments

For all three exposure scenarios, the individual's average body weight was determined through use of an Excel® 2003 spreadsheet developed by DSHS that – given a gender (males, females, or males and females combined), a starting age, and an ending age of exposure – integrates the age-specific 50 percentile body weights over time (by the method of Riemann sums [29] with up to n = 46 subintervals of age and with body weights determined for the midpoint of each age subinterval). Selecting for males and females combined, resultant average body weights were calculated to be 70.58 kg for ages 20-50 (scenarios 1 & 2 for cancer effects), 69.05 kg for ages 20-35 (scenario 3 for cancer effects), and 65.78 kg for ages 20-21 (scenarios 1, 2, & 3 for non-cancer effects). It is assumed that the technician ingests 100 mg of dioxin-contaminated sediment on each visit to a contaminated sampling station through hand-to-mouth activities with dirty hands (e.g., eating, drinking, smoking, biting nails, etc.), and it is assumed the oral absorption factor for PCDD/PCDF from sediments is 50% [26,27]. See Table 2, Appendix D for all parameters used in oral exposure scenarios. Oral exposure doses on exposure days are calculated as follows:

$$AD_o = \text{Total } TEQ_n \times IR_s \times CF_1 \times CF_2 \times AF_o \div BW_{avg}$$

Where,

AD_o = Oral absorbed dose on exposure days ($mg_{TEQ}/kg_{BW}/day$),

Total TEQ_n = TCDD TEQ concentration at the n'th sampling location (pg_{TEQ}/g_{sed}),

IR_s = Oral sediment intake rate (mg_{sed}/day),

CF_1 = Units conversion factor 1 (10^{-9} mg_{TEQ}/pg_{TEQ}),

CF_2 = Units conversion factor 2 (10^{-3} g_{sed}/mg_{sed}), and

AF_o = TCDD oral absorption factor for sediments (unitless),

BW_{avg} = Average body weight over exposure period (kg_{BW})

Since, in most conservative exposure models, toxicity/carcinogenicity (in low dose exposures) is assumed to be linear with respect to exposure dose, cutting any of the above exposure parameters in half would cut the resulting risk in half as well (except for body weight which would double the resulting risk). Similarly, doubling any of the exposure parameters (except for body weight) would double the resulting risk.

In the event that some technicians may not visit the same sampling station every day but may visit some station every day, we have calculated the average concentration for each congener and

assumed that the Total TEQ to which the individual is exposed is the average TEQ of all the sampling stations.

Calculation of Dermal Exposure Doses from Sediments

Individual dermal exposure levels for TPWD staff could not be determined from the description of the activities in which staff may participate; thus, we made a number of assumptions about possible dermal exposures and set up three scenarios describing a range of possible exposures (see exposure scenarios above). For all three exposure scenarios, the individual's "average" body weight is determined by integration of the 50%ile body weight (for males and females combined) over the time interval specified by the exposure scenario using the method of Riemann sums [29] (70.58 kg for ages 20-50, 69.05 kg for ages 20-35, and 65.78 kg for ages 20-21). On each visit it is assumed that the technician gets dioxin-contaminated sediment on both hands and forearms. The average surface area of these body parts over the exposure interval is determined using the method of Riemann sums [29] (2,056 cm^2 for ages 20-50, 2,040 cm^2 for ages 20-35. and 1,987 cm^2 for ages 20-21). [Table 6-2 in Ref 30]. The rate of sediment loading is assumed to be 1.0 mg_{sed}/cm^2 of body surface area exposed [Table 6-17 in Ref 30]. The dermal absorption factor for TCDD is reported as 0.03 [27,31]. See Table 3, Appendix D for all parameters used in dermal exposure scenarios. The dermal exposure dose on exposure days is calculated as follows:

$$AD_d = \text{Total } TEQ_n \times SL_s \times SA_{con} \times CF_1 \times CF_2 \times AF_d \div BW_{avg}$$

Where,

AD_d = Dermal absorbed dose on exposure days (mg_{TEQ}/kg_{BW}/day)

Total TEQ_n = TCDD TEQ at the n'th sampling location (pg_{TEQ}/g_{sed}),

SL_s = Sediment loading per skin surface area (mg_{sed}/cm^2),

SA_{con} = Body surface area contaminated with sediment per day (cm^2/day),

CF_1 = Units conversion factor 1 (10^{-9} mg_{TEQ}/pg_{TEQ}),

CF_2 = Units conversion factor 2 (10^{-3} g_{sed}/mg_{sed}),

AF_d = Dermal absorption factor (unitless),

BW_{avg} = Average body weight over exposure period (kg_{BW})

Exposure Factors for Cancer Risk Estimate Calculation

Exposure factors for the three scenarios for cancer risk estimates represent adjustments for less-than-hourly, less-than-daily, less-than-weekly, and less-than-lifetime exposure durations and are calculated as follows:

$$EF_n = (Hr_{ex} \div 24) \times (Da_{ex} \div 7) \times (Wk_{ex} \div 52) \times (Yr_{ex} \div 70)$$

Where,

EF_n = Exposure factor for n'th scenario (unitless),

Hr_{ex} = Hours per day individual is exposed,

Da_{ex} = Days per week individual is exposed,

Wk_{ex} = Weeks per year individual is exposed, and

Yr_{ex} = Number of years individual is exposed

Exposure Factors for Non-Cancer (Hazard Quotient) Calculations

For non-cancer effects, exposures need not be life-long in order for acute, intermediate, or chronic exposure guidelines to have been exceeded. Exposures that exceed 365 days are sufficient to qualify as *chronic*, and are compared with ATSDR's chronic MRLs or EPA's RfDs. Consequently, the exposure factor for less-than-lifetime exposures (i.e., $Yr_{ex} \div 70$) is not used and the net exposure factors for the three scenarios for hazard quotient calculations represent adjustments for less-than-hourly, less-than-daily, and less-than-weekly exposure durations and are calculated as follows:

$$EF_n = (Hr_{ex} \div 24) \times (Da_{ex} \div 7) \times (Wk_{ex} \div 52)$$

Where,

EF_n = Exposure factor for n'th scenario (unitless),

Hr_{ex} = Hours per day individual is exposed,

Da_{ex} = Days per week individual is exposed, and

Wk_{ex} = Weeks per year individual is exposed,

Calculating Theoretical Cancer Risks for Oral Sediment Exposures

Cancer risk estimates, such as those presented in this analysis, represent the theoretical probability that any exposed individual may develop cancer, over the course of a lifetime, as a result of a given carcinogen exposure scenario. The reciprocal of the cancer risk estimate (i.e., 1 divided by the cancer risk estimate) gives the size of the exposed population necessary to expect to see 1 additional cancer case above the background rate if that population is followed for a 70-year "lifetime." For example, a calculated cancer risk estimate of 1×10^{-6} implies that there is a theoretical probability of one additional cancer case over background rates in a population of 1 million people exposed continuously for a 70-year lifetime at the specified level of exposure. To put this in perspective, current US cancer statistics would indicate that approximately 4 out of 10 people will be diagnosed with cancer at some point in their lifetime [32]. This translates to an expected "background" of 400,000 cancer cases occurring in a population of 1 million people followed throughout their lifetimes. Increasing the population's risk for cancer by 1×10^{-6} brings the expected number of cases to 400,001 instead of 400,000. It should be noted that, because of the conservative models used to derive oral and dermal slope factors, the above approach provides a theoretical upper bound estimate of the excess risk; the true or actual excess risk is unknown and could be as low as zero [33].

Theoretical excess lifetime cancer risks associated with oral exposures to TCDD TEQ in sediments for each sampling location (Station ID) were calculated as follows:

$$TR_{o:m,n} = AD_{o:m} \times SF_o \times EF_n$$

Where,

$TR_{o:m,n}$ = Theoretical risk from oral exposure at the m'th sample location

for the n'th exposure scenario,

$AD_{o:m}$ = Oral absorbed dose at the m'th sample location ($mg_{TEQ}/kg_{BW}/day$),

SF_o = EPA's oral slope factor for TCDD [150,000 $(mg_{TEQ}/kg_{BW}/day)^{-1}$], and

EF_n = Exposure factor for the n'th exposure scenario (unitless).

Calculating Theoretical Cancer Risks for Dermal Sediment Exposures

Theoretical excess lifetime cancer risks associated with dermal exposures to the Total TCDD TEQ for each sampling location (Station ID) were calculated as follows:

$$TR_{d:m,n} = AD_{d:m} \times SF_d \times EF_n$$

Where,

$TR_{d:m,n}$ = Theoretical risk from dermal exposure at the m'th sample location for the n'th exposure scenario,

$AD_{d:m}$ = Dermal absorbed dose at the m'th sample location ($mg_{TEQ}/kg_{BW}/day$),

SF_d = RAIS's dermal slope factor for TCDD [27] [300,000 $(mg_{TEQ}/kg_{BW}/day)^{-1}$], and

EF_n = Exposure factor for the n'th exposure scenario (unitless).

Calculating Theoretical Cancer Risks for Both Exposures

The theoretical cancer risks for both site-related exposure routes combined were calculated as the sum of the oral exposure risks plus the dermal exposure risks for each of the sampling locations (and for all sampling locations combined). For the purpose of this risk assessment, we have assumed that the inhalation pathway contributes negligibly to site-related exposures and that ingestion of water from the SJR, HSC, or UGB does not occur. Presumably, TPWD technicians do not eat their catch; consequently, the fish consumption pathway also was eliminated from the analysis.

Theoretical excess lifetime cancer risks associated with TCDD TEQ oral plus dermal exposures combined for each exposure scenario and for each sampling location were calculated as follows:

$$TR_{tot:m,n} = TR_{o:m,n} + TR_{d:m,n}$$

Where,

$TR_{tot:m,n}$ = Theoretical risk from all exposures combined at the m'th sample location for the n'th exposure scenario,

$TR_{o:m,n}$ = Theoretical risk from oral exposure at the m'th sample location for the n'th exposure scenario,

$TR_{d:m,n}$ = Theoretical risk from dermal exposure at the m'th sample location for the n'th exposure scenario,

Calculating Hazard Quotients, Hazard Indices, and Margins of Safety

The Hazard Quotient (HQ) is defined as the ratio of an estimated exposure dose – with units of milligrams per kilogram per day (mg/kg/day) – to a screening health guideline such as a minimal risk level (MRL) or a reference dose (RfD) (also with units of mg/kg/day). Alternatively, the hazard quotient can be calculated as the ratio of the measured concentration of a contaminant in a specific medium (with units such as µg/m^3, mg/kg, ppm, µg/kg, or ppb) to a screening environmental guideline such as an environmental media evaluation guide (EMEG) with equivalent concentration units. The Hazard Index (HI) generally combines exposures from multiple routes (such as the ingestion of contaminated food, drinking water, soil, or sediment; the dermal absorption of contaminants through skin contact; and inhalation of airborne contaminants). The exposure doses from each route are added together and the sum is divided by the health guideline value to arrive at the net HI for all exposures combined. If the HQ or HI calculates to be less than 1.0, the exposure is considered to be unlikely to produce adverse human health effects. If the HQ or HI is greater than or equal to 1.0, then adverse human health effects may or may not be likely to occur, depending on a number of factors, including the magnitude of the HQ or HI, the uncertainty factors used (and whether a LOAEL or a NOAEL was used) in deriving the MRL or RfD, unique susceptibilities of exposed individuals, and the steepness of the slope of the dose-effect curve.

The "margin of safety" as used in this PHC is defined as the reciprocal of the HQ or the HI and, as such, is a measure of how close the given exposure dose is to a reference "safe" exposure dose as defined by the acute, intermediate, or chronic MRL.

Hazard quotients for the three scenarios and three exposure durations for oral and dermal exposure pathways are calculated as follows:

HQ for Acute Duration, Oral Sediment Exposure:

$$HQ_{ao} = AD_o \times EF_{NCa,n} \div MRL_{ao}$$

Where,

HQ_{ao} = Hazard quotient for acute oral sediment exposures (mg_{TEQ}/kg_{BW}/day),

AD_o = Oral absorbed dose on exposure days (mg_{TEQ}/kg_{BW}/day),

$EF_{NCa,n}$ = Exposure factor for n'th scenario (unitless), and

MRL_{ao} = ATSDR's acute oral Minimal Risk Level for TCDD (mg_{TEQ}/kg_{BW}/day).

HQ for Acute Duration, Dermal Sediment Exposure:

$$HQ_{ad} = AD_d \times EF_{NCa,n} \div MRL_{ad}$$

Where,

HQ_{ad} = Hazard quotient for acute dermal sediment exposures (mg_{TEQ}/kg_{BW}/day),

AD_d = Dermal absorbed dose on exposure days (mg_{TEQ}/kg_{BW}/day)

$EF_{NCa,n}$ = Exposure factor for n'th scenario (unitless), and

MRL_{ad} = Estimated acute dermal Minimal Risk Level for TCDD (mg_{TEQ}/kg_{BW}/day).

HI for Acute Duration, Oral & Dermal Routes Combined:

$$HI_{atot} = HQ_{ao} + HQ_{ad}$$

Where,

HI_{atot} = Hazard index for acute all exposures combined (mg_{TEQ}/kg_{BW}/day),

HQ_{ao} = Hazard quotient for acute oral sediment exposures (mg_{TEQ}/kg_{BW}/day),

HQ_{ad} = Hazard quotient for acute dermal sediment exposures (mg_{TEQ}/kg_{BW}/day), and

HQ for Intermediate Duration, Oral Sediment Exposure:

$$HQ_{io} = AD_o \times EF_{NCa,n} \div MRL_{io}$$

Where,

HQ_{io} = Hazard quotient for intermediate oral sediment exposures (mg_{TEQ}/kg_{BW}/day),

AD_o = Oral absorbed dose on exposure days (mg_{TEQ}/kg_{BW}/day),

$EF_{NCa,n}$ = Exposure factor for n'th scenario (unitless), and

MRL_{io} = ATSDR's intermed oral Minimal Risk Level for TCDD (mg_{TEQ}/kg_{BW}/day).

HQ for Intermediate Duration, Dermal Sediment Exposure:

$$HQ_{id} = AD_d \times EF_{NCa,n} \div MRL_{id}$$

Where,

HQ_{id} = Hazard quotient for intermed dermal sediment exp (mg_{TEQ}/kg_{BW}/day),

AD_d = Dermal absorbed dose on exposure days (mg_{TEQ}/kg_{BW}/day)

$EF_{NCa,n}$ = Exposure factor for n'th scenario (unitless), and

MRL_{id} = Est intermed dermal Minimal Risk Level for TCDD (mg_{TEQ}/kg_{BW}/day).

HI for Intermediate Duration, Oral & Dermal Routes Combined:

$$HI_{itot} = HQ_{io} + HQ_{id}$$

Where,

HI_{itot} = Hazard index for intermed all exp combined (mg_{TEQ}/kg_{BW}/day),

HQ_{io} = Hazard quotient for intermed oral sediment exp (mg_{TEQ}/kg_{BW}/day),

HQ_{id} = Hazard quotient for intermed dermal sediment exp (mg_{TEQ}/kg_{BW}/day), and

HQ for Chronic Duration, Oral Sediment Exposure:

$$HQ_{co} = AD_o \times EF_{NCa,n} \div MRL_{co}$$

Where,

HQ_{co} = Hazard quotient for chronic oral sediment exposures (mg_{TEQ}/kg_{BW}/day),

AD_o = Oral absorbed dose on exposure days (mg_{TEQ}/kg_{BW}/day),

$EF_{NCa,n}$ = Exposure factor for n'th scenario (unitless), and

MRL_{co} = ATSDR's chronic oral Minimal Risk Level for TCDD (mg_{TEQ}/kg_{BW}/day).

HQ for Chronic Duration, Dermal Sediment Exposure:

$$HQ_{cd} = AD_d \times EF_{NCa,n} \div MRL_{cd}$$

Where,

HQ_{cd} = Hazard quotient for chronic dermal sediment exposures (mg_{TEQ}/kg_{BW}/day),

AD_d = Dermal absorbed dose on exposure days (mg_{TEQ}/kg_{BW}/day)

$EF_{NCa,n}$ = Exposure factor for n'th scenario (unitless), and

MRL_{cd} = Estimated chronic dermal Minimal Risk Level for TCDD (mg_{TEQ}/kg_{BW}/day).

HI for Chronic Duration, Oral & Dermal Routes Combined:

$$HI_{ctot} = HQ_{co} + HQ_{cd}$$

Where,

HI_{ctot} = Hazard index for chronic all exposures combined (mg_{TEQ}/kg_{BW}/day),

HQ_{co} = Hazard quotient for chronic oral sediment exp (mg_{TEQ}/kg_{BW}/day),

HQ_{cd} = Hazard quotient for chronic dermal sediment exp (mg_{TEQ}/kg_{BW}/day), and

ATSDR's Minimal Risk Levels (MRLs)

RfDs and MRLs are derived for contaminant-specific *critical effects* (such as poor weight gain, increased liver enzymes, decreased performance on some neurological or psychological test, altered social behavior, decreased resistance to infection, decreased lung function, respiratory irritation, skin rash, or any number of other physiological effects) observed in human or animal studies at a specified contaminant dose. The lowest dose at which the critical effect is observed is called the Lowest Observed Adverse Effect Level (LOAEL) and the next lower dose (at which no adverse effects are observed) is called the No Observed Adverse Effects Level (NOAEL).

