OPERATIONAL SCIENCE ADVISORY TEAM
SUMMARY REPORT FOR FATE AND EFFECTS OF REMNANT OIL REMAINING IN THE BEACH ENVIRONMENT

Annex F: Human Health Considerations

Purpose

The purpose of this assessment is to determine the possible human health risks associated with residual petroleum hydrocarbons that may occur on Gulf beaches. This screening risk assessment is performed using generally accepted methods used by the U.S. Environmental Protection Agency (USEPA) and State agencies to determine the need for environmental cleanup of chemicals in soil and sediment.

Background

Over time, residual petroleum hydrocarbons such as tar balls, oil mats, and other bits of oil residue may appear on beaches following release of oil in the coastal environment. Oil released in the environment loses its more volatile, water-soluble, and degradable components, eventually leaving the heavier, less degradable elements of oil. The process by which oil is changed in the environment over time includes both weathering and degradation. Tar balls, oil mats, and small surface residual balls (SSRBs; these balls are bits of oil residue ~¼ inch in diameter) encountered on beaches are composed of the residual, heavier components of oil along with sand, sediment, or other non-petroleum elements. According to the National Oceanic and Atmospheric Administration (NOAA) tar balls are small pieces of weathered, emulsified crude oil that tear from larger patches of weathered oil. Over time, weathering causes the tar ball to become “hard and crusty on the outside and soft and gooey on the inside”. Factors that influence the “stickiness” of tar balls include temperature and the amount of sediment and particulate on the shoreline. Over time, sediment and sand adhere to the surface of the tar ball. According to NOAA, “the more sand and debris attached to a tar ball, the more difficult it is to break the tar ball open (NOAA, 2006).”

Humans visiting beaches may come in contact with residual petroleum in the form of tar balls, SSRBs, and oil mats, particularly while walking or playing on the beach. As humans contact these petroleum residues, portions may stick to the exposed skin. The amount of residual petroleum adhering to the skin following contact with a tar ball is likely a function of the degree of weathering, temperature, and the amount of sand in and on the surface of the tar ball. In warm temperatures, petroleum residues may be more sticky and therefore more likely to adhere to the skin.

Although there are no known studies examining the extent of beachgoer exposure to petroleum residues on beaches, persons walking on beaches may contact bits of tar that stick to the soles of their feet. Once these residues adhere to the skin, petroleum hydrocarbons in the residue may be absorbed through the skin into the body. The amount of petroleum absorbed into the bloodstream

depends on the amount of residue, how long that residue remains on the skin, and the bioavailability of the constituents of the residue.

While humans are not likely to knowingly ingest petroleum residues (if for no other reason than the unpleasant taste), risk assessments routinely conducted by the USEPA consider ingestion of chemicals in soil and sediment as a possible route of exposure. In theory, beachgoers may also inhale petroleum hydrocarbons released as vapors from petroleum residues or as airborne particles that have petroleum hydrocarbons attached to them.

Currently, there are no USEPA or State methods available to quantify human exposure and risks due to contact with tar balls or other residual weathered forms of petroleum hydrocarbons. In response to the Deepwater Horizon oil spill, the Florida Department of Health (FDOH) developed guidance entitled "Framework for Data Organization, Review, Analysis, and Interpretation for Oil Impacted Gulf Beaches." The FDOH Framework guidance documents procedures used to evaluate the potential human health risk associated with contact with petroleum hydrocarbons in water and sediment (FDOH, 2010). The screening level risk assessment presented herein uses many of the same exposure and toxicity assumptions used in the FDOH Framework guidance to assess the risks posed by petroleum residues on beaches. Modifications to the FDOH Framework guidance are discussed below.

Petroleum Residue Data Analysis

This screening risk assessment relies on 22 samples of tar balls/SSRBs collected from October 2010 through January 2011 from Grand Isle, Louisiana, and from shoreline locations in Mississippi, Alabama, and Florida, as illustrated in Figure 1. These residual petroleum samples have been analyzed for polycyclic aromatic hydrocarbons (PAHs). These data are presented in Table 1. Concentrations of chemicals in these residues are expressed in terms of milligrams of chemical per kilogram of oil extracted from the petroleum residue. Mono-aromatic hydrocarbons such as benzene, cumene, ethylbenzene, toluene, and xylenes are sufficiently volatile that they are not present in petroleum residues after months of weathering.

Analysis of three petroleum residue samples (SSRB, supratidal, and subtidal weathered oil residues) indicates that these materials contained approximately 13 percent, 8 percent, and 17 percent petroleum by weight, respectively (Table 2.1 in OSAT-2 Report). The remainder of the residue is sand, sediment, or other non-petroleum material. These data suggest that a reasonably conservative assumption for the amount of oil in these residues is about 20 percent by weight.

Screening Level Human Health Risk Assessment

The screening level risk assessment uses exposure assumptions and toxicity values outlined in the FDOH Framework guidance to assess human health risks from petroleum hydrocarbons. The FDOH Framework guidance considers two different exposure scenarios to petroleum hydrocarbons in sediment. These scenarios are the "Visitor" scenario and the "Unrestricted" scenario. The Visitor exposure scenario evaluates potential ingestion, skin contact, and inhalation exposures for a young child visiting a beach 90 days over a 120-day period for one year. The Unrestricted scenario considers potential ingestion, skin contact, and inhalation exposure to

petroleum hydrocarbons in sediment (beach sand) that would result from residential exposure conditions (i.e., daily ingestion, skin contact, and inhalation of chemicals in sediment from birth to age 30 by the ingestion, skin contact, and inhalation routes of exposure).

Exposure assumptions used in this screening risk assessment are taken from the FDOH Framework guidance and are presented in Table 2. Chemical-specific exposure assumptions are presented in Table 3. Toxicity values used to assess the potential carcinogenic and non-carcinogenic risks from exposure to chemicals in sediment are presented in Table 4.

To apply the FDOH Framework risk assessment guidance to the analysis of residual forms of petroleum such as tar balls, SSRBs, and oil mats, it is necessary to first adjust the concentrations presented in Table 1 to reflect the chemical concentration in the entire residue. Because the analysis does not take into account the remaining non-petroleum elements of the residue (such as sand), it is necessary to adjust the concentration to reflect the concentration of the chemical in the entire residue (i.e., the sum of the non-petroleum and petroleum fractions). For example, if the concentration of Chemical X in the petroleum fraction of a tar ball is 5 mg/kg and if the fraction by weight of the tar ball that is petroleum hydrocarbon is 0.2 (20percent), then the concentration of Chemical X in the entire residue is 5 mg/kg x 0.2 = 1 mg/kg. As discussed above, the upper limit of petroleum content of the tar balls, SSRBs, and oil mats is assumed to be 20percent (i.e., a fraction of 0.2).

Weathered oil residues such as tar balls and SSRBs are discrete, readily observable dark objects that are scattered on the beach by wave action and the tides. Guidance for beach cleaning indicates that if a beach surface is more than 1percent covered by petroleum residuals, then the beach is targeted for cleaning. In practice, even lesser amounts of petroleum residue impact may result in beach cleanup. As a result, it is health protective to assume that for short periods, up to 10percent of beach coverage by SSRBs and tar balls may exist. In practice, it seems unlikely that beaches whose surface is impacted with tar balls or SSRBs to an extent greater than 10percent on a surface area basis (i.e., the beach surface is 90percent sand and 10percent weathered petroleum residue) would go unnoticed and not be cleaned for a period of 120 days. Similarly, over years or decades, it is unlikely that beach surfaces would be covered by petroleum residues to an extent greater than 1percent. For these reasons, it is health protective to assume that for a short-term beach visitor, a beach could be covered up to 10percent by petroleum residues such as SSRBs and tar balls and that over years or decades, the extent of beach surface coverage would not exceed 1 percent. Figure 2 provides a visual representation of the appearance of 1percent and 10percent beach coverage.

The extent of beach coverage by tar balls and other petroleum residues can be addressed by including a factor in the risk assessment that accounts for the fraction of overall sediment exposure that is attributable to direct contact with petroleum residues. Such a term accounts for the fraction of the beach covered by petroleum residues (F_{beach}) and is similar to the FI term used by the USEPA to account for the fractional amount of soil ingestion that is attributable to a contaminated source (USEPA, 1989).

In summary, the FDOH Framework guidance can be used to address exposure to petroleum residues on beaches by making the following adjustments.

Exposure to chemicals in petroleum residues on beaches =

(mg chemical/kg of oil) x F_{oil} x F_{beach} x (Ingest + Skin + Inhale)

where:

F_{oil} = is the fraction of the petroleum residual (tar ball, SSRB, oil mat) that is oil (assume 0.2)
F_{beach} = is the fraction of the beach surface that is covered by petroleum residuals; assume F_{beach} = 0.10 for the Visitor and 0.01 for the Unrestricted exposure scenario
Ingest = default sediment ingestion assumptions used by FDOH Framework guidance
Skin = default sediment skin contact assumptions used by FDOH Framework guidance
Inhale = default sediment inhalation exposure assumptions used by FDOH Framework guidance

In addition to the toxicological assumptions made in the FDOH Framework guidance, which suggests alkylated PAH compounds be assigned their parent compound toxicity unless specific information is otherwise available, the following assumptions were made for the purpose of this screening risk assessment: (Note that no attempt was made to quantify risk for non-PAH compounds for which no toxicity information is available [e.g. dibenzothiophenes].)

