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Human Health And Ecological Baseline Risk Assessment Addendum
Terminal 1 South
2100 NW Front Avenue
Portland, Oregon

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HUMAN HEALTH AND ECOLOGICAL BASELINE RISK ASSESSMENT ADDENDUM
TERMINAL 1 SOUTH
2100 NW FRONT AVENUE
PORTLAND, OREGON

ADDENDUM

This addendum to the Human Health and Ecological Baseline Risk Assessment, Terminal 1 South (T1S), 2100 NW Front Avenue, Portland, Oregon (Hart Crowser, January 18, 2002) was prepared based on Department of Environmental Quality (DEQ) comments received on the risk assessment and feasibility study reports (DEQ Letters February 12, 2002, and May 3, 2002), a meeting held with DEQ on April 29, 2002, and a follow-up teleconference on May 28, 2002. This addendum presents the revised sections, tables, and appendices of the risk assessment reports as agreed to in the Port's response to DEQ comment letters dated March 5 and May 21, 2002, and discussed in the meeting and teleconference with DEQ.

Addendum Revisions:

This addendum contains the following revisions to the Human Health and Ecological Baseline Risk Assessment, T1S, 2100 NW Front Avenue, Portland, Oregon (Hart Crowser, January 18, 2002).

- The construction worker exposure scenario has been added to the Baseline Human Health Risk Assessment and all appropriate text and tables have been revised and included in this addendum.
- The results from the second round of groundwater monitoring have been added to both the Baseline Human Heath and Ecological Risk Assessment.
- Additional text has been added to the uncertainty section discussing the assessment of total petroleum hydrocarbons (TPH) in the Human Health Risk assessment and the uncertainty associated with the chemical characterization completed by Hahn and Associates in the Remedial Investigation for this site.
- The maximum detected concentration of benzo(a)anthracene was used as the RME exposure point concentration for total soil (0 to 15 feet below ground surface [bgs]) for both the excavation and construction worker exposure scenario.
- The DEQ requested change has been made in the Level 1 – Ecological Risk Assessment Checklist.

POPT1S601269

- A supplemental section has been added that evaluates the potential for human health risks from fish consumption due to exposure of constituents migrating to the Willamette River from shallow groundwater at the site. In addition, a human health risk-based groundwater screening table is included as Attachment A, and justification for an alternative freshwater arsenic criterion for the protection of human health via fish consumption is provided in Attachment B to this addendum.

2.6 Identification of Compounds of Potential Concern

Chemical analyses on samples collected at the T1S Site have identified diesel and oil as the fuel types present. However, due to the current lack of toxicity data for diesel or oil as a whole (each fuel type is a complex mixture of hundreds of chemical compounds), these fuels were not quantitatively evaluated in the HHRA. Instead, we focused on individual petroleum constituents within these fuel types for which appropriate toxicity data are available.

Specific chemical constituents of these fuel types are possible compounds of interest (COI). COIs are defined as compounds detected at the site, and COPCs are those COIs that exceed the risk-based screening levels as discussed below and are carried forward in the HHRA. Based on investigations conducted at the T1S Site, the COIs in soil and groundwater include the following groups of compounds: Total Petroleum Hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), polychlorinated biphenyls (PCBs), and metals.

Evaluation for COPCs. In accordance with DEQ human health risk assessment guidance (DEQ, 2000), soil COIs were conservatively screened against EPA Region 9 Residential Soil Preliminary Remediation Goals (PRGs), and groundwater COIs were conservatively screened against EPA Region 9 Tap Water PRGs (EPA, 2000a). To identify COPCs in groundwater, because exposure to groundwater is limited to inhalation of VOCs that have migrated from groundwater to indoor or outdoor air, only VOCs detected in groundwater were evaluated as potential COPCs.

Additional steps, which are described in Section 2.3.2, (3)(a) through (e) of the DEQ human health risk assessment guidance, were also performed to ensure potential cumulative effects from multiple compounds or from an individual compound detected in multiple media were accounted for.