Generally, one or more uncertainty factors are applied to the LOAEL or NOAEL (in which the LOAEL or NOAEL is divided by the total uncertainty factor) to arrive at a lower exposure dose that is felt to be protective of human health, including sensitive sup-populations. Each uncertainty factor is usually in the range of 3-10 (e.g., 3 or 10 for extrapolation from animals to humans, 3 for sensitive sub-populations, 3 or 10 for the use of a minimal LOAEL instead of a NOAEL, 10 for human variability, 3 or 10 for database deficiencies, 5 for potential increased susceptibility in children, etc.). In these calculations, two uncertainty factors of 3 are generally taken to be equivalent to a single uncertainty factor of 10, so if the three uncertainty factors for a particular MRL calculation are 3, 3, and 10, the total uncertainty factor is taken to be 100 (and not 90 as would be calculated by multiplying the three numbers). Total uncertainty factors for MRLs or RfDs (all uncertainties combined) generally range from 3 up to 2,000 or more, depending on the substance and the apparent reliability of the study upon which the MRL or RfD was based.

Thus, RfDs or MRLs represent exposure doses that are felt to be unlikely to cause adverse health effects for the specified duration of exposure, even in sensitive sub-populations (such as pregnant women, infants, children, the elderly, or individuals who are immunosuppressed). When the HQ

or HI is greater than or equal to the uncertainty factor used in deriving the health guideline dose, exposures are in the same range as those that were observed to produce the critical effect in the original study. Therefore, it is reasonable to anticipate a higher probability of adverse effects in exposed individuals (particularly, if the MRL or RfD was based on the study LOAEL).

Appendix D – Tables

Table 1. Toxicity Equivalency Factors (TEFs) for PCDDs/PCDFs

Item#	PCDD/PCDF Congener	Texas TEF [3]	WHO_{98} TEF [3]	WHO_{05} TEF [16]
1	2,3,7,8-TCDD	1	1	1
2	1,2,3,7,8-PeCDD	0.5	1	1
3	1,2,3,4,7,8-HxCDD	0.1	0.1	0.1
4	1,2,3,6,7,8-HxCDD	0.1	0.1	0.1
5	1,2,3,7,8,9-HxCDD	0.1	0.1	0.1
6	1,2,3,4,6,7,8-HpCDD		0.01	0.01
7	OCDD		0.0001	0.0003
8	2,3,7,8-TCDF	0.1	0.1	0.1
9	1,2,3,7,8-PeCDF	0.05	0.05	0.03
10	2,3,4,7,8-PeCDF	0.5	0.5	0.3
11	1,2,3,4,7,8-HxCDF	0.1	0.1	0.1
12	1,2,3,6,7,8-HxCDF	0.1	0.1	0.1
13	1,2,3,7,8,9-HxCDF	0.1	0.1	0.1
14	2,3,4,6,7,8-HxCDF	0.1	0.1	0.1
15	1,2,3,4,6,7,8-HpCDF		0.01	0.01
16	1,2,3,4,7,8,9-HpCDF		0.01	0.01
17	OCDF		0.0001	0.0003

Abbreviations: PCDDs/PCDFs = polychlorinated dibenzo-p-dioxins / polychlorinated dibenzofurans; TCDD = tetrachlorodibenzo-p-dioxin; PeCDD = pentachlorodibenzo-p-dioxin; HxCDD = hexachlorodibenzo-p-dioxin; HpCDD = heptachlorodibenzo-p-dioxin; OCDD = octachlorodibenzo-p-dioxin; TCDF = tetrachlorodibenzofuran; PeCDF = pentachlorodibenzofuran; HxCDF = hexachlorodibenzofuran; HpCDF = heptachlorodibenzofuran, OCDF = octachlorodibenzofuran; WHO = World Health Organization.

Table 2. Parameters for Oral Sediment Exposure Scenarios

Parameters for Oral TCDD TEQ Sediment Exp. for TPWD Technicians, SJR-HSC-UGB	Routine Daily Exposure	Frequent Periodic Exposure	Sporadic Exposure
Oral sediment intake rate (mg_{sed}/day)	100.00	100.00	100.00
Units Conversion Factor 1 (10^{-9} mg_{TEQ}/pg_{TEQ})	1.00E-09	1.00E-09	1.00E-09
Units Conversion Factor 2 (10^{-3} g_{sed}/mg_{sed})	1.00E-03	1.00E-03	1.00E-03
Oral Absorption Factor (unitless)	0.50	0.50	0.50
Avg body weight for Cancer exposure scenarios (kg)	70.58	70.58	69.05
Avg body weight for Non-Ca exposure scenarios (kg)	65.78	65.78	65.78
Oral Slope Factor for TCDD $(mg/kg/day)^{-1}$	150,000	150,000	150,000
Chronic Oral MRL for TCDD (mg/kg/day)	1.200E-09	1.200E-09	1.200E-09
Intermediate Oral MRL for TCDD (mg/kg/day)	2.333E-08	2.333E-08	2.333E-08
Acute Oral MRL for TCDD (mg/kg/day)	1.667E-07	1.667E-07	1.667E-07
Exposure Duration Factors for Less-Than-Daily Exposures (Less than 24-7-52-70)	**Routine Daily Exposure**	**Frequent Periodic Exposure**	**Sporadic Exposure**
Age at beginning of exposure period (years)	20	20	20
Age at ending of exposure period (years)	50	50	35
Number of hours exposed per day (hours)	8	8	8
Number of days exposed per week (days)	5	1	1
Number of weeks exposed per year (weeks)	50	26	5
Number of years of lifetime exposed (years)	30	30	15
Number of hours in a day (hours)	24	24	24
Number of days in a week (days)	7	7	7
Number of weeks in a year (weeks)	52	52	52
Number of years in a standard lifetime (years)	70	70	70
Exposure factor for Cancer scenarios (unitless)	0.0981162	0.0102041	0.0009812
Exposure factor for Non-Cancer scenarios (unitless)	0.2289377	0.0238095	0.0045788

Abbreviations: mg/pg = milligrams per picogram; g/mg = grams per milligram; mg/kg/day = milligrams per kilogram per day; TCDD TEQ = tetrachlorodibenzo-p-dioxin toxic equivalent concentration; SJR = San Jacinto River; HSC = Houston Ship Channel; UGB = Upper Galveston Bay; MRL = Minimal Risk Level.

Table 3. Parameters for Dermal Sediment Exposure Scenarios

Parameters for Dermal TCDD TEQ Sediment Exposure for TPWD Technicians, SJR-HSC-UGB	Routine Daily Exposure	Frequent Periodic Exposure	Sporadic Exposure
Body surface area contaminated (hands & forearms) for Cancer exposure scenarios (cm^2/day)	2,056.41	2,056.41	2,040.01
Body surface area contaminated (hands & forearms) for Non-Cancer exposure scenarios (cm^2/day)	1,987.35	1,987.35	1,987.35
Units Conversion Factor 1 (10^{-9} mg_{TEQ}/pg_{TEQ})	1.00E-09	1.00E-09	1.00E-09
Units Conversion Factor 2 (10^{-3} g_{Sed}/mg_{Sed})	1.00E-03	1.00E-03	1.00E-03
Quantity of sediment per surface area (mg_{Sed}/cm^2)	1.00	1.00	1.00
Dermal Absorption Factor (unitless)	0.03	0.03	0.03
Avg body weight for Cancer exposure scenarios (kg)	70.58	70.58	69.05
Avg body weight for Non-Ca exposure scenarios (kg)	65.78	65.78	65.78
Dermal Slope Factor for TCDD $(mg/kg/day)^{-1}$	300,000	300,000	300,000
Chronic Oral MRL for TCDD (mg/kg/day)	1.20E-09	1.20E-09	1.20E-09
Intermediate Oral MRL for TCDD (mg/kg/day)	2.33E-08	2.33E-08	2.33E-08
Acute Oral MRL for TCDD (mg/kg/day)	1.67E-07	1.67E-07	1.67E-07
Exposure Duration Factors for Less Than Daily Exposures	**Routine Daily Exposure**	**Frequent Periodic Exposure**	**Sporadic Exposure**
Age at beginning of exposure period (years)	20	20	20
Age at ending of exposure period (years)	50	50	35
Number of hours exposed per day (hours)	8	8	8
Number of days exposed per week (days)	5	1	1
Number of weeks exposed per year (weeks)	50	26	5
Number of years of lifetime exposed (years)	30	30	15
Number of hours in a day (hours)	24	24	24
Number of days in a week (days)	7	7	7
Number of weeks in a year (weeks)	52	52	52
Number of years in a standard lifetime (years)	70	70	70
Exposure factor for Cancer scenarios (unitless)	0.294349	0.030612	0.002943
Exposure factor for Non-Cancer scenarios (unitless)	0.686813	0.071429	0.013736

Abbreviations: cm^2 = square centimeters; mg/pg = milligrams per picogram; g/mg = grams per milligram; mg/kg/day = milligrams per kilogram per day; TCDD TEQ = tetrachlorodibenzo-p-dioxin toxic equivalent concentration; SJR = San Jacinto River; HSC = Houston Ship Channel; UGB = Upper Galveston Bay; MRL = the Agency for Toxic Substances and Disease Registry's Minimal Risk Level.

Table 4. Theoretical Cancer Risk from Dioxin in Sediments, Oral Route, SJRWP Site

SJRWP, On-Site, Soil/Sediment Pathway, Chronic Duration Exposure, Oral Route				Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Source	**Location/ Station ID**	**Collection Date**	**WHO 2005 TEQ (pg/g)**	**Theo Ca Risk (Oral Exp)**	**Ca Odds**	**Theo Ca Risk (Oral Exp)**	**Ca Odds**	**Theo Ca Risk (Oral Exp)**	**Ca Odds**
TCEQ	SE-04	7/12/2005	1,392	1.45E-05	68,909	1.51E-06	662,588	1.48E-07	6,741,878
TCEQ	SE-05	7/12/2005	1,212	1.26E-05	79,107	1.31E-06	760,641	1.29E-07	7,739,578
TCEQ	SE-07	7/12/2005	80.92	8.44E-07	1,185,296	8.77E-08	11,397,076	8.62E-09	115,966,096
TCEQ	SE-08	7/12/2005	24,031	2.51E-04	3,991	2.61E-05	38,376	2.56E-06	390,483
TCEQ	SE-09	7/13/2005	8,187	8.54E-05	11,715	8.88E-06	112,641	8.72E-07	1,146,135
TCEQ	SE-10	7/13/2005	17,359	1.81E-04	5,525	1.88E-05	53,126	1.85E-06	540,560
TCEQ	SE-11	7/13/2005	23,290	2.43E-04	4,118	2.53E-05	39,597	2.48E-06	402,899
TMDL	00015	8/18/2005	30,764	3.21E-04	3,118	3.34E-05	29,977	3.28E-06	305,017
TMDL	00015-dup	8/18/2005	34,028	3.55E-04	2,818.6	3.69E-05	27,101.8	3.63E-06	275,763
Count (All On-Site Samples)			9	* See Tables 2 & 3, Appendix D for parameters used in exposure scenarios.					
Std Dev (All On-Site Samples)			13,264						
Min (All On-Site Samples)			80.92	8.44E-07	1,185,296	8.77E-08	11,397,076	8.62E-09	115,966,096
Max (All On-Site Samples)			34,028	3.55E-04	2,818.6	3.69E-05	27,101.8	3.63E-06	275,763
Average (All On-Site Samples)			**15,594**	1.63E-04	6,151	1.69E-05	59,140	1.66E-06	601,752

Abbreviations: SJRWP = San Jacinto River Waste Pits; WHO = World Health Organization; TEQ = tetrachlorodibenzo-p-dioxin toxicity equivalents; pg/g = picograms per gram; Theo = theoretical; Ca = Cancer; Exp = Exposure; TCEQ = Texas Commission for Environmental Quality; TMDL = Total Maximum Daily Load; dup = duplicate; Std Dev = standard deviation; min = minimum; max = maximum.

E-02	Very High Increased Lifetime Risk
E-03	High Increased Lifetime Risk
E-04	Moderate Increased Lifetime Risk

E-05	Low Increased Lifetime Risk
E-06	No Apparent Increased Lifetime Risk
E-07	No Increased Lifetime Risk

Table 5. Theoretical Cancer Risk from Dioxin in Sediments, Oral Route, Downstream

Downstream, Soil/Sediment Pathway, Chronic Duration Exposure, Oral Route				Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Location Code	Location/ Station ID	Collection Date	WHO 2005 TEQ (pg/g)	Theo Ca Risk (Oral Exp)	Ca Odds	Theo Ca Risk (Oral Exp)	Ca Odds	Theo Ca Risk (Oral Exp)	Ca Odds
2	11252	8/27/2002	0.7457	7.77E-09	128,626,644	8.09E-10	1,236,794,653	7.95E-11	12,584,477,782
2	11252 dup	8/27/2002	0.7890	8.23E-09	121,557,974	8.56E-10	1,168,826,673	8.41E-11	11,892,898,516
2	11252	10/24/2002	11.65	1.21E-07	8,234,071	1.26E-08	79,173,758	1.24E-09	805,598,889
2	11252	5/28/2003	8.942	9.32E-08	10,725,780	9.70E-09	103,132,496	9.53E-10	1,049,380,831
2	11252 dup	5/28/2003	8.588	8.95E-08	11,168,482	9.31E-09	107,389,251	9.15E-10	1,092,693,635
2	11252	3/11/2004	6.210	6.47E-08	15,445,140	6.73E-09	148,510,960	6.62E-10	1,511,110,086
2	11252	11/8/2004	5.510	5.74E-08	17,407,248	5.97E-09	167,377,388	5.87E-10	1,703,077,400
2	11258	8/1/2002	1.447	1.51E-08	66,298,315	1.57E-09	637,483,796	1.54E-10	6,486,445,137
2	11258	4/30/2003	4.266	4.45E-08	22,482,526	4.63E-09	216,178,137	4.55E-10	2,199,628,659
2	11261	8/19/2002	5.657	5.90E-08	16,953,697	6.13E-09	163,016,321	6.03E-10	1,658,703,220
2	11261	10/26/2002	10.78	1.12E-07	8,896,414	1.17E-08	85,542,440	1.15E-09	870,400,699
2	11261	5/11/2003	15.10	1.57E-07	6,350,067	1.64E-08	61,058,335	1.61E-09	621,273,110
2	11261	3/24/2004	9.204	9.60E-08	10,420,519	9.98E-09	100,197,298	9.81E-10	1,019,514,978
2	11261	11/9/2004	19.43	2.03E-07	4,936,205	2.11E-08	47,463,507	2.07E-09	482,944,717
2	13309	8/30/2002	1.556	1.62E-08	61,621,290	1.69E-09	592,512,405	1.66E-10	6,028,857,887
2	13309	5/12/2003	1.750	1.82E-08	54,807,541	1.90E-09	526,995,590	1.86E-10	5,362,219,411
2	13336	8/27/2002	2.609	2.72E-08	36,756,455	2.83E-09	353,427,456	2.78E-10	3,596,150,711
2	13336 dup	8/27/2002	4.741	4.94E-08	20,230,859	5.14E-09	194,527,492	5.05E-10	1,979,331,728
2	13336	10/22/2002	13.55	1.41E-07	7,076,174	1.47E-08	68,040,131	1.44E-09	692,313,403
2	13337	8/14/2002	18.56	1.94E-07	5,166,893	2.01E-08	49,681,666	1.98E-09	505,514,659
2	13337	5/28/2003	14.30	1.49E-07	6,707,963	1.55E-08	64,499,646	1.52E-09	656,288,702
2	13339	8/22/2002	22.38	2.33E-07	4,285,725	2.43E-08	41,208,896	2.38E-09	419,303,583
2	13339	5/4/2003	7.173	7.48E-08	13,370,479	7.78E-09	128,562,298	7.64E-10	1,308,130,966
2	13340	8/6/2002	10.31	1.08E-07	9,299,281	1.12E-08	89,416,161	1.10E-09	909,816,105

Table 5 (Cont.) Theoretical Cancer Risk from Dioxin in Sediments, Oral Route, Downstream

Downstream, Soil/Sediment Pathway, Chronic Duration Exposure, Oral Route				Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Location Code	Location/ Station ID	Collection Date	WHO 2005 TEQ (pg/g)	Theo Ca Risk (Oral Exp)	Ca Odds	Theo Ca Risk (Oral Exp)	Ca Odds	Theo Ca Risk (Oral Exp)	Ca Odds
2	13340	10/23/2002	12.41	1.29E-07	7,725,680	1.35E-08	74,285,387	1.32E-09	755,859,347
2	13340	5/28/2003	9.205	9.60E-08	10,419,500	9.98E-09	100,187,502	9.81E-10	1,019,415,296
2	13340	3/11/2004	11.71	1.22E-07	8,193,413	1.27E-08	78,782,820	1.25E-09	801,621,065
2	13340	11/9/2004	8.733	9.10E-08	10,983,161	9.47E-09	105,607,321	9.31E-10	1,074,562,366
2	13342	8/21/2002	28.75	3.00E-07	3,336,596	3.12E-08	32,082,656	3.06E-09	326,443,411
2	13342	10/28/2002	25.99	2.71E-07	3,690,283	2.82E-08	35,483,491	2.77E-09	361,047,167
2	13342 dup	10/28/2002	29.74	3.10E-07	3,224,856	3.22E-08	31,008,236	3.17E-09	315,511,108
2	13342	5/11/2003	29.08	3.03E-07	3,298,669	3.15E-08	31,717,973	3.10E-09	322,732,743
2	13342	3/11/2004	29.08	3.03E-07	3,298,613	3.15E-08	31,717,428	3.10E-09	322,727,193
2	13342	11/9/2004	30.03	3.13E-07	3,193,502	3.26E-08	30,706,754	3.20E-09	312,443,507
2	14560	8/30/2002	13.14	1.37E-07	7,300,010	1.42E-08	70,192,408	1.40E-09	714,212,983
2	14560	5/12/2003	1.570	1.64E-08	61,093,744	1.70E-09	587,439,842	1.67E-10	5,977,244,175
2	14560	3/11/2004	1.390	1.45E-08	69,005,293	1.51E-09	663,512,435	1.48E-10	6,751,288,480
2	14560	11/4/2004	0.7393	7.71E-09	129,726,181	8.02E-10	1,247,367,121	7.88E-11	12,692,053,424
2	15464	8/16/2002	0.7853	8.19E-09	122,130,696	8.52E-10	1,174,333,618	8.37E-11	11,948,932,088
2	15464	11/6/2002	0.8470	8.83E-09	113,238,160	9.18E-10	1,088,828,465	9.03E-11	11,078,910,786
2	15464	5/12/2003	0.9297	9.69E-09	103,166,131	1.01E-09	991,982,029	9.91E-11	10,093,491,086
2	15908	9/11/2002	1.472	1.53E-08	65,162,315	1.60E-09	626,560,724	1.57E-10	6,375,302,070
2	15908	5/28/2003	1.522	1.59E-08	63,024,765	1.65E-09	606,007,355	1.62E-10	6,166,170,009
2	16213	9/11/2002	2.185	2.28E-08	43,899,969	2.37E-09	422,115,086	2.33E-10	4,295,052,458
2	16213	5/12/2003	2.709	2.82E-08	35,398,497	2.94E-09	340,370,161	2.89E-10	3,463,291,760
2	16499	8/22/2002	28.02	2.92E-07	3,423,539	3.04E-08	32,918,648	2.99E-09	334,949,700
2	16499	10/24/2002	18.92	1.97E-07	5,070,067	2.05E-08	48,750,644	2.02E-09	496,041,437
2	16499	3/19/2004	43.57	4.54E-07	2,201,397	4.72E-08	21,167,277	4.64E-09	215,378,623