- C1-naphthalene is assumed to be 1-methylnaphthalene for the purpose of assessing cancer risk;
- C1-naphthalene is assumed to be 2-methylnaphthalene for the purpose of assessing non-cancer risk;
- C2-, C3-, and C4-naphthalenes are assumed to have the same non-carcinogenic toxicity and potency as 2-methylnaphthalene;
- C1-, C2-, C3-, and C4-fluorenes are assumed to have the same non-carcinogenic toxicity and potency as fluorene;
- C1-, C2-, C3-, and C4-phenanthrene/anthracenes have the same non-carcinogenic toxicity and potency as anthracene;
- C1-, C2-, C3-, and C4-fluoranthene/pyrenes have the same non-carcinogenic toxicity and potency as pyrene; and,
- C1-, C2-, C3-, and C4-chrysenes have the same carcinogenic potency as chrysene.

Using the above assumptions and the exposure and toxicity assumptions presented in the FDOH Framework guidance, lifetime cancer risks and non-cancer risks (termed “Hazard Index”) were calculated for each of the 22 sample results. These calculations provide a range of cancer and non-cancer risk estimates. Attachment 1 provides risk equations and sample risk calculations for the sample TRB-20101113-SOWS1-001 for benzo(a)pyrene and C1-naphthalenes. The screening level risk assessment results are presented in Table 5.

Lifetime cancer risks calculated for the beach Visitor scenario and the Unrestricted exposure scenario exposed to the potentially carcinogenic chemicals in petroleum residues ranged from 2.2E-09 to 1.2E-07 and from 1.1E-08 to 5.9E-07, respectively. In both exposure scenarios and

for all 22 sample results, the sum of the lifetime cancer risk from the potentially carcinogenic chemicals in petroleum residues is less than 1E-06 lifetime cancer risk targeted by the USEPA and below the 1E-04 to 1E-06 range used to define acceptable lifetime cancer risk (USEPA, 1991).

Non-cancer risks (the Hazard Index) for the Visitor and Unrestricted exposure scenarios ranged from 7.1E-05 to 1.7E-02 and from 7.6E-05 to 3.0E-03, respectively. In both exposure scenarios and for all 22 sample results, the sum of the non-cancer risk is less than 1 (i.e., 1E+00), the limit often used by the USEPA to evaluate non-cancer risk.

In summary, the results of the screening risk assessment indicate that beach Visitor and Unrestricted exposures to petroleum residues on beaches would not result in significant cancer or non-cancer risks.

Screening Risk Assessment Uncertainties

All human health risk assessments are associated with some degree of uncertainty. These uncertainties relate to the methods and assumptions used to assess exposure as well as the toxicological data used to assess the risks from these exposures.

Some compounds were not detected in petroleum residue samples. For the purpose of this screening risk assessment, it was assumed that these undetected PAHs were not present in the sample (i.e., the concentration of the undetected compounds in the sample are zero). If undetected chemicals are assumed to be present at one-half of their method detection limits, calculated lifetime cancer risks are less than 1E-6 for the Unrestricted and Visitor exposure scenarios. Similarly, the hazard indices are less than one for both scenarios, indicating that even if undetected PAHs are assumed to be present at one-half their method detection limit, risks are below acceptable levels.

Important exposure uncertainties in this screening risk assessment relate to the amount of petroleum residue that visitors/residents contact or ingest and the extent of absorption of chemicals in petroleum residues into the skin. The extent of skin exposure to petroleum residues is affected by many factors such as the amount of skin surface that contacts the residue, the amount of residue that adheres to the skin, the duration of time the residue remains on the skin, and the extent to which chemicals in the residue are absorbed through the skin. The amount of skin surface assumed to contact petroleum residues was assumed to be 42percent for children and 25percent for adults. Given that the hands and feet are approximately 12-13percent (USEPA, 2009) of the overall body surface area, the assumption that 25 to 42percent of the body surface will come in contact with petroleum residues likely overestimates the amount of skin contact that beachgoers will experience.

The amount of petroleum residue adhering to the skin is likely affected by the stickiness of the residue. Holmes et al. (1996) determined that the presence of up to 10percent oil in soil may result in a “modest” increase in the adherence of wet soil to the hands but found no significant effect of oil on the skin adherence of dry soils. Based on the results of Holmes et al., it is possible that using default USEPA soil adherence rates may underestimate contact with oil

residues on the beach. However, as discussed above, the effect of petroleum residue adherence to the skin is likely balanced by the large amount of skin surface assumed to be exposed to sediment and petroleum residues.

USEPA skin absorption fractions inherently assume that chemical residues in soil and sediment are absorbed over a period of 24 hours (USEPA, 2004). As such, removing sediment and petroleum residues from the skin would decrease the exposure time and the amount of skin absorption. Due to the potentially sticky, unpleasant nature of petroleum residues, it is unlikely that exposed individuals would allow such residues to remain on the skin more than a few hours. Thus, the use of absorption factors, which assume 24-hour exposures, will tend to overestimate the extent of skin absorption of chemicals in petroleum residues.

The default skin absorption fraction used for the chemicals considered in this screening level risk assessment is 0.13 (13percent) based on the absorption of benzo(a)pyrene from soil applied to the skin of monkeys (Wester et al. 1990). From the study of Yang et al. (1989), this fraction is approximately two times the observed absorption of benzo(a)pyrene applied in crude oil to the skin of rats (5.5percent) over a 24-hour period. Because the Wester et al. and Yang et al. studies are conducted with two different species under different experimental conditions, it is difficult to directly compare the results. However, there is some basis for considering a potentially lower exposure fraction from the results of the Yang et al. study. PAHs present in a viscous, insoluble weathered mixture would likely be less available for absorption than in oil.

Ingestion of petroleum residuals in beach sediment was also considered a complete exposure pathway in the screening risk assessment. Although uncertain, it seems unlikely that individuals would ingest materials containing up to 20percent petroleum residue on a regular basis. For this reason, it seems likely that the default exposure assumptions used in this screening risk assessment will overestimate ingestion exposure of petroleum residuals.

On balance, most default exposure assumptions made to assess human exposure to petroleum residues in this screening risk assessment will tend to overestimate human exposure.

The toxicological uncertainties of the screening risk assessment primarily concern the use of animal data to assess human health risks and the lack of toxicity data for some of the petroleum constituents. Toxicity values used in the FDOH Framework guidance come from a variety of different sources having varying levels of review. Toxicity data are not available for several of the PAHs analyzed in petroleum residues. Typically, the uncertainties associated with a lack of toxicological data are discussed in qualitative terms. However, in an effort to provide a thorough screening of the compounds detected, it was assumed that alkylated PAHs were equal in toxicity to the parent compound (i.e., each of the alkyl chrysenes were equal in carcinogenic potency to chrysene). There is little scientific precedent for making such an assumption and although endorsed in the FDOH Framework guidance, the assumption of equal toxicity between alkyl PAHs and their parent compound is uncertain.

It should also be noted that tar balls and other petroleum residues are known to have occurred on Gulf beaches prior to the Deepwater Horizon incident. Although the risks from residues present on Gulf beaches prior to this most recent incident have never been assessed in the manner

performed in this screening risk assessment, it should be acknowledged that a baseline level of risk from exposure to petroleum residues on beaches existed before the Deepwater Horizon oil spill.

This screening risk assessment does not evaluate risks to a swimmer exposed to the constituents of crude oil in surface water. The risks to a child swimmer were however evaluated in the Operational Science Advisory Team report entitled "Summary Report for Sub-Sea and Sub-Surface Oil and Dispersant Detection: Sampling and Monitoring" published December 17, 2010. As stated in that report, none of the 6010 water sample results reviewed exceeded USEPA-established human health benchmarks for the child swimmer scenario.

Although water accommodated fraction [WAF] data (see description in Section 9 in the main body of this report) are not representative of surface water to which a swimmer would be exposed, these data may be used for a "worst-case" evaluation of crude oil constituents that may be released into water surrounding petroleum residues. None of the crude oil constituents detected in WAF sample results for submerged oil mats (which are listed in Annex K) exceed swimmer surface water screening levels published by USEPA in the December 17, 2010 report referenced above or in the FDOH Framework guidance.

Currently, there are no swimmer screening levels published for potentially carcinogenic PAHs. This is due to the high degree of uncertainty associated with assessing dermal exposures. The FDOH Framework guidance and USEPA guidance (USEPA, 2004) consider the dermal absorbance values (Kp values) for carcinogenic PAHs so uncertain that reliable screening levels cannot be calculated for these compounds.

Summary

The concentrations of petroleum constituents in 22 petroleum residue samples (tar balls, SSRBs, oil mats) collected from the shorelines of Louisiana, Mississippi, Alabama, and Florida (see Figure 1) were assessed to screen lifetime cancer risks and non-cancer risks for beachgoers. Two exposure scenarios were examined; a beach Visitor scenario and an Unrestricted scenario representative of residential exposure conditions. Exposure and toxicity assumptions from the Florida Department of Health's "Framework for Data Organization, Review, Analysis, and Interpretation for Oil Impacted Gulf Beaches" were used to screen human health risks from contact with petroleum residues. The Florida Framework guidance was modified to account for the extent of the beach surface that was covered by petroleum residues. In addition, chemical concentrations detected in the petroleum fraction of the residues were adjusted to reflect the chemical concentration in the entire residue.