As presented in the Risk Assessment Work Plan for this site (Hart Crowser, 2001), the site was divided into three separate Areas of Concern (AOC). The AOCs are presented on Figure 2. COPCs were identified for each area and

POPT1S601270

separate risk calculations and risk estimates were conducted for each area.

Tables 1 through 3 summarize the identification of COPCs in soil and groundwater for Areas A, B, and C, respectively. Note that Tables 1 through 3 only include compounds that were detected in soil or groundwater. COIs that were analyzed for, but not detected in soil or groundwater samples (e.g., PCBs) are not included in Tables 1 through 3. The following COPCs were identified in each area:

Area A

- Soil: Diesel, oil, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, arsenic, and lead. No soil PRGs are available for diesel and heavy oil; however, since both analytes were detected in soil they were retained as COPCs.
- Groundwater: Diesel and tetrachloroethene. Diesel was identified as a COPC because a tap water PRG is not available. Heavy oil was not detected in groundwater.

Area B

- Soil: Diesel, oil, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, and arsenic. Diesel and oil were identified as COPCs because soil PRGs are not available.
- Groundwater: Diesel. Diesel was identified as a COPC because a tap water PRG is not available. Heavy oil was not detected in groundwater. Tetrachloroethene was not identified as a COPC for Area B since it was only detected in Monitoring Well 1, which is located in Area A.

Area C

- Soil: Arsenic.
- Groundwater: None.

PCBs were identified as COIs for this site. However, PCBs were only detected in one soil sample that was collected from a depth of 67.5 feet bgs. PCBs were never detected in any soil samples evaluated as part of this risk assessment and were, therefore, not identified as COPCs.

POPT1S601271

3.1 Exposure Assessment

Potentially Exposed Populations. A beneficial land and water use survey has been completed for the site and is discussed in Section 2.4 (Hahn and Associates, 2001). Based on the Central Residential (RX) zoning designation, it is expected that the site will be used for mixed-use residential/commercial development in the future. The only identified beneficial use for groundwater in the locality of the facility is discharge to the Willamette River.

Therefore, the final CSM assumes the future area land use will be a mix of residential and commercial and that groundwater beneath the site is not and likely will not be used for drinking water. Figure 3 presents the final CSM for this site. The red boxes on the figure indicate potentially complete pathways to the indicated receptor. In addition to residential and commercial receptors, the HHRA will also evaluate utility/excavation workers and construction workers as potentially exposed populations. Utility/excavation workers will be identified as excavation workers in the remainder of the HHRA.

Potentially Complete Exposure Routes. Exposure pathways for quantitative analysis were selected based on the final CSM developed for this site. Based on available information, the exposure pathways evaluated in this HHRA are:

- Incidental ingestion of soil (all receptors);
- Dermal contact with soil (all receptors);
- Inhalation of fugitive dust from surface soil (residents and commercial workers);
- Inhalation of fugitive dust from total soil (0 to 15 feet below ground surface, excavation workers and construction workers); and
- Inhalation of VOCs from groundwater (all receptors; indoor for residents and commercial workers; outdoor air only for excavation workers and construction). No VOCs were identified as soil COPCs (see Tables 1 through 3). Outdoor air was not evaluated for residents and commercial workers since the risks and hazards associated with indoor air, which are higher than those associated with outdoor air, were acceptable.

Direct contact with groundwater is not considered a potential exposure pathway for excavation or construction workers, as the average depth of the shallow WBZ was reported to be 23 feet bgs (Hahn and Associates, 2001a). For this HHRA, residents and commercial workers are assumed to be exposed to soil down to a depth of 3 feet bgs and excavation workers and construction workers are assumed to be exposed to soils down to a depth of 15 feet bgs.