Table 5 (Cont.) Theoretical Cancer Risk from Dioxin in Sediments, Oral Route, Downstream

Downstream, Soil/Sediment Pathway, Chronic Duration Exposure, Oral Route				Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Location Code	**Location/ Station ID**	**Collection Date**	**WHO 2005 TEQ (pg/g)**	**Theo Ca Risk (Oral Exp)**	**Ca Odds**	**Theo Ca Risk (Oral Exp)**	**Ca Odds**	**Theo Ca Risk (Oral Exp)**	**Ca Odds**
2	16499	11/9/2004	86.16	8.98E-07	1,113,115	9.34E-08	10,703,031	9.18E-09	108,904,135
2	16618	8/19/2002	8.390	8.75E-08	11,431,725	9.10E-09	109,920,432	8.94E-10	1,118,448,585
2	16618	5/6/2003	62.77	6.54E-07	1,528,048	6.81E-08	14,692,770	6.69E-09	149,500,027
2	16618	3/19/2004	6.298	6.57E-08	15,227,749	6.83E-09	146,420,668	6.71E-10	1,489,841,207
2	16618	11/9/2004	19.58	2.04E-07	4,899,265	2.12E-08	47,108,315	2.09E-09	479,330,619
2	17970	8/18/2002	2.478	2.58E-08	38,711,346	2.69E-09	372,224,482	2.64E-10	3,787,411,853
2	17970	10/24/2002	3.473	3.62E-08	27,614,833	3.77E-09	265,527,240	3.70E-10	2,701,759,457
2	17971	8/24/2002	27.58	2.88E-07	3,478,104	2.99E-08	33,443,308	2.94E-09	340,288,149
2	17971 dup	8/24/2002	28.13	2.93E-07	3,409,865	3.05E-08	32,787,160	3.00E-09	333,611,800
2	17971	10/28/2002	16.23	1.69E-07	5,910,183	1.76E-08	56,828,687	1.73E-09	578,236,126
2	18390	8/11/2004	12.65	1.32E-07	7,583,053	1.37E-08	72,913,973	1.35E-09	741,905,112
Count (All Downstream Samples)			59	* See Tables 2 & 3, Appendix D for parameters used in exposure scenarios.					
Std Dev (All Downstream Samples)			15.54						
Min (All Downstream Samples)			0.7393	7.71E-09	129,726,181	8.02E-10	1,247,367,121	7.88E-11	12,692,053,424
Max (All Downstream Samples)			86.16	8.98E-07	1,113,115	9.34E-08	10,703,031	9.18E-09	108,904,135
Average (All Downstream Samples)			**13.75**	1.43E-07	6,973,260	1.49E-08	67,050,576	1.47E-09	682,244,611

Abbreviations: SJRWP = San Jacinto River Waste Pits; WHO = World Health Organization; TEQ = tetrachlorodibenzo-p-dioxin toxicity equivalents; pg/g = picograms per gram; Theo = theoretical; Ca = Cancer; Exp = Exposure; TCEQ = Texas Commission for Environmental Quality; TMDL = Total Maximum Daily Load; dup = duplicate; Std Dev = standard deviation; min = minimum; max = maximum.

E-02	Very High Increased Lifetime Risk
E-03	High Increased Lifetime Risk
E-04	Moderate Increased Lifetime Risk

E-05	Low Increased Lifetime Risk
E-06	No Apparent Increased Lifetime Risk
E-07	No Increased Lifetime Risk

Table 6. Theoretical Cancer Risk from Dioxin in Sediments, Oral Route, Site-Vicinity

SJRWP Site-Vicinity, Soil/Sediment Pathway, Chronic Duration Exposure, Oral Route				Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Location Code	Location/ Station ID	Collection Date	WHO 2005 TEQ (pg/g)	Theo Ca Risk (Oral Exp)	Ca Odds	Theo Ca Risk (Oral Exp)	Ca Odds	Theo Ca Risk (Oral Exp)	Ca Odds
3	00001	8/17/2005	80.09	8.35E-07	1,197,513	8.68E-08	11,514,544	8.54E-09	117,161,341
3	00002	8/17/2005	66.26	6.91E-07	1,447,467	7.18E-08	13,917,951	7.06E-09	141,616,185
3	00003	8/18/2005	29.40	3.07E-07	3,261,717	3.19E-08	31,362,662	3.13E-09	319,117,421
3	00004	8/17/2005	13.26	1.38E-07	7,234,430	1.44E-08	69,561,828	1.41E-09	707,796,784
3	00005	8/17/2005	11.53	1.20E-07	8,314,806	1.25E-08	79,950,059	1.23E-09	813,497,807
3	00004 dup	8/17/2005	16.44	1.71E-07	5,832,515	1.78E-08	56,081,873	1.75E-09	570,637,241
3	00006	8/15/2005	11.63	1.21E-07	8,245,113	1.26E-08	79,279,936	1.24E-09	806,679,263
3	00007	8/15/2005	14.81	1.54E-07	6,477,810	1.61E-08	62,286,636	1.58E-09	633,771,164
3	00008	8/18/2005	30.63	3.19E-07	3,131,157	3.32E-08	30,107,275	3.26E-09	306,343,765
3	00009	8/18/2005	13.18	1.37E-07	7,276,473	1.43E-08	69,966,082	1.40E-09	711,910,102
3	00010	8/30/2005	155.6	1.62E-06	616,507	1.69E-07	5,927,954	1.66E-08	60,317,372
3	00011	8/18/2005	522.8	5.45E-06	183,458	5.67E-07	1,764,019	5.57E-08	17,949,025
3	00011 dup	8/18/2005	572.5	5.97E-06	167,533	6.21E-07	1,610,894	6.10E-08	16,390,965
3	00012	8/30/2005	70.87	7.39E-07	1,353,291	7.68E-08	13,012,416	7.55E-09	132,402,301
3	00013	8/17/2005	12.90	1.34E-07	7,437,110	1.40E-08	71,510,672	1.37E-09	727,626,422
3	00014	8/18/2005	34.37	3.58E-07	2,790,800	3.73E-08	26,834,618	3.66E-09	273,044,241
3	00016	8/18/2005	138.2	1.44E-06	693,879	1.50E-07	6,671,913	1.47E-08	67,887,214
3	00017	8/17/2005	32.01	3.34E-07	2,996,565	3.47E-08	28,813,125	3.41E-09	293,175,696
3	00018	8/17/2005	38.25	3.99E-07	2,507,660	4.15E-08	24,112,112	4.08E-09	245,342,533
3	00019	8/17/2005	20.31	2.12E-07	4,721,862	2.20E-08	45,402,517	2.16E-09	461,973,999
3	00020	8/18/2005	1.997	2.08E-08	48,036,169	2.17E-09	461,886,245	2.13E-10	4,699,726,969
3	00021	8/17/2005	42.17	4.40E-07	2,274,247	4.57E-08	21,867,760	4.49E-09	222,506,091

Table 6 (Cont.) Theoretical Cancer Risk from Dioxin in Sediments, Oral Route, Site-Vicinity

Downstream, Soil/Sediment Pathway, Chronic Duration Exposure, Oral Route				Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Location Code	**Location/ Station ID**	**Collection Date**	**WHO 2005 TEQ (pg/g)**	**Theo Ca Risk (Oral Exp)**	**Ca Odds**	**Theo Ca Risk (Oral Exp)**	**Ca Odds**	**Theo Ca Risk (Oral Exp)**	**Ca Odds**
3	11193	8/8/2002	102.8	1.07E-06	932,818	1.11E-07	8,969,402	1.10E-08	91,264,330
3	11193	10/31/2002	64.43	6.72E-07	1,488,530	6.99E-08	14,312,789	6.87E-09	145,633,695
3	11193	5/13/2003	138.4	1.44E-06	692,817	1.50E-07	6,661,701	1.48E-08	67,783,306
3	11193	3/24/2004	94.47	9.85E-07	1,015,259	1.02E-07	9,762,101	1.01E-08	99,330,107
3	11193	8/11/2004	18.58	1.94E-07	5,162,166	2.01E-08	49,636,208	1.98E-09	505,052,120
3	11193 dup	8/11/2004	96.32	1.00E-06	995,769	1.04E-07	9,574,700	1.03E-08	97,423,284
3	11193	11/4/2004	40.98	4.27E-07	2,340,353	4.44E-08	22,503,390	4.37E-09	228,973,672
3	11193 dup	11/4/2004	46.90	4.89E-07	2,045,174	5.09E-08	19,665,130	5.00E-09	200,094,163
3	18389	8/10/2004	17.32	1.81E-07	5,538,643	1.88E-08	53,256,178	1.85E-09	541,885,581
Count (All Site-Vicinity Samples)			31	* See Tables 2 & 3, Appendix D for parameters used in exposure scenarios.					
Std Dev (All Site-Vicinity Samples)			131.2						
Min (All Site-Vicinity Samples)			1.997	2.08E-08	48,036,169	2.17E-09	461,886,245	2.13E-10	4,699,726,969
Max (All Site-Vicinity Samples)			572.5	5.97E-06	167,533	6.21E-07	1,610,894	6.10E-08	16,390,965
Average (All Site-Vicinity Samples)			**82.24**	8.57E-07	1,166,229	8.92E-08	11,213,740	8.76E-09	114,100,638

Abbreviations: SJRWP = San Jacinto River Waste Pits; WHO = World Health Organization; TEQ = tetrachlorodibenzo-p-dioxin toxicity equivalents; pg/g = picograms per gram; Theo = theoretical; Ca = Cancer; Exp = Exposure; TCEQ = Texas Commission for Environmental Quality; TMDL = Total Maximum Daily Load; dup = duplicate; Std Dev = standard deviation; min = minimum; max = maximum.

E-02	Very High Increased Lifetime Risk
E-03	High Increased Lifetime Risk
E-04	Moderate Increased Lifetime Risk

E-05	Low Increased Lifetime Risk
E-06	No Apparent Increased Lifetime Risk
E-07	No Increased Lifetime Risk

Table 7. Theoretical Cancer Risk from Dioxin in Sediments, Oral, Houston Ship Channel

Houston Ship Channel, Soil/Sediment Pathway, Chronic Duration Exposure, Oral Route				Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Location Code	Location/ Station ID	Collection Date	WHO 2005 TEQ (pg/g)	Theo Ca Risk (Oral Exp)	Ca Odds	Theo Ca Risk (Oral Exp)	Ca Odds	Theo Ca Risk (Oral Exp)	Ca Odds
4	00022	8/16/2005	28.54	2.98E-07	3,361,116	3.09E-08	32,318,424	3.04E-09	328,842,376
4	00023	8/16/2005	38.13	3.98E-07	2,515,420	4.13E-08	24,186,733	4.06E-09	246,101,809
4	00024	8/16/2005	63.19	6.59E-07	1,517,715	6.85E-08	14,593,410	6.73E-09	148,489,032
4	00025	8/16/2005	31.28	3.26E-07	3,066,583	3.39E-08	29,486,377	3.33E-09	300,026,086
4	00026	8/17/2005	20.91	2.18E-07	4,587,261	2.27E-08	44,108,281	2.23E-09	448,805,044
4	00027	8/17/2005	22.01	2.30E-07	4,356,794	2.39E-08	41,892,247	2.35E-09	426,256,739
4	11264	8/19/2002	14.67	1.53E-07	6,536,972	1.59E-08	62,855,503	1.56E-09	639,559,423
4	11264	5/29/2003	25.13	2.62E-07	3,816,724	2.72E-08	36,699,269	2.68E-09	373,417,798
4	11264	3/24/2004	22.44	2.34E-07	4,274,466	2.43E-08	41,100,630	2.39E-09	418,201,972
4	11264	11/4/2004	18.82	1.96E-07	5,096,740	2.04E-08	49,007,117	2.01E-09	498,651,071
4	11265	4/1/2004	31.06	3.24E-07	3,088,207	3.37E-08	29,694,302	3.31E-09	302,141,735
4	11265	11/4/2004	26.53	2.77E-07	3,615,238	2.88E-08	34,761,904	2.83E-09	353,704,965
4	11267	8/10/2004	38.67	4.03E-07	2,480,101	4.19E-08	23,847,123	4.12E-09	242,646,252
4	11267	8/16/2005	51.19	5.34E-07	1,873,617	5.55E-08	18,015,549	5.46E-09	183,309,550
4	11268	8/11/2004	35.25	3.67E-07	2,721,134	3.82E-08	26,164,752	3.76E-09	266,228,302
4	11268	8/16/2005	55.46	5.78E-07	1,729,332	6.01E-08	16,628,188	5.91E-09	169,193,052
4	11269	8/10/2004	15.65	1.63E-07	6,128,464	1.70E-08	58,927,536	1.67E-09	599,592,068
4	11270	8/28/2002	32.74	3.41E-07	2,929,807	3.55E-08	28,171,222	3.49E-09	286,644,281
4	11270	5/6/2003	4.904	5.11E-08	19,556,202	5.32E-09	188,040,400	5.23E-10	1,913,325,080
4	11270	8/10/2004	15.52	1.62E-07	6,180,992	1.68E-08	59,432,618	1.65E-09	604,731,318
4	11271	8/10/2004	11.27	1.17E-07	8,511,302	1.22E-08	81,839,442	1.20E-09	832,722,420
4	11273	8/28/2002	180.5	1.88E-06	531,257	1.96E-07	5,108,239	1.92E-08	51,976,713
4	11273 dup	8/28/2002	179.3	1.87E-06	534,819	1.94E-07	5,142,492	1.91E-08	52,325,239
4	11273	5/3/2003	143.2	1.49E-06	669,672	1.55E-07	6,439,156	1.53E-08	65,518,893

Table 7 (Cont.) Theoretical Cancer Risk from Dioxin in Sediments, Oral, Houston Ship Channel

Houston Ship Channel, Soil/Sediment Pathway, Chronic Duration Exposure, Oral Route				Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Location Code	Location/ Station ID	Collection Date	WHO 2005 TEQ (pg/g)	Theo Ca Risk (Oral Exp)	Ca Odds	Theo Ca Risk (Oral Exp)	Ca Odds	Theo Ca Risk (Oral Exp)	Ca Odds
4	11273 dup	5/3/2003	135.9	1.42E-06	705,951	1.47E-07	6,787,987	1.45E-08	69,068,275
4	11280	8/29/2002	33.69	3.51E-07	2,846,726	3.65E-08	27,372,362	3.59E-09	278,515,823
4	11280	12/2/2002	38.95	4.06E-07	2,462,147	4.22E-08	23,674,486	4.15E-09	240,889,661
4	11280 dup	12/2/2002	51.68	5.39E-07	1,855,709	5.60E-08	17,843,354	5.51E-09	181,557,462
4	11280	5/6/2003	45.54	4.75E-07	2,106,209	4.94E-08	20,252,013	4.85E-09	206,065,746
4	11280	4/1/2004	458.4	4.78E-06	209,232	4.97E-07	2,011,850	4.89E-08	20,470,723
4	11280	8/10/2004	46.71	4.87E-07	2,053,449	5.06E-08	19,744,705	4.98E-09	200,903,844
4	11280	11/4/2004	856.8	8.93E-06	111,944	9.29E-07	1,076,389	9.13E-08	10,952,342
4	11280	8/16/2005	24.37	2.54E-07	3,935,434	2.64E-08	37,840,710	2.60E-09	385,032,040
4	11287	8/26/2002	5.358	5.59E-08	17,900,755	5.81E-09	172,122,648	5.71E-10	1,751,360,768
4	11287	5/5/2003	5.297	5.52E-08	18,108,271	5.74E-09	174,117,990	5.64E-10	1,771,663,525
4	11287	4/2/2004	20.96	2.19E-07	4,576,536	2.27E-08	44,005,150	2.23E-09	447,755,683
4	11287 dup	4/2/2004	19.21	2.00E-07	4,993,516	2.08E-08	48,014,575	2.05E-09	488,551,875
4	11287	11/4/2004	22.56	2.35E-07	4,250,785	2.45E-08	40,872,931	2.40E-09	415,885,115
4	11292	9/5/2002	15.98	1.67E-07	6,002,657	1.73E-08	57,717,858	1.70E-09	587,283,506
4	11292	12/10/2002	100.5	1.05E-06	954,143	1.09E-07	9,174,452	1.07E-08	93,350,735
4	11292	5/6/2003	7.032	7.33E-08	13,640,113	7.62E-09	131,154,936	7.49E-10	1,334,511,250
4	11292	4/2/2004	11.52	1.20E-07	8,323,393	1.25E-08	80,032,625	1.23E-09	814,337,920
4	11292 dup	4/2/2004	11.34	1.18E-07	8,456,966	1.23E-08	81,316,986	1.21E-09	827,406,389
4	11292	11/4/2004	11.94	1.24E-07	8,032,702	1.29E-08	77,237,515	1.27E-09	785,897,476
4	15979	9/4/2002	440.7	4.59E-06	217,647	4.78E-07	2,092,759	4.70E-08	21,293,975
4	15979 dup	9/4/2002	264.8	2.76E-06	362,245	2.87E-07	3,483,129	2.82E-08	35,441,099
4	15979	5/29/2003	27.24	2.84E-07	3,521,116	2.95E-08	33,856,888	2.90E-09	344,496,363
4	15979 A	4/2/2004	15.50	1.62E-07	6,186,973	1.68E-08	59,490,126	1.65E-09	605,316,466