Lifetime cancer risks and non-cancer risks for each sample were below the lower end of the USEPA acceptable lifetime cancer risk range (1E-04 to 1E-06) and below the generally accepted non-cancer risk of 1. Although the screening risk assessment is somewhat uncertain, it is more likely that the risks are overestimated rather than underestimated.

References

FDOH (Florida Department of Health) 2010. Framework for Data Organization, Review, Analysis and Interpretation for Oil Impacted Gulf Beaches. September 30, 2010.

Holmes, KK, Kissel, JC, and Richter, KY. 1996. Investigation of the influence of oil on soil adherence to skin. J. Soil Contam. 5(4):301-308

NOAA (National Oceanic and Atmospheric Administration) 2006. Tar balls. National Ocean Office. Office of Response and Restoration. November 2006

USEPA 1991. Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions. OSWER Directive 9355.0-30. April 22, 1991.

USEPA 2004. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). Final. July 2004. EPA/540/R/99/005

USEPA 2009. Exposure Factors Handbook: 2009 Update. External Review Draft. July 2009. EPA/600/R-09/052A

Wester, RC, Maibach, HI, Bucks, DAW, Sedik, L, Melendres, J, Laio, C.L, and DeZio, S. 1990. Percutaneous absorption of [14C]DDT and [14C]benzo(a)pyrene from soil. Fund. Appl. Toxicol. 15:510-516.

Yang, JJ, Roy, TA, Kruger, AJ, Neil, W. and Mackerer, CR. 1989. In vitro and in vivo percutaneous absorption of benzo(a)pyrene from petroleum crude-fortified soil in the rat. Bull. Environ. Contam. Toxicol. 43:207-214.

Figure 1

Locations of Tar Balls/SSRBs Utilized in Risk Assessment

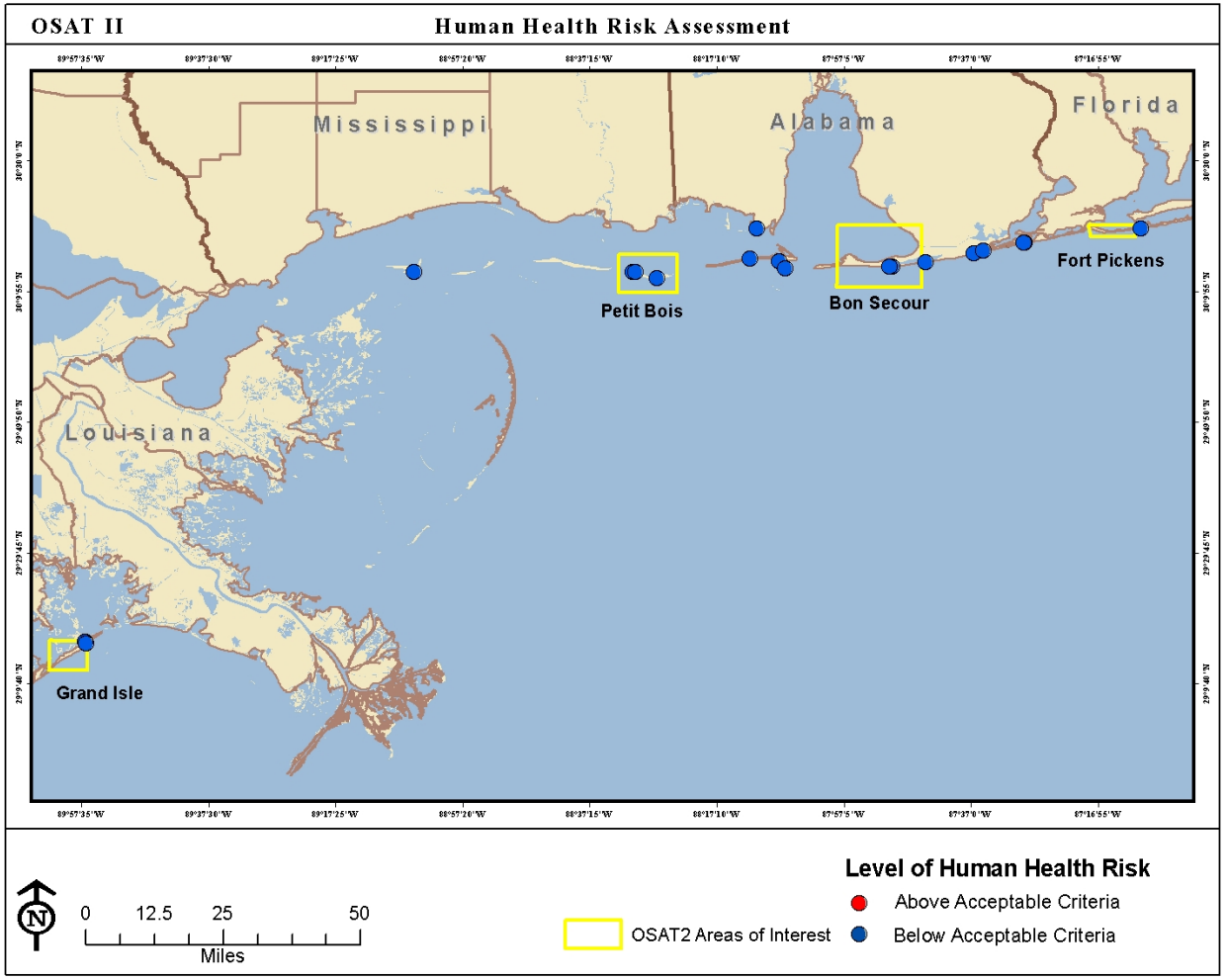
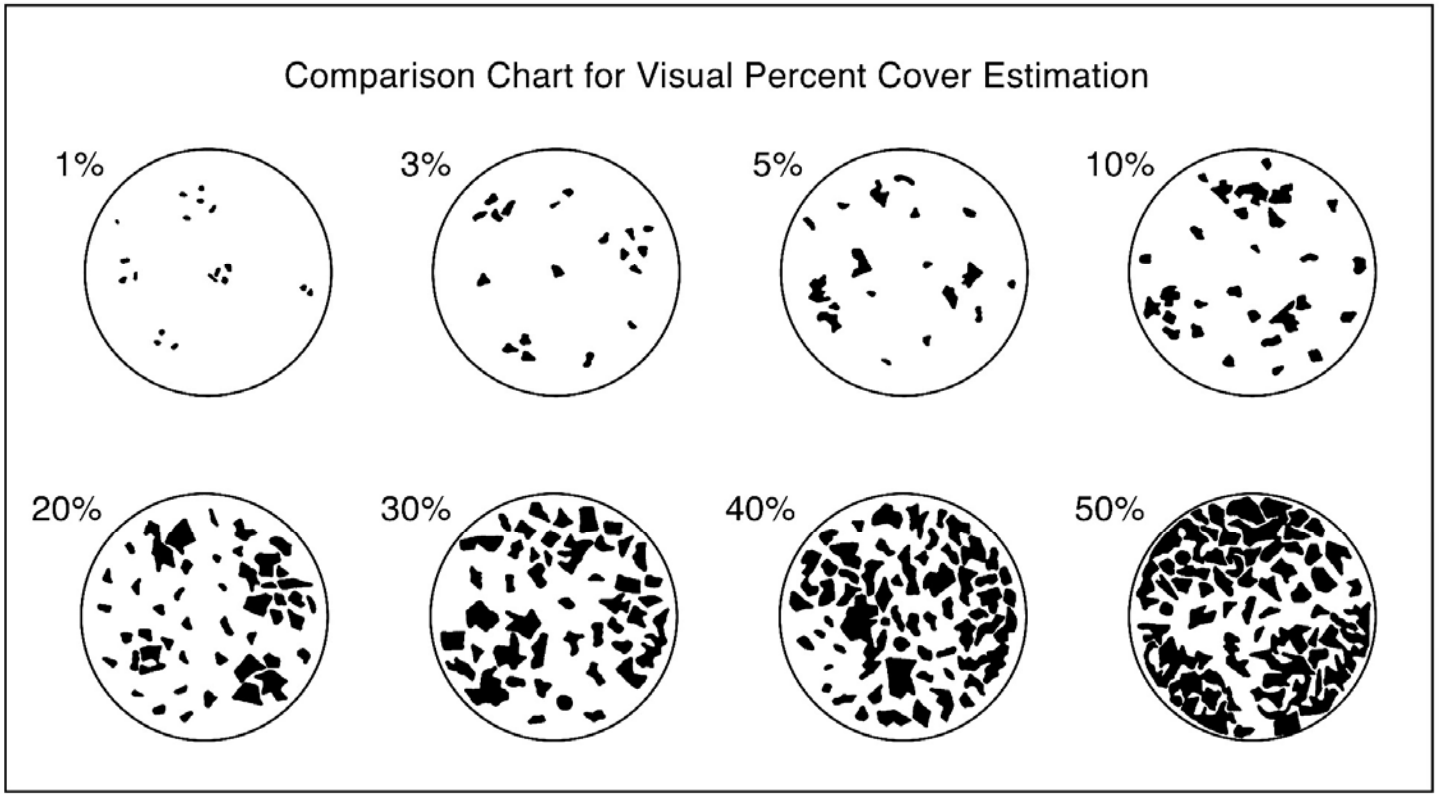