Table 7 (Cont.) Theoretical Cancer Risk from Dioxin in Sediments, Oral, Houston Ship Channel

Houston Ship Channel, Soil/Sediment Pathway, Chronic Duration Exposure, Oral Route				Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Location Code	**Location/ Station ID**	**Collection Date**	**WHO 2005 TEQ (pg/g)**	**Theo Ca Risk (Oral Exp)**	**Ca Odds**	**Theo Ca Risk (Oral Exp)**	**Ca Odds**	**Theo Ca Risk (Oral Exp)**	**Ca Odds**
4	15979 B	5/18/2004	20.78	2.17E-07	4,616,362	2.25E-08	44,388,095	2.21E-09	451,652,172
4	15979	8/10/2004	22.21	2.32E-07	4,317,762	2.41E-08	41,516,947	2.37E-09	422,438,025
4	15979 tA	8/11/2004	9.730	1.01E-07	9,857,190	1.06E-08	94,780,671	1.04E-09	964,400,396
4	15979 tB	8/11/2004	21.96	2.29E-07	4,366,712	2.38E-08	41,987,613	2.34E-09	427,227,092
4	15979 tC	8/11/2004	20.20	2.11E-07	4,747,337	2.19E-08	45,647,475	2.15E-09	464,466,458
4	15979 tD	8/11/2004	19.51	2.03E-07	4,915,460	2.12E-08	47,264,039	2.08E-09	480,915,122
4	15979 tE	8/11/2004	17.48	1.82E-07	5,485,613	1.90E-08	52,746,279	1.86E-09	536,697,315
4	15979	11/4/2004	22.57	2.35E-07	4,249,090	2.45E-08	40,856,634	2.41E-09	415,719,292
4	15979	8/16/2005	31.88	3.32E-07	3,008,720	3.46E-08	28,929,996	3.40E-09	294,364,861
4	15980	8/10/2004	24.08	2.51E-07	3,983,323	2.61E-08	38,301,185	2.57E-09	389,717,412
4	18391	8/10/2004	11.23	1.17E-07	8,538,656	1.22E-08	82,102,465	1.20E-09	835,398,696
4	18392	8/10/2004	33.24	3.47E-07	2,885,137	3.60E-08	27,741,700	3.54E-09	282,273,861
4	18392	8/16/2005	20.03	2.09E-07	4,789,297	2.17E-08	46,050,930	2.13E-09	468,571,650
4	18392 dup	8/16/2005	19.84	2.07E-07	4,833,624	2.15E-08	46,477,153	2.11E-09	472,908,494
Count (All Ho Ship Chan Samples			62	* See Tables 2 & 3, Appendix D for parameters used in exposure scenarios.					
Std Dev (All Ho Ship Chan Samples)			134.1						
Min (All Ho Ship Chan Samples)			4.904	5.11E-08	19,556,202	5.32E-09	188,040,400	5.23E-10	1,913,325,080
Max (All Ho Ship Chan Samples)			856.8	8.93E-06	111,944	9.29E-07	1,076,389	9.13E-08	10,952,342
Average (All Ho Ship Chan Samples)			**65.69**	6.85E-07	1,459,952	7.12E-08	14,038,003	7.00E-09	142,837,725

Abbreviations: SJRWP = San Jacinto River Waste Pits; WHO = World Health Organization; TEQ = tetrachlorodibenzo-p-dioxin toxicity equivalents; pg/g = picograms per gram; Theo = theoretical; Ca = Cancer; Exp = Exposure; TCEQ = Texas Commission for Environmental Quality; TMDL = Total Maximum Daily Load; dup = duplicate; Ho = Houston; Chan = channel; Std Dev = standard deviation; min = minimum; max = maximum.

E-02	Very High Increased Lifetime Risk
E-03	High Increased Lifetime Risk
E-04	Moderate Increased Lifetime Risk

E-05	Low Increased Lifetime Risk
E-06	No Apparent Increased Lifetime Risk
E-07	No Increased Lifetime Risk

Table 8. Theoretical Cancer Risk from Dioxin in Sediments, Oral, Upstream and Tributary

Upstream & Tributaries, Soil/Sediment Pathway, Chronic Duration Exposure, Oral Route				Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Location Code	Location/ Station ID	Collection Date	WHO 2005 TEQ (pg/g)	Theo Ca Risk (Oral Exp)	Ca Odds	Theo Ca Risk (Oral Exp)	Ca Odds	Theo Ca Risk (Oral Exp)	Ca Odds
5	11092	8/1/2002	21.74	2.27E-07	4,410,700	2.36E-08	42,410,580	2.32E-09	431,530,809
5	11092	4/30/2003	12.83	1.34E-07	7,475,192	1.39E-08	71,876,851	1.37E-09	731,352,313
5	11111	7/31/2002	7.959	8.30E-08	12,051,323	8.63E-09	115,878,109	8.48E-10	1,179,068,400
5	11111	5/1/2003	8.957	9.34E-08	10,707,519	9.71E-09	102,956,910	9.55E-10	1,047,594,237
5	11197	3/24/2004	10.55	1.10E-07	9,093,452	1.14E-08	87,437,039	1.12E-09	889,678,385
5	11197	8/11/2004	31.13	3.25E-07	3,081,163	3.38E-08	29,626,572	3.32E-09	301,452,578
5	11197 dup	8/11/2004	29.70	3.10E-07	3,229,091	3.22E-08	31,048,951	3.17E-09	315,925,387
5	11197	11/9/2004	15.78	1.65E-07	6,076,397	1.71E-08	58,426,894	1.68E-09	594,497,998
5	11200	9/3/2002	1.123	1.17E-08	85,420,785	1.22E-09	821,353,699	1.20E-10	8,357,335,107
5	11200 dup	9/3/2002	1.303	1.36E-08	73,617,016	1.41E-09	707,855,924	1.39E-10	7,202,486,785
5	11200	11/21/2002	0.7588	7.91E-09	126,395,879	8.23E-10	1,215,344,992	8.09E-11	12,366,225,877
5	11272	7/25/2002	9.893	1.03E-07	9,695,074	1.07E-08	93,221,864	1.05E-09	948,539,414
5	11272	4/30/2003	13.90	1.45E-07	6,900,033	1.51E-08	66,346,470	1.48E-09	675,080,278
5	11274	7/30/2002	10.44	1.09E-07	9,189,554	1.13E-08	88,361,097	1.11E-09	899,080,748
5	11274	5/1/2003	5.486	5.72E-08	17,482,448	5.95E-09	168,100,460	5.85E-10	1,710,434,709
5	11274 dup	5/1/2003	3.780	3.94E-08	25,375,822	4.10E-09	243,998,289	4.03E-10	2,482,700,777
5	11274	5/18/2004	4.762	4.97E-08	20,140,370	5.16E-09	193,657,406	5.07E-10	1,970,478,541
5	11298	7/29/2002	24.78	2.58E-07	3,871,103	2.69E-08	37,222,148	2.64E-09	378,738,128
5	11298	5/2/2003	16.25	1.69E-07	5,901,910	1.76E-08	56,749,131	1.73E-09	577,426,633
5	11300	9/5/2002	100.4	1.05E-06	955,398	1.09E-07	9,186,516	1.07E-08	93,473,481
5	11300 dup	9/5/2002	102.9	1.07E-06	932,120	1.12E-07	8,962,689	1.10E-08	91,196,033
5	11300	5/29/2003	50.60	5.28E-07	1,895,613	5.49E-08	18,227,052	5.39E-09	185,461,615
5	11302	8/26/2002	3.696	3.85E-08	25,949,799	4.01E-09	249,517,298	3.94E-10	2,538,857,104
5	11302	5/1/2003	11.35	1.18E-07	8,447,284	1.23E-08	81,223,880	1.21E-09	826,459,033

Table 8 (Cont.) Theoretical Cancer Risk from Dioxin in Sediments, Oral, Upstream, and Tributary

Upstream & Tributaries, Soil/Sediment Pathway, Chronic Duration Exposure, Oral Route				Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Location Code	Location/ Station ID	Collection Date	WHO 2005 TEQ (pg/g)	Theo Ca Risk (Oral Exp)	Ca Odds	Theo Ca Risk (Oral Exp)	Ca Odds	Theo Ca Risk (Oral Exp)	Ca Odds
5	11305	8/13/2002	3.718	3.88E-08	25,794,169	4.03E-09	248,020,852	3.96E-10	2,523,630,653
5	11305 dup	8/13/2002	3.759	3.92E-08	25,516,923	4.08E-09	245,355,025	4.01E-10	2,496,505,669
5	11305	5/4/2003	4.683	4.88E-08	20,482,090	5.08E-09	196,943,170	4.99E-10	2,003,911,430
5	11347	8/12/2002	2.040	2.13E-08	47,005,713	2.21E-09	451,978,011	2.17E-10	4,598,909,948
5	11347	5/4/2003	2.562	2.67E-08	37,440,890	2.78E-09	360,008,562	2.73E-10	3,663,113,953
5	11382	8/12/2002	6.207	6.47E-08	15,451,734	6.73E-09	148,574,364	6.61E-10	1,511,755,225
5	11382	5/5/2003	4.234	4.41E-08	22,654,319	4.59E-09	217,829,989	4.51E-10	2,216,436,375
5	13338	8/22/2002	27.84	2.90E-07	3,445,387	3.02E-08	33,128,726	2.97E-09	337,087,254
5	13338 dup	8/22/2002	28.06	2.93E-07	3,417,805	3.04E-08	32,863,514	2.99E-09	334,388,706
5	13338	10/22/2002	8.826	9.20E-08	10,866,809	9.57E-09	104,488,549	9.41E-10	1,063,178,774
5	13338	3/19/2004	16.30	1.70E-07	5,885,016	1.77E-08	56,586,691	1.74E-09	575,773,796
5	13338	11/8/2004	11.50	1.20E-07	8,337,720	1.25E-08	80,170,382	1.23E-09	815,739,608
5	13341	8/6/2002	13.74	1.43E-07	6,978,046	1.49E-08	67,096,600	1.46E-09	682,712,910
5	13341	5/28/2003	0.9372	9.77E-09	102,336,144	1.02E-09	984,001,380	9.99E-11	10,012,287,383
5	13343	8/20/2002	4.493	4.68E-08	21,349,017	4.87E-09	205,279,006	4.79E-10	2,088,729,184
5	13343	5/11/2003	7.160	7.47E-08	13,394,941	7.76E-09	128,797,510	7.63E-10	1,310,524,267
5	13344	8/21/2002	28.98	3.02E-07	3,309,711	3.14E-08	31,824,143	3.09E-09	323,813,029
5	13344	10/27/2002	36.30	3.79E-07	2,641,943	3.94E-08	25,403,298	3.87E-09	258,480,452
5	13344	3/19/2004	20.92	2.18E-07	4,584,082	2.27E-08	44,077,712	2.23E-09	448,494,007
5	13344	11/8/2004	29.29	3.05E-07	3,274,288	3.18E-08	31,483,543	3.12E-09	320,347,394
5	13344 dup	11/8/2004	28.44	2.96E-07	3,372,972	3.08E-08	32,432,422	3.03E-09	330,002,316
5	13355	8/18/2002	2.310	2.41E-08	41,518,780	2.50E-09	399,219,036	2.46E-10	4,062,083,443
5	13355	5/28/2003	1.110	1.16E-08	86,402,314	1.20E-09	830,791,484	1.18E-10	8,453,365,276
5	13363	8/16/2002	0.8100	8.45E-09	118,408,703	8.78E-10	1,138,545,217	8.63E-11	11,584,782,447

Table 8 (Cont.) Theoretical Cancer Risk from Dioxin in Sediments, Oral, Upstream, and Tributary

Upstream & Tributaries, Soil/Sediment Pathway, Chronic Duration Exposure, Oral Route				Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Location Code	**Location/ Station ID**	**Collection Date**	**WHO 2005 TEQ (pg/g)**	**Theo Ca Risk (Oral Exp)**	**Ca Odds**	**Theo Ca Risk (Oral Exp)**	**Ca Odds**	**Theo Ca Risk (Oral Exp)**	**Ca Odds**
5	13363	11/6/2002	2.006	2.09E-08	47,819,421	2.17E-09	459,802,129	2.14E-10	4,678,520,929
5	13589	8/16/2002	1.181	1.23E-08	81,225,325	1.28E-09	781,012,736	1.26E-10	7,946,862,798
5	13589	5/22/2003	1.937	2.02E-08	49,527,734	2.10E-09	476,228,212	2.06E-10	4,845,657,556
5	16496	8/21/2002	35.40	3.69E-07	2,709,500	3.84E-08	26,052,880	3.77E-09	265,089,994
5	16496	5/11/2003	33.37	3.48E-07	2,873,937	3.62E-08	27,634,008	3.56E-09	281,178,091
5	16622	9/3/2002	0.9701	1.01E-08	98,862,491	1.05E-09	950,600,875	1.03E-10	9,672,434,760
5	16622	5/29/2003	6.197	6.46E-08	15,476,293	6.72E-09	148,810,510	6.60E-10	1,514,158,031
5	18388	8/2/2004	18.80	1.96E-07	5,101,620	2.04E-08	49,054,039	2.00E-09	499,128,503
Count (All Upstream & Trib Samples)			56	* See Tables 2 & 3, Appendix D for parameters used in exposure scenarios.					
Std Dev (All Upstream & Trib Samples)			20.40						
Min (All Upstream & Trib Samples)			0.7588	7.91E-09	126,395,879	8.23E-10	1,215,344,992	8.09E-11	12,366,225,877
Max (All Upstream & Trib Samples)			102.9	1.07E-06	932,120	1.12E-07	8,962,689	1.10E-08	91,196,033
Average (All Upstream & Trib Samples)			**15.97**	1.66E-07	6,006,908	1.73E-08	57,758,728	1.70E-09	587,699,367

Abbreviations: SJRWP = San Jacinto River Waste Pits; WHO = World Health Organization; TEQ = tetrachlorodibenzo-p-dioxin toxicity equivalents; pg/g = picograms per gram; Theo = theoretical; Ca = Cancer; Exp = Exposure; TCEQ = Texas Commission for Environmental Quality; TMDL = Total Maximum Daily Load; dup = duplicate; Std Dev = standard deviation; min = minimum; max = maximum.

E-02	Very High Increased Lifetime Risk
E-03	High Increased Lifetime Risk
E-04	Moderate Increased Lifetime Risk

E-05	Low Increased Lifetime Risk
E-06	No Apparent Increased Lifetime Risk
E-07	No Increased Lifetime Risk

Table 9. Theoretical Cancer Risk from Dioxin in Sediments, Oral, On/Off-Site

On and Off-Site, Soil/Sediment Pathway, Chronic Duration Exposure, Oral Route			Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Sediment Sample Collection Location	**Sample**	**TCDD TEQ (pg/g)**	**Theo Ca Risk (Oral Exp)**	**Ca Odds**	**Theo Ca Risk (Oral Exp)**	**Ca Odds**	**Theo Ca Risk (Oral Exp)**	**Ca Odds**
SJRWP, On-Site Samples	Average	15,594	1.63E-04	6,151	1.69E-05	59,140	1.66E-06	601,752
	Max	34,028	3.55E-04	2,819	3.69E-05	27,102	3.63E-06	275,763
Down-Stream from SJRWP SJR, HSC, & UGB	Average	13.75	1.43E-07	6,973,260	1.49E-08	67,050,576	1.47E-09	682,244,611
	Max	86.16	8.98E-07	1,113,115	9.34E-08	10,703,031	9.18E-09	108,904,135
SJRWP Site-Vicinity, SJR Near SJRWP	Average	82.24	8.57E-07	1,166,229	8.92E-08	11,213,740	8.76E-09	114,100,638
	Max	572.5	5.97E-06	167,533	6.21E-07	1,610,894	6.10E-08	16,390,965
Houston Ship Channel, Above/West of SJR	Average	65.69	6.85E-07	1,459,952	7.12E-08	14,038,003	7.00E-09	142,837,725
	Max	856.8	8.93E-06	111,944	9.29E-07	1,076,389	9.13E-08	10,952,342
Up-Stream & Tributaries to SJR-HSC-UGB	Average	15.97	1.66E-07	6,006,908	1.73E-08	57,758,728	1.70E-09	587,699,367
	Max	102.9	1.07E-06	932,120	1.12E-07	8,962,689	1.10E-08	91,196,033
All Off-Site Samples	Average	40.04	4.17E-07	2,395,429	4.34E-08	23,032,974	4.27E-09	234,362,226
	Max	856.8	8.93E-06	111,944	9.29E-07	1,076,389	9.13E-08	10,952,342

Abbreviations: Avg = average; Max = maximum; Exp = exposure; Theo = theoretical; Ca = cancer; SJRWP = San Jacinto River Waste Pitts; SJR = San Jacinto River; HSC = Houston Ship Channel; UGB = Upper Galveston Bay; pg/g = picograms per gram; TCDD TEQ = tetrachlorodibenzo-p-dioxin toxic equivalent concentration.

E-02	Very High Increased Lifetime Risk
E-03	High Increased Lifetime Risk
E-04	Moderate Increased Lifetime Risk

E-05	Low Increased Lifetime Risk
E-06	No Apparent Increased Lifetime Risk
E-07	No Increased Lifetime Risk

- See Tables 2 & 3, Appendix D for parameters used in exposure scenarios.
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Table 10. Theoretical Cancer Risk from Dioxin in Sediments, Dermal, SJRWP Site

SJRWP, On-Site, Soil/Sediment Pathway, Chronic Duration Exposure, Dermal Route				Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Source	**Location/ Station ID**	**Collection Date**	**WHO 2005 TEQ (pg/g)**	**Theo Ca Risk (Dermal Exp)**	**Ca Odds**	**Theo Ca Risk (Dermal Exp)**	**Ca Odds**	**Theo Ca Risk (Dermal Exp)**	**Ca Odds**
TCEQ	SE-04	7/12/2005	1,392	3.58E-05	27,924	3.72E-06	268,504	3.63E-07	2,754,022
TCEQ	SE-05	7/12/2005	1,212	3.12E-05	32,057	3.24E-06	308,239	3.16E-07	3,161,577
TCEQ	SE-07	7/12/2005	80.92	2.08E-06	480,325	2.17E-07	4,618,505	2.11E-08	47,371,541
TCEQ	SE-08	7/12/2005	24,031	6.18E-04	1,617	6.43E-05	15,552	6.27E-06	159,510
TCEQ	SE-09	7/13/2005	8,187	2.11E-04	4,747	2.19E-05	45,646	2.14E-06	468,190
TCEQ	SE-10	7/13/2005	17,359	4.47E-04	2,239	4.64E-05	21,529	4.53E-06	220,816
TCEQ	SE-11	7/13/2005	23,290	5.99E-04	1,669	6.23E-05	16,046	6.08E-06	164,582
TMDL	00015	8/18/2005	30,764	7.92E-04	1,263	8.23E-05	12,148	8.03E-06	124,598
TMDL	00015-dup	8/18/2005	34,028	8.76E-04	1,142	9.11E-05	10,983	8.88E-06	112,648
Count (All On-Site Samples)			9	* See Tables 2 & 3, Appendix D for parameters used in exposure scenarios.					
Std Dev (All On-Site Samples)			13,264						
Min (All On-Site Samples)			80.92	2.08E-06	480,325	2.17E-07	4,618,505	2.11E-08	47,371,541
Max (All On-Site Samples)			34,028	8.76E-04	1,142	9.11E-05	10,983	8.88E-06	112,648
Average (All On-Site Samples)			**15,594**	4.01E-04	2,492	4.17E-05	23,966	4.07E-06	245,812

Abbreviations: SJRWP = San Jacinto River Waste Pits; WHO = World Health Organization; TEQ = tetrachlorodibenzo-p-dioxin toxicity equivalents; pg/g = picograms per gram; Theo = theoretical; Ca = Cancer; Exp = Exposure; TCEQ = Texas Commission for Environmental Quality; TMDL = Total Maximum Daily Load; dup = duplicate; Std Dev = standard deviation; min = minimum; max = maximum.

E-02	Very High Increased Lifetime Risk
E-03	High Increased Lifetime Risk
E-04	Moderate Increased Lifetime Risk

E-05	Low Increased Lifetime Risk
E-06	No Apparent Increased Lifetime Risk
E-07	No Increased Lifetime Risk

Table 11. Theoretical Cancer Risk from Dioxin in Sediments, Dermal, Downstream

Downstream, Soil/Sediment Pathway, Chronic Duration Exposure, Dermal Route				Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Location Code	Location/ Station ID	Collection Date	WHO 2005 TEQ (pg/g)	Theo Ca Risk (Dermal Exp)	Ca Odds	Theo Ca Risk (Dermal Exp)	Ca Odds	Theo Ca Risk (Dermal Exp)	Ca Odds
2	11252	8/27/2002	0.7457	1.92E-08	52,124,145	2.00E-09	501,193,698	1.95E-10	5,140,693,067
2	11252 dup	8/27/2002	0.7890	2.03E-08	49,259,665	2.11E-09	473,650,627	2.06E-10	4,858,186,570
2	11252	10/24/2002	11.65	3.00E-07	3,336,742	3.12E-08	32,084,056	3.04E-09	329,082,914
2	11252	5/28/2003	8.942	2.30E-07	4,346,472	2.39E-08	41,792,998	2.33E-09	428,666,557
2	11252 dup	5/28/2003	8.588	2.21E-07	4,525,871	2.30E-08	43,517,989	2.24E-09	446,359,610
2	11252	3/11/2004	6.210	1.60E-07	6,258,926	1.66E-08	60,181,985	1.62E-09	617,280,532
2	11252	11/8/2004	5.510	1.42E-07	7,054,043	1.47E-08	67,827,341	1.44E-09	695,698,172
2	11258	8/1/2002	1.447	3.72E-08	26,866,463	3.87E-09	258,331,373	3.77E-10	2,649,678,765
2	11258	4/30/2003	4.266	1.10E-07	9,110,729	1.14E-08	87,603,160	1.11E-09	898,536,752
2	11261	8/19/2002	5.657	1.46E-07	6,870,248	1.51E-08	66,060,079	1.48E-09	677,571,552
2	11261	10/26/2002	10.78	2.77E-07	3,605,147	2.88E-08	34,664,875	2.81E-09	355,554,113
2	11261	5/11/2003	15.10	3.89E-07	2,573,276	4.04E-08	24,743,034	3.94E-09	253,786,802
2	11261	3/24/2004	9.204	2.37E-07	4,222,769	2.46E-08	40,603,551	2.40E-09	416,466,513
2	11261	11/9/2004	19.43	5.00E-07	2,000,328	5.20E-08	19,233,921	5.07E-09	197,280,380
2	13309	8/30/2002	1.556	4.00E-08	24,971,164	4.16E-09	240,107,348	4.06E-10	2,462,756,777
2	13309	5/12/2003	1.750	4.50E-08	22,209,988	4.68E-09	213,557,577	4.57E-10	2,190,438,461
2	13336	8/27/2002	2.609	6.71E-08	14,895,038	6.98E-09	143,221,523	6.81E-10	1,469,008,675
2	13336 dup	8/27/2002	4.741	1.22E-07	8,198,272	1.27E-08	78,829,540	1.24E-09	808,546,614
2	13336	10/22/2002	13.55	3.49E-07	2,867,520	3.63E-08	27,572,309	3.54E-09	282,806,388
2	13337	8/14/2002	18.56	4.78E-07	2,093,811	4.97E-08	20,132,799	4.84E-09	206,500,083
2	13337	5/28/2003	14.30	3.68E-07	2,718,308	3.83E-08	26,137,577	3.73E-09	268,090,487
2	13339	8/22/2002	22.38	5.76E-07	1,736,730	5.99E-08	16,699,327	5.84E-09	171,283,311
2	13339	5/4/2003	7.173	1.85E-07	5,418,199	1.92E-08	52,098,069	1.87E-09	534,364,628
2	13340	8/6/2002	10.31	2.65E-07	3,768,403	2.76E-08	36,234,646	2.69E-09	371,655,100

Table 11 (Cont.) Theoretical Cancer Risk from Dioxin in Sediments, Dermal, Downstream

Downstream, Soil/Sediment Pathway, Chronic Duration Exposure, Dermal Route				Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Location Code	Location/ Station ID	Collection Date	WHO 2005 TEQ (pg/g)	Theo Ca Risk (Dermal Exp)	Ca Odds	Theo Ca Risk (Dermal Exp)	Ca Odds	Theo Ca Risk (Dermal Exp)	Ca Odds
2	13340	10/23/2002	12.41	3.19E-07	3,130,724	3.32E-08	30,103,112	3.24E-09	308,764,573
2	13340	5/28/2003	9.205	2.37E-07	4,222,356	2.46E-08	40,599,581	2.40E-09	416,425,793
2	13340	3/11/2004	11.71	3.01E-07	3,320,266	3.13E-08	31,925,634	3.05E-09	327,457,994
2	13340	11/9/2004	8.733	2.25E-07	4,450,772	2.34E-08	42,795,887	2.28E-09	438,953,082
2	13342	8/21/2002	28.75	7.40E-07	1,352,109	7.69E-08	13,001,046	7.50E-09	133,350,419
2	13342	10/28/2002	25.99	6.69E-07	1,495,435	6.95E-08	14,379,187	6.78E-09	147,485,871
2	13342 dup	10/28/2002	29.74	7.65E-07	1,306,828	7.96E-08	12,565,653	7.76E-09	128,884,630
2	13342	5/11/2003	29.08	7.48E-07	1,336,739	7.78E-08	12,853,264	7.59E-09	131,834,630
2	13342	3/11/2004	29.08	7.48E-07	1,336,716	7.78E-08	12,853,043	7.59E-09	131,832,363
2	13342	11/9/2004	30.03	7.73E-07	1,294,122	8.04E-08	12,443,482	7.84E-09	127,631,532
2	14560	8/30/2002	13.14	3.38E-07	2,958,227	3.52E-08	28,444,490	3.43E-09	291,752,252
2	14560	5/12/2003	1.570	4.04E-08	24,757,383	4.20E-09	238,051,762	4.10E-10	2,441,672,847
2	14560	3/11/2004	1.390	3.58E-08	27,963,428	3.72E-09	268,879,114	3.63E-10	2,757,865,879
2	14560	11/4/2004	0.7393	1.90E-08	52,569,716	1.98E-09	505,478,042	1.93E-10	5,184,637,152
2	15464	8/16/2002	0.7853	2.02E-08	49,491,753	2.10E-09	475,882,239	2.05E-10	4,881,075,990
2	15464	11/6/2002	0.8470	2.18E-08	45,888,177	2.27E-09	441,232,474	2.21E-10	4,525,676,858
2	15464	5/12/2003	0.9297	2.39E-08	41,806,629	2.49E-09	401,986,814	2.43E-10	4,123,138,087
2	15908	9/11/2002	1.472	3.79E-08	26,406,115	3.94E-09	253,904,952	3.84E-10	2,604,277,406
2	15908	5/28/2003	1.522	3.92E-08	25,539,903	4.07E-09	245,575,987	3.97E-10	2,518,848,058
2	16213	9/11/2002	2.185	5.62E-08	17,789,847	5.85E-09	171,056,222	5.70E-10	1,754,506,367
2	16213	5/12/2003	2.709	6.97E-08	14,344,745	7.25E-09	137,930,237	7.07E-10	1,414,736,491
2	16499	8/22/2002	28.02	7.21E-07	1,387,341	7.50E-08	13,339,821	7.31E-09	136,825,193
2	16499	10/24/2002	18.92	4.87E-07	2,054,574	5.06E-08	19,755,515	4.94E-09	202,630,321
2	16499	3/19/2004	43.57	1.12E-06	892,085	1.17E-07	8,577,742	1.14E-08	87,981,036

Table 11 (Cont.) Theoretical Cancer Risk from Dioxin in Sediments, Dermal, Downstream

Downstream, Soil/Sediment Pathway, Chronic Duration Exposure, Dermal Route				Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Location Code	**Location/ Station ID**	**Collection Date**	**WHO 2005 TEQ (pg/g)**	**Theo Ca Risk (Dermal Exp)**	**Ca Odds**	**Theo Ca Risk (Dermal Exp)**	**Ca Odds**	**Theo Ca Risk (Dermal Exp)**	**Ca Odds**
2	16499	11/9/2004	86.16	2.22E-06	451,074	2.31E-07	4,337,253	2.25E-08	44,486,767
2	16618	8/19/2002	8.390	2.16E-07	4,632,546	2.24E-08	44,543,714	2.19E-09	456,880,372
2	16618	5/6/2003	62.77	1.61E-06	619,220	1.68E-07	5,954,039	1.64E-08	61,069,976
2	16618	3/19/2004	6.298	1.62E-07	6,170,832	1.69E-08	59,334,923	1.64E-09	608,592,307
2	16618	11/9/2004	19.58	5.04E-07	1,985,358	5.24E-08	19,089,984	5.11E-09	195,804,040
2	17970	8/18/2002	2.478	6.37E-08	15,687,230	6.63E-09	150,838,754	6.46E-10	1,547,137,846
2	17970	10/24/2002	3.473	8.94E-08	11,190,524	9.29E-09	107,601,192	9.06E-10	1,103,654,546
2	17971	8/24/2002	27.58	7.09E-07	1,409,453	7.38E-08	13,552,432	7.19E-09	139,005,921
2	17971 dup	8/24/2002	28.13	7.24E-07	1,381,800	7.53E-08	13,286,537	7.34E-09	136,278,668
2	17971	10/28/2002	16.23	4.18E-07	2,395,019	4.34E-08	23,029,029	4.23E-09	236,206,420
2	18390	8/11/2004	12.65	3.25E-07	3,072,926	3.38E-08	29,547,366	3.30E-09	303,064,341
Count (All Downstream Samples)			59	* See Tables 2 & 3, Appendix D for parameters used in exposure scenarios.					
Std Dev (All Downstream Samples)			15.54						
Min (All Downstream Samples)			0.7393	1.90E-08	52,569,716	1.98E-09	505,478,042	1.93E-10	5,184,637,152
Max (All Downstream Samples)			86.16	2.22E-06	451,074	2.31E-07	4,337,253	2.25E-08	44,486,767
Average (All Downstream Samples)			**13.75**	3.54E-07	2,825,816	3.68E-08	27,171,306	3.59E-09	278,693,340

Abbreviations: SJRWP = San Jacinto River Waste Pits; WHO = World Health Organization; TEQ = tetrachlorodibenzo-p-dioxin toxicity equivalents; pg/g = picograms per gram; Theo = theoretical; Ca = Cancer; Exp = Exposure; TCEQ = Texas Commission for Environmental Quality; TMDL = Total Maximum Daily Load; dup = duplicate; Std Dev = standard deviation; min = minimum; max = maximum.

E-02	Very High Increased Lifetime Risk
E-03	High Increased Lifetime Risk
E-04	Moderate Increased Lifetime Risk

E-05	Low Increased Lifetime Risk
E-06	No Apparent Increased Lifetime Risk
E-07	No Increased Lifetime Risk

Table 12. Theoretical Cancer Risk from Dioxin in Sediments, Dermal, Site-Vicinity

SJRWP Site-Vicinity, Soil/Sediment Pathway, Chronic Duration Exposure, Dermal Route				Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Location Code	Location/ Station ID	Collection Date	WHO 2005 TEQ (pg/g)	Theo Ca Risk (Dermal Exp)	Ca Odds	Theo Ca Risk (Dermal Exp)	Ca Odds	Theo Ca Risk (Dermal Exp)	Ca Odds
3	00001	8/17/2005	80.09	2.06E-06	485,275	2.14E-07	4,666,107	2.09E-08	47,859,793
3	00002	8/17/2005	66.26	1.70E-06	586,566	1.77E-07	5,640,054	1.73E-08	57,849,468
3	00003	8/18/2005	29.40	7.57E-07	1,321,765	7.87E-08	12,709,279	7.67E-09	130,357,790
3	00004	8/17/2005	13.26	3.41E-07	2,931,651	3.55E-08	28,188,956	3.46E-09	289,131,268
3	00005	8/17/2005	11.53	2.97E-07	3,369,459	3.09E-08	32,398,641	3.01E-09	332,309,581
3	00004 dup	8/17/2005	16.44	4.23E-07	2,363,545	4.40E-08	22,726,393	4.29E-09	233,102,315
3	00006	8/15/2005	11.63	2.99E-07	3,341,217	3.11E-08	32,127,083	3.03E-09	329,524,241
3	00007	8/15/2005	14.81	3.81E-07	2,625,042	3.96E-08	25,240,786	3.86E-09	258,892,191
3	00008	8/18/2005	30.63	7.88E-07	1,268,857	8.20E-08	12,200,551	7.99E-09	125,139,819
3	00009	8/18/2005	13.18	3.39E-07	2,948,689	3.53E-08	28,352,774	3.44E-09	290,811,537
3	00010	8/30/2005	155.6	4.00E-06	249,831	4.16E-07	2,402,220	4.06E-08	24,639,330
3	00011	8/18/2005	522.8	1.35E-05	74,344	1.40E-06	714,844	1.36E-07	7,332,083
3	00011 dup	8/18/2005	572.5	1.47E-05	67,890	1.53E-06	652,792	1.49E-07	6,695,623
3	00012	8/30/2005	70.87	1.82E-06	548,402	1.90E-07	5,273,099	1.85E-08	54,085,644
3	00013	8/17/2005	12.90	3.32E-07	3,013,785	3.45E-08	28,978,698	3.36E-09	297,231,571
3	00014	8/18/2005	34.37	8.84E-07	1,130,933	9.20E-08	10,874,353	8.97E-09	111,537,138
3	00016	8/18/2005	138.2	3.56E-06	281,185	3.70E-07	2,703,699	3.61E-08	27,731,571
3	00017	8/17/2005	32.01	8.24E-07	1,214,316	8.56E-08	11,676,115	8.35E-09	119,760,732
3	00018	8/17/2005	38.25	9.84E-07	1,016,194	1.02E-07	9,771,095	9.98E-09	100,221,136
3	00019	8/17/2005	20.31	5.23E-07	1,913,468	5.44E-08	18,398,734	5.30E-09	188,713,952
3	00020	8/18/2005	1.997	5.14E-08	19,465,984	5.34E-09	187,172,927	5.21E-10	1,919,813,779
3	00021	8/17/2005	42.17	1.09E-06	921,607	1.13E-07	8,861,603	1.10E-08	90,892,569

Table 12 (Cont.) Theoretical Cancer Risk from Dioxin in Sediments, Dermal, Site-Vicinity

SJRWP Site-Vicinity, Soil/Sediment Pathway, Chronic Duration Exposure, Dermal Route				Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Location Code	**Location/ Station ID**	**Collection Date**	**WHO 2005 TEQ (pg/g)**	**Theo Ca Risk (Dermal Exp)**	**Ca Odds**	**Theo Ca Risk (Dermal Exp)**	**Ca Odds**	**Theo Ca Risk (Dermal Exp)**	**Ca Odds**
3	11193	8/8/2002	102.8	2.65E-06	378,011	2.75E-07	3,634,724	2.68E-08	37,280,999
3	11193	10/31/2002	64.43	1.66E-06	603,206	1.72E-07	5,800,057	1.68E-08	59,490,599
3	11193	5/13/2003	138.4	3.56E-06	280,754	3.70E-07	2,699,561	3.61E-08	27,689,124
3	11193	3/24/2004	94.47	2.43E-06	411,419	2.53E-07	3,955,955	2.46E-08	40,575,827
3	11193	8/11/2004	18.58	4.78E-07	2,091,895	4.97E-08	20,114,378	4.85E-09	206,311,138
3	11193 dup	8/11/2004	96.32	2.48E-06	403,521	2.58E-07	3,880,013	2.51E-08	39,796,900
3	11193	11/4/2004	40.98	1.05E-06	948,395	1.10E-07	9,119,183	1.07E-08	93,534,542
3	11193 dup	11/4/2004	46.90	1.21E-06	828,778	1.25E-07	7,969,018	1.22E-08	81,737,414
3	18389	8/10/2004	17.32	4.46E-07	2,244,457	4.63E-08	21,581,320	4.52E-09	221,357,413
Count (All Site-Vicinity Samples)			31	* See Tables 2 & 3, Appendix D for parameters used in exposure scenarios.					
Std Dev (All Site-Vicinity Samples)			131.2						
Min (All Site-Vicinity Samples)			1.997	5.14E-08	19,465,984	5.34E-09	187,172,927	5.21E-10	1,919,813,779
Max (All Site-Vicinity Samples)			572.5	1.47E-05	67,890	1.53E-06	652,792	1.49E-07	6,695,623
Average (All Site-Vicinity Samples)			**82.24**	2.12E-06	472,598	2.20E-07	4,544,211	2.15E-08	46,609,511

Abbreviations: SJRWP = San Jacinto River Waste Pits; WHO = World Health Organization; TEQ = tetrachlorodibenzo-p-dioxin toxicity equivalents; pg/g = picograms per gram; Theo = theoretical; Ca = Cancer; Exp = Exposure; TCEQ = Texas Commission for Environmental Quality; TMDL = Total Maximum Daily Load; dup = duplicate; Std Dev = standard deviation; min = minimum; max = maximum.