Figure 2
Visual Comparison of the Estimated Percent Coverage of Oil Residue on a Sandy Beach



Attachment 1

Risk Equations and Example Risk Calculations

Risk Equations-Unrestricted Exposure Scenario

Lifetime Cancer Risk - Mutagenic Carcinogens

Child

Ingestion and Dermal Risk Equation

$$\frac{Conc.in\ oil\ \left(\frac{mg}{kg}\right) x\ F_{oil}\ x\ F_{beach}\ x\ EF\ x\ ED\ x\ \left[(IRS_c + (SA_c\ x\ AF_c\ x \frac{1}{GIABS} x\ ABS)\right]\ x\ ADAF\ x\ SF_o\ x\ \frac{kg}{1{,}000{,}000\ mg}}{AT_c\ x\ LT\ x\ BW_c}$$

Inhalation Risk Equation

$$\frac{Conc.in\ oil\ \left(\frac{mg}{kg}\right) x\ F_{oil}\ x\ F_{beach}\ x\ EF\ x\ ED\ x\ ET\ x\ 0.0417\frac{days}{hr} x\ 1000\ \frac{ug}{mg} x\ \left(\frac{1}{VF} + \frac{1}{PEF}\right)\ x\ ADAF\ x\ IUR}{AT_c\ x\ LT}$$

Adult

Ingestion and Dermal Risk Equation

$$\frac{Conc.in\ oil\ \left(\frac{mg}{kg}\right) x\ F_{oil}\ x\ F_{beach}\ x\ EF\ x\ ED\ x\ \left[(IRS_a + (SA_a\ x\ AF_a\ x \frac{1}{GIABS} x\ ABS)\right]\ x\ ADAF\ x\ SF_o\ x\ \frac{kg}{1{,}000{,}000\ mg}}{AT_c\ x\ LT\ x\ BW_a}$$

Inhalation Risk Equation

$$\frac{Conc.in\ oil\ \left(\frac{mg}{kg}\right) x\ F_{oil}\ x\ F_{beach}\ x\ EF\ x\ ED\ x\ ET\ x\ 0.0417\frac{days}{hr} x\ 1000\ \frac{ug}{mg} x\ \left(\frac{1}{VF} + \frac{1}{PEF}\right)\ x\ ADAF\ x\ IUR}{AT_c\ x\ LT}$$

Total Risk = (Child Ingestion and Dermal Risk + Child Inhalation Risk) + (Adult Ingestion and Dermal Risk + Adult Inhalation Risk)

Risk Equations-Unrestricted Exposure Scenario

Lifetime Cancer Risk - Non-Mutagenic Carcinogens

Child

Ingestion and Dermal Risk Equation

$$\frac{Conc.in\ oil\ \left(\frac{mg}{kg}\right) x\ F_{oil}\ x\ F_{beach}\ x\ EF\ x\ ED\ x\left[(IRS_c + (SA_c\ x\ AF_c\ x \frac{1}{GIABS} x\ ABS)\right]\ x\ SF_o\ x\ \frac{kg}{1{,}000{,}000\ mg}}{AT_c\ x\ LT\ x\ BW_c}$$

Inhalation Risk Equation

$$\frac{Conc.in\ oil\ \left(\frac{mg}{kg}\right) x\ F_{oil}\ x\ F_{beach}\ x\ EF\ x\ ED\ x\ ET\ x\ 0.0417\frac{days}{hr} x\ 1000\ \frac{ug}{mg} x\ \left(\frac{1}{VF} + \frac{1}{PEF}\right)\ x\ IUR}{AT_c\ x\ LT}$$

Adult

Ingestion and Dermal Risk Equation

$$\frac{Conc.in\ oil\ \left(\frac{mg}{kg}\right) x\ F_{oil}\ x\ F_{beach}\ x\ EF\ x\ ED\ x\ \left[(IRS_a + (SA_a\ x\ AF_a\ x \frac{1}{GIABS} x\ ABS)\right]\ x\ SF_o\ x\ \frac{kg}{1{,}000{,}000\ mg}}{AT_c\ x\ LT\ x\ BW_a}$$

Inhalation Risk Equation

$$\frac{Conc.in\ oil\ \left(\frac{mg}{kg}\right) x\ F_{oil}\ x\ F_{beach}\ x\ EF\ x\ ED\ x\ ET\ x\ 0.0417\frac{days}{hr} x\ 1000\ \frac{ug}{mg} x\ \left(\frac{1}{VF} + \frac{1}{PEF}\right)\ x\ IUR}{AT_c\ x\ LT}$$

Total Risk = (Child Ingestion and Dermal Risk + Child Inhalation Risk) + (Adult Ingestion and Dermal Risk + Adult Inhalation Risk)

Risk Equations-Unrestricted Exposure Scenario

Non-Cancer Risk (Hazard Index)

Child

Ingestion and Dermal Risk Equation

$$\frac{Conc.in\ oil\ \left(\frac{mg}{kg}\right) x\ F_{oil}\ x\ F_{beach}\ x\ EF\ x\ ED_c\ x\left[(IRS_c + (SA_c\ x\ AF_c\ x \frac{1}{GIABS} x\ ABS)\right]\ x\ RfD_o\ x\ \frac{kg}{1{,}000{,}000\ mg}}{AT_{nc}\ x\ ED_c\ x\ BW_c}$$

Inhalation Risk Equation

$$\frac{Conc.in\ oil\ \left(\frac{mg}{kg}\right) x\ F_{oil}\ x\ F_{beach}\ x\ EF\ x\ ED_c\ x\ ET\ x\ 0.0417\ \frac{days}{hr} x\left(\frac{1}{VF} + \frac{1}{PEF}\right)\ x\ \frac{1}{RfC}}{AT_{nc}\ x\ LT}$$

Total Risk = (Child Ingestion and Dermal Risk) + Child Inhalation Risk

Example Calculation
Unrestricted Scenario – Mutagenic Carcinogen Lifetime Cancer Risk
(Benzo(a)pyrene in petroleum residue = 3.45 mg/kg)

Ingestion and Dermal Risk:

0-2 year old

$$\frac{3.45\ x\ 0.2\ x\ 0.01\ x\ 350\ x\ 2\ x\left[(200+(2800\ x\ 0.2\ x\frac{1}{1}x\ 0.13)\right]\ x\ 10\ x\ 7.3\ x\ \frac{kg}{1{,}000{,}000\ mg}}{365\ x\ 70\ x\ 15}=2.5E-7$$

2-6 year old

$$\frac{3.45\ x\ 0.2\ x\ 0.01\ x\ 350\ x\ 4\ x\left[(200+(2800\ x\ 0.2\ x\frac{1}{1}x\ 0.13)\right]\ x\ 3\ x\ 7.3\ x\ \frac{kg}{1{,}000{,}000\ mg}}{365\ x\ 70\ x\ 15}=1.5E-7$$

6-16 year old

$$\frac{3.45\ x\ 0.2\ x\ 0.01\ x\ 350\ x\ 10\ x\left[(100+(5700\ x\ 0.07\ x\frac{1}{1}x\ 0.13)\right]\ x\ 3\ x\ 7.3\ x\ \frac{kg}{1{,}000{,}000\ mg}}{365\ x\ 70\ x\ 70}=4.5E-8$$

16-30 year old

$$\frac{3.45\ x\ 0.2\ x\ 0.01\ x\ 350\ x\ 14\ x\left[(100+(5700\ x\ 0.07\ x\frac{1}{1}x\ 0.13)\right]\ x\ 1\ x\ 7.3\ x\ \frac{kg}{1{,}000{,}000\ mg}}{365\ x\ 70\ x\ 70}=2.1E-8$$

Sum of Ingestion and Dermal Risks = 2.5E-7 + 1.5E-7 + 4.5E-8 + 2.1 E-8 = 4.7E-7

Example Calculation
Unrestricted Scenario – Mutagenic Carcinogen Lifetime Cancer Risk
(Benzo(a)pyrene in petroleum residue = 3.45 mg/kg)

Inhalation Risk

0-2 year old

$$\frac{3.45\ x\ 0.2\ x\ 0.01\ x\ 350\ x\ 2\ x\ 24\ x\ 0.0417\frac{days}{hr}x\ 1000\ \frac{ug}{mg}x\ \left(\frac{1}{NA^{*}}+\frac{1}{1.4E+9}\right)\ x\ 10\ x\ 1.1E-3}{365\ x\ 70}=1.5E-12$$

2-6 year old

$$\frac{3.45\ x\ 0.2\ x\ 0.01\ x\ 350\ x\ 4\ x\ 24\ x\ 0.0417\frac{days}{hr}x\ 1000\ \frac{ug}{mg}x\ \left(\frac{1}{NA}+\frac{1}{1.4E+9}\right)\ x\ 3\ x\ 1.1E-3}{365\ x\ 70}=8.9E-13$$

6-16 year old

$$\frac{3.45\ x\ 0.2\ x\ 0.01\ x\ 350\ x\ 10\ x\ 24\ x\ 0.0417\frac{days}{hr}x\ 1000\ \frac{ug}{mg}x\ \left(\frac{1}{NA}+\frac{1}{1.4E+9}\right)\ x\ 3\ x\ 1.1E-3}{365\ x\ 70}=2.2E-12$$