E-02	Very High Increased Lifetime Risk
E-03	High Increased Lifetime Risk
E-04	Moderate Increased Lifetime Risk

E-05	Low Increased Lifetime Risk
E-06	No Apparent Increased Lifetime Risk
E-07	No Increased Lifetime Risk

Table 13. Theoretical Cancer Risk from Dioxin in Sediments, Dermal, Houston Ship Chan

Houston Ship Channel, Soil/Sediment Pathway, Chronic Duration Exposure, Dermal Route				Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Location Code	Location/ Station ID	Collection Date	WHO 2005 TEQ (pg/g)	Theo Ca Risk (Dermal Exp)	Ca Odds	Theo Ca Risk (Dermal Exp)	Ca Odds	Theo Ca Risk (Dermal Exp)	Ca Odds
4	00022	8/16/2005	28.54	7.34E-07	1,362,045	7.64E-08	13,096,588	7.44E-09	134,330,383
4	00023	8/16/2005	38.13	9.81E-07	1,019,339	1.02E-07	9,801,334	9.95E-09	100,531,296
4	00024	8/16/2005	63.19	1.63E-06	615,033	1.69E-07	5,913,775	1.65E-08	60,656,989
4	00025	8/16/2005	31.28	8.05E-07	1,242,690	8.37E-08	11,948,941	8.16E-09	122,559,080
4	00026	8/17/2005	20.91	5.38E-07	1,858,923	5.59E-08	17,874,263	5.45E-09	183,334,503
4	00027	8/17/2005	22.01	5.66E-07	1,765,530	5.89E-08	16,976,246	5.74E-09	174,123,639
4	11264	8/19/2002	14.67	3.77E-07	2,649,016	3.93E-08	25,471,311	3.83E-09	261,256,665
4	11264	5/29/2003	25.13	6.47E-07	1,546,674	6.72E-08	14,871,864	6.56E-09	152,539,209
4	11264	3/24/2004	22.44	5.77E-07	1,732,167	6.00E-08	16,655,454	5.85E-09	170,833,309
4	11264	11/4/2004	18.82	4.84E-07	2,065,383	5.04E-08	19,859,447	4.91E-09	203,696,343
4	11265	4/1/2004	31.06	7.99E-07	1,251,453	8.31E-08	12,033,200	8.10E-09	123,423,312
4	11265	11/4/2004	26.53	6.83E-07	1,465,025	7.10E-08	14,086,774	6.92E-09	144,486,620
4	11267	8/10/2004	38.67	9.95E-07	1,005,026	1.03E-07	9,663,712	1.01E-08	99,119,719
4	11267	8/16/2005	51.19	1.32E-06	759,257	1.37E-07	7,300,549	1.34E-08	74,880,988
4	11268	8/11/2004	35.25	9.07E-07	1,102,702	9.43E-08	10,602,899	9.20E-09	108,752,863
4	11268	8/16/2005	55.46	1.43E-06	700,787	1.48E-07	6,738,340	1.45E-08	69,114,473
4	11269	8/10/2004	15.65	4.03E-07	2,483,474	4.19E-08	23,879,558	4.08E-09	244,930,210
4	11270	8/28/2002	32.74	8.42E-07	1,187,263	8.76E-08	11,415,993	8.54E-09	117,092,683
4	11270	5/6/2003	4.904	1.26E-07	7,924,877	1.31E-08	76,200,736	1.28E-09	781,583,245
4	11270	8/10/2004	15.52	3.99E-07	2,504,760	4.15E-08	24,084,235	4.05E-09	247,029,567
4	11271	8/10/2004	11.27	2.90E-07	3,449,086	3.02E-08	33,164,287	2.94E-09	340,162,734
4	11273	8/28/2002	180.5	4.65E-06	215,284	4.83E-07	2,070,042	4.71E-08	21,232,214
4	11273 dup	8/28/2002	179.3	4.61E-06	216,728	4.80E-07	2,083,923	4.68E-08	21,374,585
4	11273	5/3/2003	143.2	3.68E-06	271,375	3.83E-07	2,609,378	3.74E-08	26,764,124

Table 13 (Cont.) Theoretical Cancer Risk from Dioxin in Sediments, Dermal, Houston Ship Chan

Houston Ship Channel, Soil/Sediment Pathway, Chronic Duration Exposure, Dermal Route				Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Location Code	Location/ Station ID	Collection Date	WHO 2005 TEQ (pg/g)	Theo Ca Risk (Dermal Exp)	Ca Odds	Theo Ca Risk (Dermal Exp)	Ca Odds	Theo Ca Risk (Dermal Exp)	Ca Odds
4	11273 dup	5/3/2003	135.9	3.50E-06	286,077	3.64E-07	2,750,737	3.54E-08	28,214,028
4	11280	8/29/2002	33.69	8.67E-07	1,153,596	9.02E-08	11,092,266	8.79E-09	113,772,251
4	11280	12/2/2002	38.95	1.00E-06	997,750	1.04E-07	9,593,754	1.02E-08	98,402,161
4	11280 dup	12/2/2002	51.68	1.33E-06	752,000	1.38E-07	7,230,769	1.35E-08	74,165,269
4	11280	5/6/2003	45.54	1.17E-06	853,512	1.22E-07	8,206,845	1.19E-08	84,176,775
4	11280	4/1/2004	458.4	1.18E-05	84,788	1.23E-06	815,274	1.20E-07	8,362,183
4	11280	8/10/2004	46.71	1.20E-06	832,132	1.25E-07	8,001,265	1.22E-08	82,068,165
4	11280	11/4/2004	856.8	2.20E-05	45,364	2.29E-06	436,192	2.24E-07	4,473,974
4	11280	8/16/2005	24.37	6.27E-07	1,594,779	6.52E-08	15,334,417	6.36E-09	157,283,566
4	11287	8/26/2002	5.358	1.38E-07	7,254,030	1.43E-08	69,750,290	1.40E-09	715,421,674
4	11287	5/5/2003	5.297	1.36E-07	7,338,123	1.42E-08	70,558,875	1.38E-09	723,715,243
4	11287	4/2/2004	20.96	5.39E-07	1,854,577	5.61E-08	17,832,470	5.47E-09	182,905,845
4	11287 dup	4/2/2004	19.21	4.94E-07	2,023,552	5.14E-08	19,457,233	5.01E-09	199,570,874
4	11287	11/4/2004	22.56	5.81E-07	1,722,571	6.04E-08	16,563,182	5.89E-09	169,886,885
4	11292	9/5/2002	15.98	4.11E-07	2,432,493	4.28E-08	23,389,353	4.17E-09	239,902,227
4	11292	12/10/2002	100.5	2.59E-06	386,653	2.69E-07	3,717,818	2.62E-08	38,133,285
4	11292	5/6/2003	7.032	1.81E-07	5,527,465	1.88E-08	53,148,700	1.83E-09	545,140,836
4	11292	4/2/2004	11.52	2.96E-07	3,372,938	3.08E-08	32,432,099	3.01E-09	332,652,763
4	11292 dup	4/2/2004	11.34	2.92E-07	3,427,067	3.03E-08	32,952,569	2.96E-09	337,991,164
4	11292	11/4/2004	11.94	3.07E-07	3,255,140	3.19E-08	31,299,421	3.11E-09	321,034,990
4	15979	9/4/2002	440.7	1.13E-05	88,198	1.18E-06	848,061	1.15E-07	8,698,477
4	15979 dup	9/4/2002	264.8	6.81E-06	146,795	7.08E-07	1,411,489	6.91E-08	14,477,503
4	15979	5/29/2003	27.24	7.01E-07	1,426,883	7.29E-08	13,720,029	7.11E-09	140,724,955
4	15979 A	4/2/2004	15.50	3.99E-07	2,507,184	4.15E-08	24,107,540	4.04E-09	247,268,597

Table 13 (Cont.) Theoretical Cancer Risk from Dioxin in Sediments, Dermal, Houston Ship Channel

Houston Ship Channel, Soil/Sediment Pathway, Chronic Duration Exposure, Dermal Route				Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Location Code	**Location/ Station ID**	**Collection Date**	**WHO 2005 TEQ (pg/g)**	**Theo Ca Risk (Dermal Exp)**	**Ca Odds**	**Theo Ca Risk (Dermal Exp)**	**Ca Odds**	**Theo Ca Risk (Dermal Exp)**	**Ca Odds**
4	15979 B	5/18/2004	20.78	5.35E-07	1,870,716	5.56E-08	17,987,653	5.42E-09	184,497,540
4	15979	8/10/2004	22.21	5.72E-07	1,749,713	5.94E-08	16,824,161	5.79E-09	172,563,714
4	15979 tA	8/11/2004	9.730	2.50E-07	3,994,488	2.60E-08	38,408,539	2.54E-09	393,952,496
4	15979 tB	8/11/2004	21.96	5.65E-07	1,769,549	5.88E-08	17,014,892	5.73E-09	174,520,023
4	15979 tC	8/11/2004	20.20	5.20E-07	1,923,792	5.41E-08	18,497,999	5.27E-09	189,732,108
4	15979 tD	8/11/2004	19.51	5.02E-07	1,991,921	5.22E-08	19,153,089	5.09E-09	196,451,301
4	15979 tE	8/11/2004	17.48	4.50E-07	2,222,968	4.68E-08	21,374,690	4.56E-09	219,238,034
4	15979	11/4/2004	22.57	5.81E-07	1,721,884	6.04E-08	16,556,578	5.89E-09	169,819,147
4	15979	8/16/2005	31.88	8.20E-07	1,219,241	8.53E-08	11,723,475	8.32E-09	120,246,499
4	15980	8/10/2004	24.08	6.20E-07	1,614,186	6.44E-08	15,521,018	6.28E-09	159,197,516
4	18391	8/10/2004	11.23	2.89E-07	3,460,171	3.01E-08	33,270,873	2.93E-09	341,255,979
4	18392	8/10/2004	33.24	8.55E-07	1,169,161	8.90E-08	11,241,935	8.67E-09	115,307,390
4	18392	8/16/2005	20.03	5.15E-07	1,940,795	5.36E-08	18,661,494	5.22E-09	191,409,058
4	18392 dup	8/16/2005	19.84	5.11E-07	1,958,758	5.31E-08	18,834,215	5.18E-09	193,180,636
Count (All Ho Ship Channel Samples)			62	* See Tables 2 & 3, Appendix D for parameters used in exposure scenarios.					
Std Dev (All Ho Ship Channel Samples)			134.1						
Min (All Ho Ship Channel Samples)			4.904	1.26E-07	7,924,877	1.31E-08	76,200,736	1.28E-09	781,583,245
Max (All Ho Ship Channel Samples)			856.8	2.20E-05	45,364	2.29E-06	436,192	2.24E-07	4,473,974
Average (All Ho Ship Chan Samples)			**65.69**	1.69E-06	591,625	1.76E-07	5,688,704	1.71E-08	58,348,460

Abbreviations: WHO = World Health Organization; TEQ = tetrachlorodibenzo-p-dioxin toxicity equivalents; pg/g = picograms per gram; Theo = theoretical; Ca = Cancer; Exp = Exposure; dup = duplicate; Ho = Houston; Std Dev = standard deviation; min = minimum; max = maximum.

E-02	Very High Increased Lifetime Risk
E-03	High Increased Lifetime Risk
E-04	Moderate Increased Lifetime Risk

E-05	Low Increased Lifetime Risk
E-06	No Apparent Increased Lifetime Risk
E-07	No Increased Lifetime Risk

Table 14. Theoretical Cancer Risk, Dioxin in Sediments, Dermal, Upstream & Tributary

Upstream & Tributaries, Soil/Sediment Pathway, Chronic Duration Exposure, Dermal Route				Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Location Code	Location/ Station ID	Collection Date	WHO 2005 TEQ (pg/g)	Theo Ca Risk (Dermal Exp)	Ca Odds	Theo Ca Risk (Dermal Exp)	Ca Odds	Theo Ca Risk (Dermal Exp)	Ca Odds
5	11092	8/1/2002	21.74	5.59E-07	1,787,374	5.82E-08	17,186,293	5.67E-09	176,278,068
5	11092	4/30/2003	12.83	3.30E-07	3,029,217	3.43E-08	29,127,086	3.35E-09	298,753,578
5	11111	7/31/2002	7.959	2.05E-07	4,883,630	2.13E-08	46,957,980	2.08E-09	481,643,248
5	11111	5/1/2003	8.957	2.30E-07	4,339,072	2.40E-08	41,721,845	2.34E-09	427,936,743
5	11197	3/24/2004	10.55	2.71E-07	3,684,994	2.82E-08	35,432,634	2.75E-09	363,428,947
5	11197	8/11/2004	31.13	8.01E-07	1,248,598	8.33E-08	12,005,753	8.12E-09	123,141,795
5	11197 dup	8/11/2004	29.70	7.64E-07	1,308,544	7.95E-08	12,582,152	7.75E-09	129,053,861
5	11197	11/9/2004	15.78	4.06E-07	2,462,375	4.22E-08	23,676,680	4.12E-09	242,849,309
5	11200	9/3/2002	1.123	2.89E-08	34,615,576	3.00E-09	332,842,074	2.93E-10	3,413,927,490
5	11200 dup	9/3/2002	1.303	3.35E-08	29,832,264	3.49E-09	286,848,692	3.40E-10	2,942,178,017
5	11200	11/21/2002	0.7588	1.95E-08	51,220,158	2.03E-09	492,501,524	1.98E-10	5,051,538,311
5	11272	7/25/2002	9.893	2.55E-07	3,928,793	2.65E-08	37,776,854	2.58E-09	387,473,368
5	11272	4/30/2003	13.90	3.58E-07	2,796,142	3.72E-08	26,885,977	3.63E-09	275,766,747
5	11274	7/30/2002	10.44	2.69E-07	3,723,938	2.79E-08	35,807,096	2.72E-09	367,269,763
5	11274	5/1/2003	5.486	1.41E-07	7,084,517	1.47E-08	68,120,355	1.43E-09	698,703,594
5	11274 dup	5/1/2003	3.780	9.72E-08	10,283,196	1.01E-08	98,876,887	9.86E-10	1,014,170,226
5	11274	5/18/2004	4.762	1.23E-07	8,161,603	1.27E-08	78,476,949	1.24E-09	804,930,133
5	11298	7/29/2002	24.78	6.37E-07	1,568,710	6.63E-08	15,083,754	6.46E-09	154,712,536
5	11298	5/2/2003	16.25	4.18E-07	2,391,666	4.35E-08	22,996,790	4.24E-09	235,875,746
5	11300	9/5/2002	100.4	2.58E-06	387,161	2.69E-07	3,722,707	2.62E-08	38,183,426
5	11300 dup	9/5/2002	102.9	2.65E-06	377,728	2.75E-07	3,632,004	2.68E-08	37,253,101
5	11300	5/29/2003	50.60	1.30E-06	768,171	1.35E-07	7,386,257	1.32E-08	75,760,095
5	11302	8/26/2002	3.696	9.51E-08	10,515,792	9.89E-09	101,113,388	9.64E-10	1,037,109,790
5	11302	5/1/2003	11.35	2.92E-07	3,423,143	3.04E-08	32,914,839	2.96E-09	337,604,173

Table 14 (Cont.) Theoretical Cancer Risk from Dioxin in Sediments, Dermal, Upstream & Tributary

Upstream & Tributaries, Soil/Sediment Pathway, Chronic Duration Exposure, Dermal Route				Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Location Code	Location/ Station ID	Collection Date	WHO 2005 TEQ (pg/g)	Theo Ca Risk (Dermal Exp)	Ca Odds	Theo Ca Risk (Dermal Exp)	Ca Odds	Theo Ca Risk (Dermal Exp)	Ca Odds
5	11305	8/13/2002	3.718	9.57E-08	10,452,725	9.95E-09	100,506,974	9.70E-10	1,030,889,865
5	11305 dup	8/13/2002	3.759	9.67E-08	10,340,375	1.01E-08	99,426,685	9.81E-10	1,019,809,452
5	11305	5/4/2003	4.683	1.20E-07	8,300,080	1.25E-08	79,808,459	1.22E-09	818,587,293
5	11347	8/12/2002	2.040	5.25E-08	19,048,406	5.46E-09	183,157,754	5.32E-10	1,878,630,556
5	11347	5/4/2003	2.562	6.59E-08	15,172,396	6.85E-09	145,888,424	6.68E-10	1,496,362,807
5	11382	8/12/2002	6.207	1.60E-07	6,261,599	1.66E-08	60,207,678	1.62E-09	617,544,068
5	11382	5/5/2003	4.234	1.09E-07	9,180,345	1.13E-08	88,272,550	1.10E-09	905,402,616
5	13338	8/22/2002	27.84	7.16E-07	1,396,195	7.45E-08	13,424,952	7.26E-09	137,698,372
5	13338 dup	8/22/2002	28.06	7.22E-07	1,385,018	7.51E-08	13,317,478	7.32E-09	136,596,030
5	13338	10/22/2002	8.826	2.27E-07	4,403,622	2.36E-08	42,342,520	2.30E-09	434,302,944
5	13338	3/19/2004	16.30	4.19E-07	2,384,820	4.36E-08	22,930,963	4.25E-09	235,200,571
5	13338	11/8/2004	11.50	2.96E-07	3,378,744	3.08E-08	32,487,923	3.00E-09	333,225,345
5	13341	8/6/2002	13.74	3.54E-07	2,827,756	3.68E-08	27,189,957	3.59E-09	278,884,637
5	13341	5/28/2003	0.9372	2.41E-08	41,470,288	2.51E-09	398,752,767	2.45E-10	4,089,966,801
5	13343	8/20/2002	4.493	1.16E-07	8,651,390	1.20E-08	83,186,440	1.17E-09	853,234,899
5	13343	5/11/2003	7.160	1.84E-07	5,428,112	1.92E-08	52,193,386	1.87E-09	535,342,279
5	13344	8/21/2002	28.98	7.46E-07	1,341,214	7.75E-08	12,896,288	7.56E-09	132,275,921
5	13344	10/27/2002	36.30	9.34E-07	1,070,610	9.71E-08	10,294,331	9.47E-09	105,587,907
5	13344	3/19/2004	20.92	5.38E-07	1,857,635	5.60E-08	17,861,875	5.46E-09	183,207,446
5	13344	11/8/2004	29.29	7.54E-07	1,326,859	7.84E-08	12,758,264	7.64E-09	130,860,228
5	13344 dup	11/8/2004	28.44	7.32E-07	1,366,850	7.61E-08	13,142,785	7.42E-09	134,804,213
5	13355	8/18/2002	2.310	5.94E-08	16,824,904	6.18E-09	161,777,919	6.03E-10	1,659,339,748
5	13355	5/28/2003	1.110	2.86E-08	35,013,327	2.97E-09	336,666,605	2.90E-10	3,453,155,310
5	13363	8/16/2002	0.8100	2.08E-08	47,983,467	2.17E-09	461,379,491	2.11E-10	4,732,322,774

Table 14 (Cont.) Theoretical Cancer Risk from Dioxin in Sediments, Dermal, Upstream, and Tributary

Upstream & Tributaries, Soil/Sediment Pathway, Chronic Duration Exposure, Dermal Route				Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Location Code	**Location/ Station ID**	**Collection Date**	**WHO 2005 TEQ (pg/g)**	**Theo Ca Risk (Dermal Exp)**	**Ca Odds**	**Theo Ca Risk (Dermal Exp)**	**Ca Odds**	**Theo Ca Risk (Dermal Exp)**	**Ca Odds**
5	13363	11/6/2002	2.006	5.16E-08	19,378,150	5.37E-09	186,328,368	5.23E-10	1,911,151,223
5	13589	8/16/2002	1.181	3.04E-08	32,915,424	3.16E-09	316,494,464	3.08E-10	3,246,251,708
5	13589	5/22/2003	1.937	4.98E-08	20,070,420	5.18E-09	192,984,808	5.05E-10	1,979,425,657
5	16496	8/21/2002	35.40	9.11E-07	1,097,987	9.47E-08	10,557,564	9.23E-09	108,287,870
5	16496	5/11/2003	33.37	8.59E-07	1,164,623	8.93E-08	11,198,294	8.71E-09	114,859,773
5	16622	9/3/2002	0.9701	2.50E-08	40,062,639	2.60E-09	385,217,681	2.53E-10	3,951,138,790
5	16622	5/29/2003	6.197	1.59E-07	6,271,551	1.66E-08	60,303,373	1.62E-09	618,525,602
5	18388	8/2/2004	18.80	4.84E-07	2,067,360	5.03E-08	19,878,462	4.90E-09	203,891,372
Count (All Upstream & Trib Samples)			56	* See Tables 2 & 3, Appendix D for parameters used in exposure scenarios.					
Std Dev (All Upstream & Trib Samples)			20.40						
Min (All Upstream & Trib Samples)			0.7588	1.95E-08	51,220,158	2.03E-09	492,501,524	1.98E-10	5,051,538,311
Max (All Upstream & Trib Samples)			102.9	2.65E-06	377,728	2.75E-07	3,632,004	2.68E-08	37,253,101
Avg (All Upstream & Trib Samples)			**15.97**	4.11E-07	2,434,215	4.27E-08	23,405,915	4.17E-09	240,072,104

Abbreviations: SJRWP = San Jacinto River Waste Pits; WHO = World Health Organization; TEQ = tetrachlorodibenzo-p-dioxin toxicity equivalents; pg/g = picograms per gram; Theo = theoretical; Ca = Cancer; Exp = Exposure; Trib = tributary; dup = duplicate; Std Dev = standard deviation; min = minimum; max = maximum; Avg = average.

E-02	Very High Increased Lifetime Risk
E-03	High Increased Lifetime Risk
E-04	Moderate Increased Lifetime Risk

E-05	Low Increased Lifetime Risk
E-06	No Apparent Increased Lifetime Risk
E-07	No Increased Lifetime Risk

Table 15. Theoretical Cancer Risk from Dioxin in Sediments, Dermal, On/Off-Site

On & Off-Site, Soil/Sediment Pathway, Chronic Duration Exposure, Dermal Route			Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Sediment Sample Collection Location	Sample	TCDD TEQ (pg/g)	Theo Ca Risk (Dermal Exp)	Ca Odds	Theo Ca Risk (Dermal Exp)	Ca Odds	Theo Ca Risk (Dermal Exp)	Ca Odds
SJRWP, On-Site Samples	Average	15,594	4.01E-04	2,492	4.17E-05	23,966	4.07E-06	245,812
	Max	34,028	8.76E-04	1,142	9.11E-05	10,983	8.88E-06	112,648
Down-Stream from JRWP, SJR, HSC, & UGB	Average	13.75	3.54E-07	2,825,816	3.68E-08	27,171,306	3.59E-09	278,693,340
	Max	86.16	2.22E-06	451,074	2.31E-07	4,337,253	2.25E-08	44,486,767
SJRWP Site-Vicinity, SJR Near SJRWP	Average	82.24	2.12E-06	472,598	2.20E-07	4,544,211	2.15E-08	46,609,511
	Max	572.5	1.47E-05	67,890	1.53E-06	652,792	1.49E-07	6,695,623
Houston Ship Channel, Above/West of SJR	Average	65.69	1.69E-06	591,625	1.76E-07	5,688,704	1.71E-08	58,348,460
	Max	856.8	2.20E-05	45,364	2.29E-06	436,192	2.24E-07	4,473,974
Up-Stream & Tributaries to SJR-HSC-UGB	Average	15.97	4.11E-07	2,434,215	4.27E-08	23,405,915	4.17E-09	240,072,104
	Max	102.9	2.65E-06	377,728	2.75E-07	3,632,004	2.68E-08	37,253,101
All Off-Site Samples	Average	40.04	1.03E-06	970,714	1.07E-07	9,333,790	1.04E-08	95,735,738
	Max	856.8	2.20E-05	45,364	2.29E-06	436,192	2.24E-07	4,473,974

Abbreviations: Avg = average; Max = maximum; Exp = exposure; Theo = theoretical; Ca = cancer; SJRWP = San Jacinto River Waste Pitts; SJR = San Jacinto River; HSC = Houston Ship Channel; UGB = Upper Galveston Bay; pg/g = picograms per gram; TCDD TEQ = tetrachlorodibenzo-p-dioxin toxic equivalent concentration.

E-02	Very High Increased Lifetime Risk
E-03	High Increased Lifetime Risk
E-04	Moderate Increased Lifetime Risk

E-05	Low Increased Lifetime Risk
E-06	No Apparent Increased Lifetime Risk
E-07	No Increased Lifetime Risk

* See Tables 2 & 3, Appendix D for parameters used in exposure scenarios.

Table 16. Theoretical Cancer Risk from Dioxin in Sediments, Oral + Dermal, On/Off-Site

On & Off-Site, Soil/Sediment Pathway, Chronic Duration Exposure, Oral + Dermal Routes			Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Sediment Sample Collection Location	Sample	TCDD TEQ (pg/g)	Theo Ca Risk (Dermal Exp)	Ca Odds	Theo Ca Risk (Dermal Exp)	Ca Odds	Theo Ca Risk (Dermal Exp)	Ca Odds
SJRWP, On-Site Samples	Average	15,594	5.64E-04	1,774	5.86E-05	17,054	5.73E-06	174,521
	Max	34,028	1.23E-03	812.8	1.28E-04	7,816	1.25E-05	79,977
Down-Stream from SJRWP, SJR, HSC, & UGB	Average	13.75	4.97E-07	2,010,919	5.17E-08	19,335,760	5.05E-09	197,866,084
	Max	86.16	3.12E-06	320,995	3.24E-07	3,086,495	3.17E-08	31,584,617
SJRWP Site-Vicinity, SJR Near SJRWP	Average	82.24	2.97E-06	336,312	3.09E-07	3,233,771	3.02E-08	33,091,718
	Max	572.5	2.07E-05	48,312	2.15E-06	464,543	2.10E-07	4,753,744
Houston Ship Channel, Above/West of SJR	Average	65.69	2.38E-06	421,015	2.47E-07	4,048,220	2.41E-08	41,426,112
	Max	856.8	3.10E-05	32,282	3.22E-06	310,405	3.15E-07	3,176,422
Up-Stream & Tributaries to SJR-HSC-UGB	Average	15.97	5.77E-07	1,732,247	6.00E-08	16,656,217	5.87E-09	170,445,864
	Max	102.9	3.72E-06	268,801	3.87E-07	2,584,622	3.78E-08	26,448,874
All Off-Site Samples	Average	40.04	1.45E-06	690,784	1.51E-07	6,642,151	1.47E-08	67,970,249
	Max	856.8	3.10E-05	32,282	3.22E-06	310,405	3.15E-07	3,176,422

Abbreviations: Avg = average; Max = maximum; Exp = exposure; Theo = theoretical; Ca = cancer; SJRWP = San Jacinto River Waste Pitts; SJR = San Jacinto River; HSC = Houston Ship Channel; UGB = Upper Galveston Bay; pg/g = picograms per gram; TCDD TEQ = tetrachlorodibenzo-p-dioxin toxic equivalent concentration.

E-02	Very High Increased Lifetime Risk
E-03	High Increased Lifetime Risk
E-04	Moderate Increased Lifetime Risk

E-05	Low Increased Lifetime Risk
E-06	No Apparent Increased Lifetime Risk
E-07	No Increased Lifetime Risk

* See Tables 2 & 3, Appendix D for parameters used in exposure scenarios.

Table 17. Hazard Quotients for Dioxin in Sediments, Acute Exposure, Oral, On/Off-Site

On & Off-Site, Soil/Sediment Pathway, Acute Duration Exposures, Oral Ingestion Route			Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Sediment Sample Collection Location	Sample	TCDD TEQ (pg/g)	Hazard Quotient	Margin of Safety	Hazard Quotient	Margin of Safety	Hazard Quotient	Margin of Safety
SJRWP, On-Site Samples	Average	15,594	1.63E-02	61.41	1.69E-03	590.5	3.26E-04	3,071
	Max	34,028	3.55E-02	28.14	3.70E-03	270.6	7.11E-04	1,407
Down-Stream from SJRWP, SJR, HSC, & UGB	Average	13.75	1.44E-05	69,630	1.49E-06	669,518	2.87E-07	3,481,491
	Max	86.16	9.00E-05	11,115	9.36E-06	106,873	1.80E-06	555,737
SJRWP Site-Vicinity, SJR Near SJRWP	Average	82.24	8.59E-05	11,645	8.93E-06	111,972	1.72E-06	582,255
	Max	572.5	5.98E-04	1,673	6.22E-05	16,085	1.20E-05	83,643
Houston Ship Channel, Above/West of SJR	Average	65.69	6.86E-05	14,578	7.13E-06	140,173	1.37E-06	728,900
	Max	856.8	8.95E-04	1,118	9.30E-05	10,748	1.79E-05	55,890
Up-Stream & Tributaries to SJR-HSC-UGB	Average	15.97	1.67E-05	59,981	1.73E-06	576,736	3.33E-07	2,999,027
	Max	102.9	1.07E-04	9,307	1.12E-05	89,495	2.15E-06	465,373
All Off-Site Samples	Average	40.04	4.18E-05	23,919	4.35E-06	229,990	8.36E-07	1,195,949
	Max	856.8	8.95E-04	1,118	9.30E-05	10,748	1.79E-05	55,890

Abbreviations: Avg = average; Max = maximum; Exp = exposure; SJRWP = San Jacinto River Waste Pitts; SJR = San Jacinto River; HSC = Houston Ship Channel; UGB = Upper Galveston Bay; pg/g = picograms per gram; TCDD TEQ = tetrachlorodibenzo-p-dioxin toxic equivalent concentration.

E+03	Very High Increased Risk
E+02	High Increased Risk
E+01	Moderately Increased Risk

E+00	Low Increased Risk
E-01	No Apparent Increased Risk
E-02	No Increased Risk

* See Tables 2 & 3, Appendix D for parameters used in exposure scenarios.

Table 18. Hazard Quotients, Dioxin in Sediments, Acute Exposure, Dermal, On/Off-Site

On & Off-Site, Soil/Sediment Pathway, Acute Duration Exposure, Dermal Absorption Route			Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Sediment Sample Collection Location	Sample	TCDD TEQ (pg/g)	Hazard Quotient	Margin of Safety	Hazard Quotient	Margin of Safety	Hazard Quotient	Margin of Safety
SJRWP, On-Site Samples	Average	15,594	1.94E-02	51.50	2.02E-03	495.2	3.88E-04	2,575
	Max	34,028	4.24E-02	23.60	4.41E-03	227.0	8.47E-04	1,180
Down-Stream from SJRWP, SJR, HSC, & UGB	Average	13.75	1.71E-05	58,394	1.78E-06	561,484	3.42E-07	2,919,716
	Max	86.16	1.07E-04	9,321	1.12E-05	89,628	2.15E-06	466,063
SJRWP Site-Vicinity, SJR Near SJRWP	Average	82.24	1.02E-04	9,766	1.06E-05	93,904	2.05E-06	488,302
	Max	572.5	7.13E-04	1,403	7.41E-05	13,490	1.43E-05	70,146
Houston Ship Channel, Above/West of SJR	Average	65.69	8.18E-05	12,226	8.51E-06	117,555	1.64E-06	611,285
	Max	856.8	1.07E-03	937.4	1.11E-04	9,014	2.13E-05	46,871
Up-Stream & Tributaries to SJR-HSC-UGB	Average	15.97	1.99E-05	50,302	2.07E-06	483,674	3.98E-07	2,515,103
	Max	102.9	1.28E-04	7,806	1.33E-05	75,054	2.56E-06	390,280
All Off-Site Samples	Average	40.04	4.99E-05	20,059	5.18E-06	192,879	9.97E-07	1,002,971
	Max	856.8	1.07E-03	937.4	1.11E-04	9,014	2.13E-05	46,871

Abbreviations: Avg = average; Max = maximum; Exp = exposure; SJRWP = San Jacinto River Waste Pitts; SJR = San Jacinto River; HSC = Houston Ship Channel; UGB = Upper Galveston Bay; pg/g = picograms per gram; TCDD TEQ = tetrachlorodibenzo-p-dioxin toxic equivalent concentration.

E+03	Very High Increased Risk
E+02	High Increased Risk
E+01	Moderately Increased Risk

E+00	Low Increased Risk
E-01	No Apparent Increased Risk
E-02	No Increased Risk

* See Tables 2 & 3, Appendix D for parameters used in exposure scenarios.