16-30 year old

$$\frac{3.45\ x\ 0.2\ x\ 0.01\ x\ 350\ x\ 14\ x\ 24\ x\ 0.0417\frac{days}{hr}x\ 1000\ \frac{ug}{mg}x\ \left(\frac{1}{NA}+\frac{1}{1.4E+9}\right)\ x\ 1\ x\ 1.1E-3}{365\ x\ 70}=1.0E-12$$

Sum of Inhalation Risk = 1.5E-12 + 8.9E-13 + 2.2E-12 + 1.0E-12 = 5.6E-12

Sum of (Ingestion + Dermal) + Inhalation Risks = 4.7E-7 + 5.6E-12 = 4.7E-7

NA* – no value available; 1/NA assumed to be zero

Example Calculation
Unrestricted Scenario – Non-mutagenic Carcinogen Lifetime Cancer Risk
(C1-Napthalenes in petroleum residue = 1 mg/kg)**

Child

Ingestion and Dermal Risk Equation

$$\frac{1\ x\ 0.2\ x\ 0.01\ x\ 350\ x\ 6\ x\left[(200+(2800\ x\ 0.2\ x\frac{1}{1}x\ NA^{*})\right]\ x\ 0.029\ x\ \frac{kg}{1{,}000{,}000\ mg}}{365\ x\ 70\ x\ 15}=6.4E-11$$

Inhalation Risk Equation

$$\frac{1\ x\ 0.2\ x\ 0.01\ x\ 350\ x\ 6\ \ x\ 24\ x\ 0.0417\frac{days}{hr}x\ 1000\ \frac{ug}{mg}x\ \left(\frac{1}{6.3E+4}+\frac{1}{1.4E+9}\right)\ x\ NA^{*}}{365\ x\ 70}=0$$

Adult

Ingestion and Dermal Risk Equation

$$\frac{1\ x\ 0.2\ x\ 0.01\ x\ 350\ x\ 24\ x\left[(100+(5700\ x\ 0.07\ x\frac{1}{1}x\ NA)\right]\ x\ 0.029\ x\ \frac{kg}{1{,}000{,}000\ mg}}{365\ x\ 70\ x\ 70}=2.7E-11$$

Inhalation Risk Equation

$$\frac{1\ x\ 0.2\ x\ 0.01\ x\ 350\ x\ 24\ \ x\ 24\ x\ 0.0417\frac{days}{hr}x\ 1000\ \frac{ug}{mg}x\ \left(\frac{1}{6.3E+4}+\frac{1}{1.4E+9}\right)\ x\ NA^{*}}{365\ x\ 70}=0$$

Total Risk = 6.4E-11 + 0 + 2.7E-11 + 0 = 9.1E-11

NA* – no value available; NA assumed to be zero
**for the purpose of calculating lifetime cancer risk, C1-Napthalenes assumed to be 1-Methylnaphthalene

Example Calculation
Unrestricted Scenario – Non-Cancer Risk (Hazard Index)
(C1-Napthalenes in petroleum residue = 1 mg/kg)**

Non-Cancer Risk (Hazard Index)

Child

Ingestion and Dermal Risk Equation

$$\frac{1\ x\ 0.2\ x\ 0.01\ x\ 350\ x\ 6\ x\left[(200+(2800\ x\ 0.2\ x\frac{1}{1}x\ NA^{*})\right]\ x\ \frac{1}{4E-3}\ x\ \frac{kg}{1{,}000{,}000\ mg}}{365\ x\ 6\ x\ 15}=6.4E-6$$

Inhalation Risk Equation

$$\frac{1\ x\ 0.2\ x\ 0.01\ x\ 350\ x\ 6\ x\ 24\ x\ 0.0417\ \frac{days}{hr}x\left(\frac{1}{6.2E+4}+\frac{1}{1.4E+9}\right)\ x\ \frac{1}{NA^{*}}}{365\ x\ 6}=0$$

Total Risk = 6.4E-6 + 0 = 6.4E-6

NA* – no value available; NA and 1/NA assumed to be zero
**for the purpose of calculating non-cancer risk, C1-Napthalenes assumed to be 2-Methylnaphthalene

Summary Table for Risk Calculations – Sample Number TRB-20101113-SOWS1-001

Chemical Conc. in Petroleum Residue		Unrestricted Exposure Scenario	
	mg/kg oil	Lifetime Cancer Risk	Non-Cancer Risk
Naphthalene	0.72 U	ND	ND
C1-Naphthalenes	1 J	9.1E-11	6.4E-06
C2-Naphthalenes	5.84	NV	3.7E-05
C3-Naphthalenes	12.21	NV	7.8E-05
C4-Naphthalenes	14.43	NV	9.2E-05
Biphenyl	0.84 U	NV	ND
Acenaphthylene	0.78 U	NV	ND
Acenaphthene	1.3 U	NV	ND
Dibenzofuran	2.04 U	NV	ND
Fluorene	2.47 U	NV	ND
C1-Fluorenes	3.97	NV	3.5E-06
C2-Fluorenes	11.2	NV	9.8E-06
C3-Fluorenes	15.66	NV	1.4E-05
Anthracene	1.58 U	NV	ND
Phenanthrene	4.27	NV	5.0E-07
C1-Phenanthrenes/Anthracenes	21.05	NV	5.2E-05
C2-Phenanthrenes/Anthracenes	41.43	NV	4.8E-06
C3-Phenanthrenes/Anthracenes	49.56	NV	5.8E-06
C4-Phenanthrenes/Anthracenes	31.41	NV	3.7E-06
Dibenzothiophene	4.3	NV	NV
C1-Dibenzothiophenes	27.16	NV	NV
C2-Dibenzothiophenes	75.93	NV	NV
C3-Dibenzothiophenes	108.51	NV	NV
C4-Dibenzothiophenes	76.02	NV	NV
Fluoranthene	2.12	NV	1.8E-06
Pyrene	5.96	NV	6.9E-06
C1-Fluoranthenes/Pyrenes	16.85	NV	2.0E-05
C2-Fluoranthenes/Pyrenes	32.95	NV	3.8E-05
C3-Fluoranthenes/Pyrenes	50.73	NV	5.9E-05
Benzo(a)anthracene	1.55 J	2.1E-08	NV
Chrysene	7.96	1.1E-09	NV
C1-Chrysenes	23.63	3.2E-09	NV
C2-Chrysenes	47.12	6.4E-09	NV
C3-Chrysenes	62.13	8.4E-09	NV
C4-Chrysenes	62.22	8.4E-09	NV
Benzo(b)fluoranthene	3.1	4.2E-08	NV
Benzo(k)fluoranthene	0.66 U	ND	NV
Benzo(e)pyrene	6.48	NV	NV
Benzo(a)pyrene	3.45	4.7E-07	NV
Perylene	1.48 J	NV	NV
Indeno(1,2,3-cd)pyrene	2.17	2.9E-08	NV
Dibenz(a,h)anthracene	0.45 U	ND	NV
Benzo(g,h,i)perylene	5	NV	NV
	Sum of Risks	5.9E-07	4.3E-04

Shading indicates sample risk calculation provided

U- not detected (detection limit provided)