Table 19. Hazard Indices, Dioxin in Sediments, Acute Exp, Oral + Dermal, On/Off-Site

On & Off-Site, Soil/Sediment Pathway, Acute Duration Exposure, Dermal Absorption Route			Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Sediment Sample Collection Location	Sample	TCDD TEQ (pg/g)	Hazard Index (O+D)	Margin of Safety	Hazard Index (O+D)	Margin of Safety	Hazard Index O+D)	Margin of Safety
SJRWP, On-Site Samples	Average	15,594	3.57E-02	28.01	3.71E-03	269.4	7.14E-04	1,401
	Max	34,028	7.79E-02	12.84	8.10E-03	123.4	1.56E-03	641.9
Down-Stream from SJRWP, SJR, HSC, & UGB	Average	13.75	3.15E-05	31,760	3.27E-06	305,380	6.30E-07	1,587,976
	Max	86.16	1.97E-04	5,070	2.05E-05	48,747	3.95E-06	253,483
SJRWP Site-Vicinity, SJR Near SJRWP	Average	82.24	1.88E-04	5,312	1.96E-05	51,073	3.77E-06	265,578
	Max	572.5	1.31E-03	763.0	1.36E-04	7,337	2.62E-05	38,151
Houston Ship Channel, Above/West of SJR	Average	65.69	1.50E-04	6,649	1.56E-05	63,936	3.01E-06	332,466
	Max	856.8	1.96E-03	509.8	2.04E-04	4,902	3.92E-05	25,492
Up-Stream & Tributaries to SJR-HSC-UGB	Average	15.97	3.66E-05	27,358	3.80E-06	263,061	7.31E-07	1,367,915
	Max	102.9	2.36E-04	4,245	2.45E-05	40,820	4.71E-06	212,266
All Off-Site Samples	Average	40.04	9.17E-05	10,910	9.53E-06	104,903	1.83E-06	545,496
	Max	856.8	1.96E-03	509.8	2.04E-04	4,902	3.92E-05	25,492

Abbreviations: Avg = average; Max = maximum; Exp = exposure; SJRWP = San Jacinto River Waste Pitts; SJR = San Jacinto River; HSC = Houston Ship Channel; UGB = Upper Galveston Bay; pg/g = picograms per gram; TCDD TEQ = tetrachlorodibenzo-p-dioxin toxic equivalent concentration.

E+03	Very High Increased Risk
E+02	High Increased Risk
E+01	Moderately Increased Risk

E+00	Low Increased Risk
E-01	No Apparent Increased Risk
E-02	No Increased Risk

* See Tables 2 & 3, Appendix D for parameters used in exposure scenarios.

Table 20. Hazard Quotients, Dioxin in Sediments, Intermediate, Oral, On/Off-Site

On & Off-Site, Soil/Sediment Pathway, Intermediate Duration Exposure, Oral Ingestion Route			Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Sediment Sample Collection Location	Sample	TCDD TEQ (pg/g)	Hazard Quotient	Margin of Safety	Hazard Quotient	Margin of Safety	Hazard Quotient	Margin of Safety
SJRWP, On-Site Samples	Average	15,594	1.16E-01	8.598	1.21E-02	82.67	2.33E-03	429.9
	Max	34,028	2.54E-01	3.940	2.64E-02	37.89	5.08E-03	197.0
Down-Stream from SJRWP, SJR, HSC, & UGB	Average	13.75	1.03E-04	9,748	1.07E-05	93,732	2.05E-06	487,409
	Max	86.16	6.43E-04	1,556	6.68E-05	14,962	1.29E-05	77,803
SJRWP Site-Vicinity, SJR Near SJRWP	Average	82.24	6.13E-04	1,630	6.38E-05	15,676	1.23E-05	81,516
	Max	572.5	4.27E-03	234.2	4.44E-04	2,252	8.54E-05	11,710
Houston Ship Channel, Above/West of SJR	Average	65.69	4.90E-04	2,041	5.10E-05	19,624	9.80E-06	102,046
	Max	856.8	6.39E-03	156.5	6.65E-04	1,505	1.28E-04	7,825
Up-Stream & Tributaries to SJR-HSC-UGB	Average	15.97	1.19E-04	8,397	1.24E-05	80,743	2.38E-06	419,864
	Max	102.9	7.67E-04	1,303	7.98E-05	12,529	1.53E-05	65,152
All Off-Site Samples	Average	40.04	2.99E-04	3,349	3.11E-05	32,199	5.97E-06	167,433
	Max	856.8	6.39E-03	156.5	6.65E-04	1,505	1.28E-04	7,825

Abbreviations: Avg = average; Max = maximum; Exp = exposure; SJRWP = San Jacinto River Waste Pitts; SJR = San Jacinto River; HSC = Houston Ship Channel; UGB = Upper Galveston Bay; pg/g = picograms per gram; TCDD TEQ = tetrachlorodibenzo-p-dioxin toxic equivalent concentration.

E+03	Very High Increased Risk
E+02	High Increased Risk
E+01	Moderately Increased Risk

E+00	Low Increased Risk
E-01	No Apparent Increased Risk
E-02	No Increased Risk

* See Tables 2 & 3, Appendix D for parameters used in exposure scenarios.

Table 21. Hazard Quotients, Dioxin in Sediments, Intermediate, Dermal, On/Off-Site

On & Off-Site, Soil/Sediment Pathway, Intermediate Duration Exposure, Dermal Absorption Route			Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Sediment Sample Collection Location	Sample	TCDD TEQ (pg/g)	Hazard Quotient	Margin of Safety	Hazard Quotient	Margin of Safety	Hazard Quotient	Margin of Safety
SJRWP, On-Site Samples	Average	15,594	1.39E-01	7.211	1.44E-02	69.33	2.77E-03	360.5
	Max	34,028	3.03E-01	3.304	3.15E-02	31.77	6.05E-03	165.2
Down-Stream from SJRWP, SJR, HSC, & UGB	Average	13.75	1.22E-04	8,175	1.27E-05	78,608	2.45E-06	408,760
	Max	86.16	7.66E-04	1,305	7.97E-05	12,548	1.53E-05	65,249
SJRWP Site-Vicinity, SJR Near SJRWP	Average	82.24	7.31E-04	1,367	7.61E-05	13,147	1.46E-05	68,362
	Max	572.5	5.09E-03	196.4	5.30E-04	1,889	1.02E-04	9,820
Houston Ship Channel, Above/West of SJR	Average	65.69	5.84E-04	1,712	6.08E-05	16,458	1.17E-05	85,580
	Max	856.8	7.62E-03	131.2	7.92E-04	1,262	1.52E-04	6,562
Up-Stream & Tributaries to SJR-HSC-UGB	Average	15.97	1.42E-04	7,042	1.48E-05	67,714	2.84E-06	352,114
	Max	102.9	9.15E-04	1,093	9.52E-05	10,508	1.83E-05	54,639
All Off-Site Samples	Average	40.04	3.56E-04	2,808	3.70E-05	27,003	7.12E-06	140,416
	Max	856.8	7.62E-03	131.2	7.92E-04	1,262	1.52E-04	6,562

Abbreviations: Avg = average; Max = maximum; Exp = exposure; SJRWP = San Jacinto River Waste Pitts; SJR = San Jacinto River; HSC = Houston Ship Channel; UGB = Upper Galveston Bay; pg/g = picograms per gram; TCDD TEQ = tetrachlorodibenzo-p-dioxin toxic equivalent concentration.

E+03	Very High Increased Risk
E+02	High Increased Risk
E+01	Moderately Increased Risk

E+00	Low Increased Risk
E-01	No Apparent Increased Risk
E-02	No Increased Risk

* See Tables 2 & 3, Appendix D for parameters used in exposure scenarios.

Table 22. Hazard Indices, Dioxin in Sediments, Intermediate, Oral + Dermal, On/Off-Site

On & Off-Site, Soil/Sediment Pathway, Intermediate Duration Exposure, Dermal Absorption Route			Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Sediment Sample Collection Location	Sample	TCDD TEQ (pg/g)	Hazard Index (O+D)	Margin of Safety	Hazard Index (O+D)	Margin of Safety	Hazard Index (O+D)	Margin of Safety
SJRWP, On-Site Samples	Average	15,594	2.55E-01	3.922	2.65E-02	37.71	5.10E-03	196.1
	Max	34,028	5.56E-01	1.797	5.79E-02	17.28	1.11E-02	89.86
Down-Stream from SJRWP, SJR, HSC, & UGB	Average	13.75	2.25E-04	4,446	2.34E-05	42,753	4.50E-06	222,317
	Max	86.16	1.41E-03	709.8	1.47E-04	6,825	2.82E-05	35,488
SJRWP Site-Vicinity, SJR Near SJRWP	Average	82.24	1.34E-03	743.6	1.40E-04	7,150	2.69E-05	37,181
	Max	572.5	9.36E-03	106.8	9.74E-04	1,027	1.87E-04	5,341
Houston Ship Channel, Above/West of SJR	Average	65.69	1.07E-03	930.9	1.12E-04	8,951	2.15E-05	46,545
	Max	856.8	1.40E-02	71.38	1.46E-03	686.3	2.80E-04	3,569
Up-Stream & Tributaries to SJR-HSC-UGB	Average	15.97	2.61E-04	3,830	2.72E-05	36,828	5.22E-06	191,508
	Max	102.9	1.68E-03	594.3	1.75E-04	5,715	3.37E-05	29,717
All Off-Site Samples	Average	40.04	6.55E-04	1,527	6.81E-05	14,686	1.31E-05	76,369
	Max	856.8	1.40E-02	71.38	1.46E-03	686.3	2.80E-04	3,569

Abbreviations: Avg = average; Max = maximum; Exp = exposure; SJRWP = San Jacinto River Waste Pitts; SJR = San Jacinto River; HSC = Houston Ship Channel; UGB = Upper Galveston Bay; pg/g = picograms per gram; TCDD TEQ = tetrachlorodibenzo-p-dioxin toxic equivalent concentration.

E+03	Very High Increased Risk
E+02	High Increased Risk
E+01	Moderately Increased Risk

E+00	Low Increased Risk
E-01	No Apparent Increased Risk
E-02	No Increased Risk

* See Tables 2 & 3, Appendix D for parameters used in exposure scenarios.

Table 23. Hazard Quotients, Dioxin in Sediments, Chronic Exposure, Oral, On/Off-Site

On & Off-Site, Soil/Sediment Pathway, Chronic Duration Exposure, Oral Ingestion Route			Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Sediment Sample Collection Location	Sample	TCDD TEQ (pg/g)	Hazard Quotient	Margin of Safety	Hazard Quotient	Margin of Safety	Hazard Quotient	Margin of Safety
SJRWP, On-Site Samples	Average	15,594	2.26E+00	0.4422	2.35E-01	4.252	4.52E-02	22.11
	Max	34,028	4.93E+00	0.2026	5.13E-01	1.948	9.87E-02	10.13
Down-Stream from SJRWP, SJR, HSC, & UGB	Average	13.75	1.99E-03	501.3	2.07E-04	4,821	3.99E-05	25,067
	Max	86.16	1.25E-02	80.03	1.30E-03	769.5	2.50E-04	4,001
SJRWP Site-Vicinity, SJR Near SJRWP	Average	82.24	1.19E-02	83.84	1.24E-03	806.2	2.39E-04	4,192
	Max	572.5	8.30E-02	12.04	8.63E-03	115.8	1.66E-03	602.2
Houston Ship Channel, Above/West of SJR	Average	65.69	9.53E-03	105.0	9.91E-04	1,009	1.91E-04	5,248
	Max	856.8	1.24E-01	8.048	1.29E-02	77.39	2.49E-03	402.4
Up-Stream & Tributaries to SJR-HSC-UGB	Average	15.97	2.32E-03	431.9	2.41E-04	4,152	4.63E-05	21,593
	Max	102.9	1.49E-02	67.01	1.55E-03	644.4	2.98E-04	3,351
All Off-Site Samples	Average	40.04	5.81E-03	172.2	6.04E-04	1,656	1.16E-04	8,611
	Max	856.8	1.24E-01	8.048	1.29E-02	77.39	2.49E-03	402.4

Abbreviations: Avg = average; Max = maximum; Exp = exposure; SJRWP = San Jacinto River Waste Pitts; SJR = San Jacinto River; HSC = Houston Ship Channel; UGB = Upper Galveston Bay; pg/g = picograms per gram; TCDD TEQ = tetrachlorodibenzo-p-dioxin toxic equivalent concentration.

E+03	Very High Increased Risk
E+02	High Increased Risk
E+01	Moderately Increased Risk

E+00	Low Increased Risk
E-01	No Apparent Increased Risk
E-02	No Increased Risk

* See Tables 2 & 3, Appendix D for parameters used in exposure scenarios.

Table 24. Hazard Quotients, Dioxin in Sediments, Chronic, Dermal, On/Off-Site

On & Off-Site, Soil/Sediment Pathway, Chronic Duration Exposure, Dermal Absorption Route			Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Sediment Sample Collection Location	Sample	TCDD TEQ (pg/g)	Hazard Quotient	Margin of Safety	Hazard Quotient	Margin of Safety	Hazard Quotient	Margin of Safety
SJRWP, On-Site Samples	Average	15,594	2.70E+00	0.3708	2.80E-01	3.566	5.39E-02	18.54
	Max	34,028	5.88E+00	0.1699	6.12E-01	1.634	1.18E-01	8.497
Down-Stream from SJRWP, SJR, HSC, & UGB	Average	13.75	2.38E-03	420.4	2.47E-04	4,043	4.76E-05	21,022
	Max	86.16	1.49E-02	67.11	1.55E-03	645.3	2.98E-04	3,356
SJRWP Site-Vicinity, SJR Near SJRWP	Average	82.24	1.42E-02	70.32	1.48E-03	676.1	2.84E-04	3,516
	Max	572.5	9.90E-02	10.10	1.03E-02	97.13	1.98E-03	505.1
Houston Ship Channel, Above/West of SJR	Average	65.69	1.14E-02	88.02	1.18E-03	846.4	2.27E-04	4,401
	Max	856.8	1.48E-01	6.749	1.54E-02	64.90	2.96E-03	337.5
Up-Stream & Tributaries to SJR-HSC-UGB	Average	15.97	2.76E-03	362.2	2.87E-04	3,482	5.52E-05	18,109
	Max	102.9	1.78E-02	56.20	1.85E-03	540.4	3.56E-04	2,810
All Off-Site Samples	Average	40.04	6.92E-03	144.4	7.20E-04	1,389	1.38E-04	7,221
	Max	856.8	1.48E-01	6.749	1.54E-02	64.90	2.96E-03	337.5

Abbreviations: Avg = average; Max = maximum; Exp = exposure; SJRWP = San Jacinto River Waste Pitts; SJR = San Jacinto River; HSC = Houston Ship Channel; UGB = Upper Galveston Bay; pg/g = picograms per gram; TCDD TEQ = tetrachlorodibenzo-p-dioxin toxic equivalent concentration.

E+03	Very High Increased Risk
E+02	High Increased Risk
E+01	Moderately Increased Risk

E+00	Low Increased Risk
E-01	No Apparent Increased Risk
E-02	No Increased Risk

* See Tables 2 & 3, Appendix D for parameters used in exposure scenarios.

Table 25. Hazard Indices, Dioxin in Sediments, Chronic, Oral + Dermal, On/Off-Site

On & Off-Site, Soil/Sediment Pathway, Chronic Duration Exposure, Oral + Dermal Routes			Routine Daily Exposure*		Frequent Periodic Exposure*		Sporadic Exposure*	
Sediment Sample Collection Location	Sample	TCDD TEQ (pg/g)	Hazard Index (O+D)	Margin of Safety	Hazard Index (O+D)	Margin of Safety	Hazard Index (O+D)	Margin of Safety
SJRWP, On-Site Samples	Average	15,594	4.96E+00	0.2017	5.16E-01	1.939	9.92E-02	10.08
	Max	34,028	1.08E+01	0.09243	1.13E+00	0.8887	2.16E-01	4.621
Down-Stream from SJRWP, SJR, HSC, & UGB	Average	13.75	4.37E-03	228.7	4.55E-04	2,199	8.75E-05	11,433
	Max	86.16	2.74E-02	36.50	2.85E-03	351.0	5.48E-04	1,825
SJRWP Site-Vicinity, SJR Near SJRWP	Average	82.24	2.61E-02	38.24	2.72E-03	367.7	5.23E-04	1,912
	Max	572.5	1.82E-01	5.494	1.89E-02	52.82	3.64E-03	274.7
Houston Ship Channel, Above/West of SJR	Average	65.69	2.09E-02	47.88	2.17E-03	460.3	4.18E-04	2,394
	Max	856.8	2.72E-01	3.671	2.83E-02	35.30	5.45E-03	183.5
Up-Stream & Tributaries to SJR-HSC-UGB	Average	15.97	5.08E-03	197.0	5.28E-04	1,894	1.02E-04	9,849
	Max	102.9	3.27E-02	30.57	3.40E-03	293.9	6.54E-04	1,528
All Off-Site Samples	Average	40.04	1.27E-02	78.55	1.32E-03	755.3	2.55E-04	3,928
	Max	856.8	2.72E-01	3.671	2.83E-02	35.30	5.45E-03	183.5

Abbreviations: Avg = average; Max = maximum; Exp = exposure; SJRWP = San Jacinto River Waste Pitts; SJR = San Jacinto River; HSC = Houston Ship Channel; UGB = Upper Galveston Bay; pg/g = picograms per gram; TCDD TEQ = tetrachlorodibenzo-p-dioxin toxic equivalent concentration; O + D = oral plus dermal.

E+03	Very High Increased Risk
E+02	High Increased Risk
E+01	Moderately Increased Risk

E+00	Low Increased Risk
E-01	No Apparent Increased Risk
E-02	No Increased Risk

* See Tables 2 & 3, Appendix D for parameters used in exposure scenarios.

Certification

This public health consultation for the Sediments of the San Jacinto River, Texas was prepared by the Texas Department of State Health Services (DSHS) under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methods and procedures existing when the time the public health assessment was initiated. Editorial review was completed by the Cooperative Agreement partner.

Technical Project Officer, CAT, CAPEB, DHAC, ATSDR

The Division of Health Assessment and Consultation, ATSDR, has reviewed this public health assessment and concurs with its findings.

Team Lead, CAT, CAPEB, DHAC, ATSDR