J- estimated value

ND- not detected; no risk calculated

NV- no toxicity value available; no risk calculated

Table 1
Summary of Analyses of Petroleum Residues

Sample number	TRB-20101025-SOWS1-001	TRB-20101024-SOWS2-001	TRB-20101023-SOWS2-001	TRB-20101022-SOWS2-001	TRB-20101023-SOWS1-001
Collection Date	10/25/10	10/24/10	10/23/10	10/22/10	10/23/10
Latitude	30.22856	30.26186	30.32636	30.28873	30.19933
Longitude	-87.82455	-87.60920	-87.16860	-87.47482	-88.44479
Units	MG/KG_OIL	MG/KG_OIL	MG/KG_OIL	MG/KG_OIL	MG/KG_OIL
Naphthalene	0.79 U	1.06 U	1.17 U	0.99 U	1.32 U
C1-Naphthalenes	0.77 U	1.02 U	1.13 U	0.96 U	1.27 U
C2-Naphthalenes	1.56 U	2.09 U	2.3 U	1.95 U	2.6 U
C3-Naphthalenes	1.66 U	2.22 U	2.44 U	2.07 U	4.03
C4-Naphthalenes	1.36 U	1.82 U	2.01 U	4.93	21.07
Biphenyl	0.92 U	1.23 U	1.36 U	1.15 U	1.53 U
Acenaphthylene	0.85 U	1.14 U	1.26 U	1.07 U	1.42 U
Acenaphthene	1.43 U	1.91 U	2.1 U	1.78 U	2.37 U
Dibenzofuran	2.24 U	2.99 U	3.29 U	2.79 U	3.71 U
Fluorene	2.71 U	3.62 U	3.99 U	3.38 U	4.5 U
C1-Fluorenes	1.39 U	1.86 U	2.05 U	1.74 U	4.16
C2-Fluorenes	1.3 U	9.49	1.92 U	17.42	42.79
C3-Fluorenes	16.83	40.44	37.69	60.64	110.05
Anthracene	1.73 U	2.31 U	2.55 U	2.16 U	2.87 U
Phenanthrene	1.22 U	1.63 U	1.79 U	1.52 U	2.02 U
C1-Phenanthrenes/Anthracenes	2.29	11.01	2.62 U	28.68	50.58
C2-Phenanthrenes/Anthracenes	7.6	98.3	33.62	127.16	284.06
C3-Phenanthrenes/Anthracenes	30.08	138.27	115.35	145.27	294.58
C4-Phenanthrenes/Anthracenes	33.61	70.53	73.78	77.64	123.7
Dibenzothiophene	2.82 U	3.76 U	4.15 U	3.52 U	4.68 U
C1-Dibenzothiophenes	1.69 J	4.31	2.1 J	9.63	17.87
C2-Dibenzothiophenes	6.14	39.18	16.91	61.43	111.73
C3-Dibenzothiophenes	20.23	74.37	67.51	91.11	146.23
C4-Dibenzothiophenes	33.38	52.68	59.35	58.77	84.95
Fluoranthene	0.43 U	0.58 U	0.64 U	0.54 U	1.19 J
Pyrene	2.9	3.72	4.77	4.09	7.92
C1-Fluoranthenes/Pyrenes	14.48	18.01	20.52	21.38	38.42
C2-Fluoranthenes/Pyrenes	27.27	30.02	39.41	33.57	57.24
C3-Fluoranthenes/Pyrenes	58.31	57.74	74.38	68.65	90.56
Benzo(a)anthracene	0.66 U	0.88 U	0.97 U	0.82 U	1.09 U
Chrysene	53.25	64.58	60.14	67.65	81.47
C1-Chrysenes	75.88	105.15	110.34	104.24	134.85
C2-Chrysenes	70.86	76.38	94.35	82.12	109.84
C3-Chrysenes	39.34	33.91	48.64	39.73	52.05
C4-Chrysenes	35.16	28.65	33.03	31.34	41.15
Benzo(b)fluoranthene	6.06	6.47	7.89	6.81	8.11
Benzo(k)fluoranthene	0.73 U	0.97 U	1.07 U	0.91 U	1.21 U
Benzo(e)pyrene	9.99	8.34	10.62	9.66	12.38
Benzo(a)pyrene	0.91 U	1.21 U	1.34 U	1.13 U	1.51 U
Perylene	0.99 U	1.32 U	1.45 U	1.23 U	1.64 U
Indeno(1,2,3-cd)pyrene	0.54 U	0.72 U	0.8 U	0.68 U	0.9 U
Dibenz(a,h)anthracene	0.49 U	0.66 U	0.73 U	0.61 U	0.9 J
Benzo(g,h,i)perylene	1.4 J	1.18 J	1.46 J	0.95 J	1.59 J

U- not detected (detection limit provided)
J- estimated value

Table 1
Summary of Analyses of Petroleum

Sample number	TRB-20101104-SOWS1-001	TRB-20101106-SOWS1-001	TRB-20101111-SOWS1-001	TRB-20101112-SOWS1-001	TRB-20101113-SOWS1-001
Collection Date	11/04/10	11/06/10	11/11/10	11/12/10	11/13/10
Latitude	30.24268	30.26801	30.22463	30.21395	30.24890
Longitude	-88.12253	-87.58571	-89.74951	-88.50755	-88.19881
Units	MG/KG_OIL	MG/KG_OIL	MG/KG_OIL	MG/KG_OIL	MG/KG_OIL
Naphthalene	0.79 U	1.01 U	1.16 U	1.14 U	0.72 U
C1-Naphthalenes	0.76 U	0.98 U	1.12 U	1.1 U	1 J
C2-Naphthalenes	1.56 U	1.99 U	2.28 U	2.25 U	5.84
C3-Naphthalenes	1.65 U	2.12 U	2.42 U	2.39 U	12.21
C4-Naphthalenes	4.08	1.74 U	1.99 U	1.96 U	14.43
Biphenyl	0.92 U	1.18 U	1.35 U	1.33 U	0.84 U
Acenaphthylene	0.85 U	1.09 U	1.25 U	1.23 U	0.78 U
Acenaphthene	1.42 U	1.82 U	2.09 U	2.06 U	1.3 U
Dibenzofuran	2.23 U	2.85 U	3.27 U	3.22 U	2.04 U
Fluorene	2.7 U	3.45 U	3.95 U	3.9 U	2.47 U
C1-Fluorenes	2.82	1.77 U	2.03 U	2 U	3.97
C2-Fluorenes	20.58	6.47	1.91 U	14.07	11.2
C3-Fluorenes	40.9	28.52	2.14 U	40.32	15.66
Anthracene	1.72 U	2.21 U	2.53 U	2.49 U	1.58 U
Phenanthrene	8.03	1.55 U	1.78 U	1.75 U	4.27
C1-Phenanthrenes/Anthracenes	122.38	2.37 J	3.71	42.99	21.05
C2-Phenanthrenes/Anthracenes	261.62	17.33	11.52	191.41	41.43
C3-Phenanthrenes/Anthracenes	163.81	57.67	18.8	160.52	49.56
C4-Phenanthrenes/Anthracenes	66.96	47.08	28.33	62.51	31.41
Dibenzothiophene	2.81 U	3.59 U	4.11 U	4.06 U	4.3
C1-Dibenzothiophenes	19.87	3.21	6.5	1.29 U	27.16
C2-Dibenzothiophenes	77.79	14.48	12.48	68.21	75.93
C3-Dibenzothiophenes	87.63	48.29	26.97	92.13	108.51
C4-Dibenzothiophenes	50.72	45.15	27.19	54.37	76.02
Fluoranthene	1.87	0.55 U	0.63 U	3.72	2.12
Pyrene	3.21	3.01	0.73 J	3.22	5.96
C1-Fluoranthenes/Pyrenes	14.44	15.26	9.36	18.81	16.85
C2-Fluoranthenes/Pyrenes	19.62	24.19	15.47	25.13	32.95
C3-Fluoranthenes/Pyrenes	46.44	57.62	33.53	60.3	50.73
Benzo(a)anthracene	0.66 U	0.84 U	0.96 U	0.95 U	1.55 J
Chrysene	68.25	53.14	42.54	69.32	7.96
C1-Chrysenes	104.2	80.64	62.36	111.67	23.63
C2-Chrysenes	69.26	67.65	38.61	81.39	47.12
C3-Chrysenes	31.19	34.9	31.36	40.47	62.13
C4-Chrysenes	23.24	28.7	26.58	34.82	62.22
Benzo(b)fluoranthene	6.41	5.48	1.45 U	6.91	3.1
Benzo(k)fluoranthene	0.72 U	0.93 U	1.06 U	1.05 U	0.66 U
Benzo(e)pyrene	7.21	8.2	8.87	8.42	6.48
Benzo(a)pyrene	0.9 U	1.16 U	1.32 U	1.31 U	3.45
Perylene	0.98 U	1.26 U	1.44 U	1.42 U	1.48 J
Indeno(1,2,3-cd)pyrene	0.54 U	0.69 U	0.79 U	0.78 U	2.17
Dibenz(a,h)anthracene	0.49 U	0.63 U	0.72 U	0.71 U	0.45 U
Benzo(g,h,i)perylene	1.01 J	1.02 J	1.45 J	1.11 J	5

U- not detected (detection limit provide
J- estimated value

Table 1
Summary of Analyses of Petroleum

Sample number	TRB-20101114-SOWS1-001	TRB-20101116-SOWS1-001	TRB-20101117-SOWS1-001	TRB-20101210-SOWS-001	TRB-20101210-SOWS-002
Collection Date	11/14/10	11/16/10	11/17/10	12/10/10	12/10/10
Latitude	30.32481	30.22810	30.28839	30.22829	30.22829
Longitude	-88.18073	-87.83115	-87.47728	-87.83120	-87.83120
Units	MG/KG_OIL	MG/KG_OIL	MG/KG_OIL	MG/KG_OIL	MG/KG_OIL
Naphthalene	1.34 U	0.92 U	0.93 U	1.08 U	1.18 U
C1-Naphthalenes	1.3 U	0.89 U	0.9 U	1.05 U	1.14 U
C2-Naphthalenes	2.65 U	1.82 U	1.84 U	2.14 U	2.33 U
C3-Naphthalenes	2.81 U	1.93 U	1.96 U	2.27 U	2.47 U
C4-Naphthalenes	2.3 U	1.58 U	1.61 U	1.86 U	2.03 U
Biphenyl	1.56 U	1.07 U	1.09 U	1.26 U	1.38 U
Acenaphthylene	1.44 U	0.99 U	1.01 U	1.17 U	1.27 U
Acenaphthene	2.42 U	1.66 U	1.68 U	1.95 U	2.13 U
Dibenzofuran	3.78 U	2.6 U	2.64 U	3.06 U	3.33 U
Fluorene	4.58 U	3.14 U	3.19 U	3.7 U	4.03 U
C1-Fluorenes	2.35 U	1.61 U	1.64 U	1.9 U	2.07 U
C2-Fluorenes	16.37	1.52 U	1.54 U	1.78 U	4.83
C3-Fluorenes	60.14	41.5	15.69	28.91	19.33
Anthracene	2.93 U	2.01 U	2.04 U	2.37 U	2.58 U
Phenanthrene	2.06 U	1.41 U	1.43 U	1.66 U	1.81 U
C1-Phenanthrenes/Anthracenes	6.48	5.44	2.1 U	2.43 U	5.16
C2-Phenanthrenes/Anthracenes	81.13	35.65	15.09	11.86	10.78
C3-Phenanthrenes/Anthracenes	148.32	71.66	41.83	51.97	18.68
C4-Phenanthrenes/Anthracenes	81.98	52.95	31.64	39.68	22.18
Dibenzothiophene	4.77 U	3.27 U	3.32 U	3.85 U	4.19 U
C1-Dibenzothiophenes	5.72	4.44	2.63	2.72	3.61
C2-Dibenzothiophenes	46.74	22.29	10.82	16.06	12.51
C3-Dibenzothiophenes	101.62	56.46	31.54	41.17	23.81
C4-Dibenzothiophenes	68.51	50.3	33.73	41.03	27.28
Fluoranthene	0.73 U	0.5 U	0.51 U	0.59 U	0.64 U
Pyrene	4.07	3.38	1.65 J	2.3 J	1.28 J
C1-Fluoranthenes/Pyrenes	24.23	16.07	10.9	12.99	6.25
C2-Fluoranthenes/Pyrenes	35.06	29.71	18.77	21.89	12.56
C3-Fluoranthenes/Pyrenes	77.79	71.98	44.65	48.72	32.16
Benzo(a)anthracene	1.11 U	0.76 U	0.78 U	0.9 U	0.98 U
Chrysene	69.75	58.3	42.94	47.3	39.37
C1-Chrysenes	120.02	86.89	64.15	69.64	47.9
C2-Chrysenes	93.35	69.29	49.79	56.71	33.5
C3-Chrysenes	50.55	43.35	29.52	28.05	20.6
C4-Chrysenes	40.92	36.22	26.08	23.95	15.88
Benzo(b)fluoranthene	7.63	4.26	3.66	3.83	1.48 U
Benzo(k)fluoranthene	1.23 U	0.84 U	0.86 U	0.99 U	1.08 U
Benzo(e)pyrene	10.16	9.75	5.87	7.13	5.13
Benzo(a)pyrene	1.53 U	1.05 U	1.07 U	1.24 U	1.35 U
Perylene	1.67 U	1.14 U	1.16 U	1.35 U	1.47 U
Indeno(1,2,3-cd)pyrene	0.92 U	0.63 U	0.64 U	0.74 U	0.81 U
Dibenz(a,h)anthracene	0.83 U	0.57 U	0.58 U	0.67 U	0.73 U
Benzo(g,h,i)perylene	0.75 U	1.18 J	0.52 U	0.6 U	0.66 U

U- not detected (detection limit provide
J- estimated value

Table 1
Summary of Analyses of Petroleum

Sample number	TRB-20101210-SOWS-003	TRB-20101110-SOWS1-001	TRB-20101208-SOWS-001	TRB-20101208-SOWS-002	TC-20110104-WAF1-002
Collection Date	12/10/10	11/10/10	12/08/10	12/08/10	01/04/11
Latitude	30.22404	30.24019			29.26895
Longitude	-88.10612	-87.73713			-89.95278
Units	MG/KG_OIL	MG/KG_OIL	MG/KG_OIL	MG/KG_OIL	MG/KG_OIL
Naphthalene	1.31 U	0.84 U	0.81 U	1.03 U	1.22 U
C1-Naphthalenes	1.26 U	0.82 U	0.78 U	1 U	1.18 U
C2-Naphthalenes	2.58 U	1.67 U	13.02	2.04 U	35.08
C3-Naphthalenes	2.73 U	29.57	72.59	2.17 U	140.43
C4-Naphthalenes	2.25 U	69.42	97	1.78 U	140.13
Biphenyl	1.52 U	0.99 U	0.94 U	1.21 U	1.47
Acenaphthylene	1.41 U	0.91 U	0.87 U	1.11 U	1.32 U
Acenaphthene	2.36 U	1.52 U	1.46 U	1.87 U	2.21 U
Dibenzofuran	3.69 U	2.38 U	2.28 U	2.92 U	3.46 U
Fluorene	4.46 U	2.89 U	7.98	3.54 U	15.85
C1-Fluorenes	2.29 U	38.79	62.91	1.82 U	94.22
C2-Fluorenes	2.28 J	131.03	156.5	1.71 U	229.26
C3-Fluorenes	18.72	172.12	173.09	1.91 U	193.50
Anthracene	2.85 U	3.02	4.4	2.26 U	3.97
Phenanthrene	2.01 U	62.68	92.93	1.59 U	122.10
C1-Phenanthrenes/Anthracenes	4.48	445.98	445.92	2.33 U	552.64
C2-Phenanthrenes/Anthracenes	35.71	691.84	631.9	1.72 U	715.76
C3-Phenanthrenes/Anthracenes	45.38	390.74	365.68	22.91	433.14
C4-Phenanthrenes/Anthracenes	27.78	138.82	128.78	37.67	156.02
Dibenzothiophene	4.64 U	7.47	12.42	3.68 U	17.34
C1-Dibenzothiophenes	1.48 U	83.33	91.59	1.17 U	109.58
C2-Dibenzothiophenes	14.75	218.85	210.01	1.23 U	237.45
C3-Dibenzothiophenes	27.01	179.55	169.36	1.74 U	207.54
C4-Dibenzothiophenes	23.17	90.85	91.23	41.01	104.85
Fluoranthene	0.71 U	0.46 U	1.76 J	0.56 U	2.57
Pyrene	1.58 J	8.29	9.51	1.2 J	12.89
C1-Fluoranthenes/Pyrenes	8.16	52.34	51.29	1.73 U	60.31
C2-Fluoranthenes/Pyrenes	14.92	64.62	61.72	20.85	83.31
C3-Fluoranthenes/Pyrenes	31.79	91.64	83.71	50.59	99.40
Benzo(a)anthracene	1.09 U	0.7 U	0.67 U	0.86 U	1.02 U
Chrysene	50.18	90.88	80.58	48.73	100.83
C1-Chrysenes	69.09	149.3	133.05	1.32 U	164.55
C2-Chrysenes	50.06	117.43	106.51	1.06 U	128.49
C3-Chrysenes	24.16	59.49	54.27	0.66 U	64.24
C4-Chrysenes	19.73	38.42	34.43	29.61	40.99
Benzo(b)fluoranthene	2.86 J	9.35	7.6	1.29 U	8.93
Benzo(k)fluoranthene	1.2 U	0.77 U	0.74 U	0.95 U	1.12 U
Benzo(e)pyrene	6.97	11.7	10.4	9.63	13.72
Benzo(a)pyrene	1.49 U	0.97 U	0.93 U	1.18 U	1.4 U
Perylene	1.62 U	1.05 U	1.01 U	1.29 U	1.52 U
Indeno(1,2,3-cd)pyrene	0.89 U	0.58 U	0.55 U	0.71 U	0.84 U
Dibenz(a,h)anthracene	0.81 U	0.53 U	0.5 U	0.64 U	0.76 U
Benzo(g,h,i)perylene	0.83 J	1.74 J	1.37 J	1.08 J	1.60

U- not detected (detection limit provide
J- estimated value

Table 1
Summary of Analyses of Petroleum

Sample number	TC-20110104-WAF1-003		TRB-20110104-WAF1-001	
Collection Date	01/04/11		01/04/11	
Latitude	29.26760		29.26284	
Longitude	-89.95157		-89.95000	
Units	MG/KG_OIL		MG/KG_OIL	
Naphthalene	0.9	U	0.98	U
C1-Naphthalenes	0.87		0.95	U
C2-Naphthalenes	36.01		13.52	
C3-Naphthalenes	137.01		94.73	
C4-Naphthalenes	131.04		114.92	
Biphenyl	1.57		1.15	U
Acenaphthylene	0.97	U	1.06	U
Acenaphthene	1.62	U	1.77	U
Dibenzofuran	2.54	U	2.77	U
Fluorene	15.57		10.18	
C1-Fluorenes	93.62		82.18	
C2-Fluorenes	222.74		207.84	
C3-Fluorenes	196.66		191.99	
Anthracene	5.69		4.18	
Phenanthrene	124.89		111.25	
C1-Phenanthrenes/Anthracenes	533.94		512.36	
C2-Phenanthrenes/Anthracenes	685.75		677.88	
C3-Phenanthrenes/Anthracenes	415.99		389.77	
C4-Phenanthrenes/Anthracenes	153.47		147.64	
Dibenzothiophene	17.64		15.80	
C1-Dibenzothiophenes	105.76		103.01	
C2-Dibenzothiophenes	227.26		221.60	
C3-Dibenzothiophenes	198.17		190.72	
C4-Dibenzothiophenes	96.81		96.17	
Fluoranthene	2.57		3.42	
Pyrene	13.31		11.26	
C1-Fluoranthenes/Pyrenes	64.51		61.01	
C2-Fluoranthenes/Pyrenes	94.54		94.59	
C3-Fluoranthenes/Pyrenes	103.58		97.23	
Benzo(a)anthracene	1.41		1.15	
Chrysene	100.68		102.62	
C1-Chrysenes	160.68		165.88	
C2-Chrysenes	130.54		132.27	
C3-Chrysenes	64.79		61.69	
C4-Chrysenes	40.56		44.87	
Benzo(b)fluoranthene	8.84		9.76	
Benzo(k)fluoranthene	0.82	U	0.9	U
Benzo(e)pyrene	13.20		13.93	
Benzo(a)pyrene	1.03	U	1.12	U
Perylene	1.12	U	1.22	U
Indeno(1,2,3-cd)pyrene	0.61	U	0.67	U
Dibenz(a,h)anthracene	0.56	U	0.98	
Benzo(g,h,i)perylene	2.12		2.43	

U- not detected (detection limit provide
J- estimated value

Table 2
Exposure and Risk Assessment Assumptions

Parameter	Description	Units	Visitor Scenario	Unrestricted Scenario
*$ADAF_c$	mutagenic adjustment factor - child	NA	3	NA
*$ADAF_{0-2}$	mutagenic adjustment factor 0-2 yr	NA	NA	10
*$ADAF_{2-6}$	mutagenic adjustment factor 2-6 yr	NA	NA	3
*$ADAF_{6-16}$	mutagenic adjustment factor 6-16 yr	NA	NA	3
*$ADAF_{16-30}$	mutagenic adjustment factor 16-30 yr	NA	NA	1
AF_c	skin adherence - child	mg/cm^2	0.2	0.2
AF_a	skin adherence - adult	mg/cm^2	NA	0.07
AT_{nc}	non-carcinogenic averaging time	days/year	120	365
AT_c	carcinogenic averaging time	days/year	365	365
EF	exposure frequency	days/year	90	350
ED_c	exposure duration - child	years	1	6
ED_a	exposure duration - adult	years	NA	24
ED_r	exposure duration - resident	years	NA	30
*ED_{0-2}	exposure duration -0-2 yr old resident	years	NA	2
*ED_{2-6}	exposure duration -2-6 yr old resident	years	NA	4
*ED_{6-16}	exposure duration -6-16 yr old resident	years	NA	10
*ED_{16-30}	exposure duration -16-30 yr old resident	years	NA	14
F_{oil}	fraction of petroleum residue that is oil	NA	0.2	0.2
F_{beach}	fraction of beach surface covered with petroleum residue	NA	0.1	0.01
LT	lifetime	years	70	70
ET	exposure time	hours/event	8	24
BW_c	body weight of child	kg	15	15
BW_a	body weight of adult	kg	NA	70
IRS_c	sediment ingesition - child	mg/day	200	200
IRS_a	sediment ingestion - adult	mg/day	NA	100
SA_c	exposed skin surface area - child	cm^2	2800	2800
SA_a	exposed skin surface area - adult	cm^2	NA	5700

*Used in calculating lifetime cancer risks for mutagenic carcinogens for the mutagenic carcinogens.
These chemicals are assumed to be benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene and its alkylated derivatives, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene
NA - not applicable

All values from FDOH, 2010
NA - not applicable

Table 3
Chemical-Specific Parameters

Chemical	Volatilization Factor (VF) (m3/kg)	Particulate Emission Factor (PEF) (m3/kg)	Skin Absorption (ABS) (unitless)	Gastrointestinal Absorption (GIABS) (unitless)
Acenapthene	nd	nd	nd	nd
Anthracene (and alkylated anthracenes)	5.6E+05	1.4E+09	0.13	1
Benz(a)anthracene	*	1.4E+09	0.13	1
Benzo(a)pyrene	*	1.4E+09	0.13	1
Benzo(b)fluoranthene	*	1.4E+09	0.13	1
Benzo(k)fluoranthene	nd	nd	nd	nd
Chrysene (and alkylated chrysenes)	*	1.4E+09	0.13	1
Dibenz(a,h)anthracene	*	1.4E+09	0.13	1
Fluoranthene (and alkylated fluoranthenes)	*	1.4E+09	0.13	1
Fluorene (and alkylated fluorenes)	3.0E+05	1.4E+09	0.13	1
Indeno(1,2,3-cd)pyrene	*	1.4E+09	0.13	1
Methylnaphthalene, 1-	6.3E+04	1.4E+09	0.13	1
Methylnaphthalene, 2-	6.2E+04	1.4E+09	*	1
Naphthalene	nd	nd	nd	nd
Phenanthrene (and alkylated phenanthrenes)	6.9E+05	1.4E+09	0.13	1
Pyrene	2.6E+06	1.4E+09	0.13	1

* Value is assumed to be zero
All values from FDOH, 2010
nd - chemical not detected in 22 samples; no chemical-specific information presented

Table 4
Toxicity Values

Chemical	Oral Slope Factor (SF_o) $(mg/kg/day)^{-1}$	Inhalation Unit Risk Factor (IUR) $(ug/m^3)^{-1}$	Chronic Oral Reference Dose (RfD_o) (mg/kg/day)	Subchronic Oral Reference Dose ($SRfD_o$) (mg/kg/day)	Chronic Reference Concentration (RfC) (mg/m^3)	Subchronic Reference Concentration (SRfC) (mg/m^3)
Acenapthene	nd	nd	nd	nd	nd	nd
Anthracene (and alkylated anthracenes)	nc	nc	3.0E-01	1.0E-01	na	na
Benz(a)anthracene	7.3E-01	1.1E-04	na	na	na	na
Benzo(a)pyrene	7.3E+00	1.1E-03	na	na	na	na
Benzo(b)fluoranthene	7.3E-01	1.1E-04	na	na	na	na
Benzo(k)fluoranthene	nd	nd	nd	nd	nd	nd
Chrysene (and alkylated chrysenes)	7.3E-03	1.1E-05	na	na	na	na
Dibenz(a,h)anthracene	7.3E+00	1.2E-03	na	na	na	na
Fluoranthene (and alkylated fluoranthenes)	nc	nc	4.0E-02	4.0E-01	na	na
Fluorene (and alkylated fluorenes)	nc	nc	4.0E-02	4.0E-01	na	na
Indeno(1,2,3-cd)pyrene	7.3E-01	1.1E-04	na	na	na	na
Methylnaphthalene, 1-	2.9E-02	nc	7.0E-02	7.0E-02[A]	na	na
Methylnaphthalene, 2-	nc	nc	4.0E-03	4.0E-03	na	na
Naphthalene	nd	nd	nd	nd	nd	nd
Phenanthrene (and alkylated phenanthrenes)	nc	nc	3.0E-01	1.0E+00	na	na
Pyrene	nc	nc	3.0E-02	3.0E-01	na	na

nc- not considered carcinogenic by this route of exposure

na- not available

A- no subchronic value available, chronic value used

unless indicated, all values from FDOH, 2010

nd - chemical not detected in 22 samples; no chemical-specific information presented

Table 5
Summary of Lifetime Cancer Risks and Noncancer Risks
Human Exposure to Petroleum Residues on Beaches

Sample Number	Visitor Scenario		Unrestricted Resident Scenario	
	Lifetime Cancer Risk	Hazard Index	Lifetime Cancer Risk	Hazard Index
TRB-20101025-SOWS1-001	4.5E-08	1.4E-04	2.2E-07	1.5E-04
TRB-20101024-SOWS2-001	2.7E-08	2.2E-04	1.3E-07	2.1E-04
TRB-20101023-SOWS2-001	3.2E-08	2.1E-04	1.5E-07	2.2E-04
TRB-20101022-SOWS2-001	2.8E-08	5.1E-04	1.4E-07	2.9E-04
TRB-20101023-SOWS1-001	6.0E-08	1.7E-03	2.9E-07	6.1E-04
TRB-20101104-SOWS1-001	2.6E-08	4.6E-04	1.3E-07	2.4E-04
TRB-20101106-SOWS1-001	2.3E-08	1.5E-04	1.1E-07	1.6E-04
TRB-20101111-SOWS1-001	5.7E-09	7.1E-05	2.7E-08	7.6E-05
TRB-20101112-SOWS1-001	2.9E-08	3.7E-04	1.4E-07	2.8E-04
TRB-20101113-SOWS1-001	1.2E-07	1.9E-03	5.9E-07	4.3E-04
TRB-20101114-SOWS1-001	3.2E-08	2.7E-04	1.5E-07	2.7E-04
TRB-20101116-SOWS1-001	2.0E-08	1.8E-04	9.8E-08	2.0E-04
TRB-20101117-SOWS1-001	1.6E-08	1.0E-04	7.8E-08	1.1E-04
TRB-20101210-SOWS-001	1.7E-08	1.3E-04	8.2E-08	1.4E-04
TRB-20101210-SOWS-002	4.4E-09	7.8E-05	2.1E-08	8.8E-05
TRB-20101210-SOWS-003	1.4E-08	9.5E-05	6.8E-08	9.7E-05
TRB-20101110-SOWS1-001	3.9E-08	5.7E-03	1.9E-07	1.3E-03
TRB-20101208-SOWS-001	3.3E-08	9.9E-03	1.6E-07	1.9E-03
TRB-20101208-SOWS-002	2.2E-09	8.3E-05	1.1E-08	9.1E-05
TC-20110104-WAF1-002	3.9E-08	1.7E-02	1.9E-07	2.8E-03
TC-20110104-WAF1-003	4.3E-08	1.6E-02	2.1E-07	3.0E-03
TRB-20110104-WAF1-001	7.2E-08	1.2E-02	3.5E-07	2.4E-03
Minimum calculated risk	2.2E-09	7.1E-05	1.1E-08	7.6E-05
Maximum calculated risk	1.2E-07	1.7E-02	5.9E-07	3.0E-03