POPT1S601272

3.1.2 Development of Exposure Point Concentrations

Exposure point concentrations (EPCs) represent the chemical concentrations in the soil and groundwater that the receptor will potentially contact during the exposure period. The EPCs for the site's COPCs were derived from either data obtained from sampling or from a combination of sample data and fate and transport modeling. For example, air EPCs were modeled from groundwater EPCs for volatile constituents. Indoor and outdoor air EPCs were calculated using the modeling equations presented in DEQ's Risk-Based Decision Making Guidance (DEQ, 1999). Groundwater data from monitoring well samples collected in September and October 2001 and January 2002 were used to represent current and future groundwater conditions.

The residential and commercial worker scenarios were evaluated based on exposure to surface soil (0 to 3 feet bgs), while the excavation and construction worker scenario was based on exposure to surface and subsurface soil (0 to 15 feet bgs). No VOCs were identified as soil COPCs, therefore, soil from 15 feet bgs down to groundwater was not considered in the volatilization to indoor and outdoor air pathways.

In accordance with EPA guidance (EPA, 1989) for chemicals detected at one sampling location but not at others, a proxy concentration equal to half the sample quantification limit (SQL) were used to represent the concentration of the chemical of concern in a sample where it is not detected.

The 90% upper confidence limit (UCL) on the arithmetic mean concentration of COPCs in each environmental medium of concern were used to evaluate the reasonable maximum exposure (RME) scenario, while the arithmetic mean were used to evaluate the central tendency (CT) exposure scenario (EPA, 1989). The RME scenario is intended to be a conservative estimate of potential exposure, while the CT exposure scenario is intended to be a more realistic exposure scenario. Using both the RME and CT allows for a range of potential risk and hazard estimates. The 90% UCL is calculated based on EPA (1992) guidance. The manner of calculating the 90% UCL were as follows:

- As a first step, the underlying distribution of the data was evaluated using the Shapiro and Wilk W-Test (Gilbert, 1987) to determine if the data are normal or lognormal. If the normal and lognormal distributions are indicated, the 90% UCL were calculated appropriately.
- If the normality test rejects both normal and lognormal distributions at a significance level of 95 percent, the test was rerun by adjusting the W-Test

POPT1S601273

quantile downward by 0.1 from the original quantile (providing a greater tolerance for accepting a distribution). If the data set conforms to a normal or lognormal distribution with the greater tolerance, the distribution was reported as weak lognormal (or weak normal).

- If the normal and lognormal distributions are rejected with the greater tolerance, the data were assumed to fit a lognormal distribution for calculation of the 90% UCL (assumed lognormal distribution; EPA, 1992).
- In cases where the 90% UCL or the calculated mean concentration exceed the maximum detected value (which can occur in data sets with a large variance), the maximum detected value were used to define the upper limit of this range.

EPCs for this HHRA are presented in Table 4. All of the EPCs presented in Table 4 were calculated using the methodology presented above, with the following exceptions:

Area A: Total Soil (0 to 15 feet bgs). The 90% UCL for benzo(a)anthracene of 0.35 mg/kg is less than the arithmetic mean of 0.37 mg/kg. This is primarily due to the elevated detection of 9.35 mg/kg, which was detected in the soil sample B-68. To be conservative, the RME concentration for benzo(a)anthracene was set at 9.35 mg/kg.

Area B: Total Soil (0 to 15 feet bgs). The 90% UCLs and arithmetic means for the cPAHs were significantly affected by the elevated SQL of 67 mg/kg in soil sample B-63. Since one-half of 67 mg/kg is over 10 times greater than the maximum detected concentrations of the five cPAHs, the cPAH results for soil sample B-63 were not included in the statistical evaluation for this data set. However, subsurface soil samples collected adjacent to sample B-63 (e.g., Samples B-66 and B-67) had detected concentrations of cPAHs that were included in the calculations of EPCs. Therefore, this area was represented in the calculated risk estimates and the exclusion of cPAH SQLs from Sample B-63 had no impact on HHRA objectives.

EPA's Risk Assessment Guidance for Superfund (RAGS) addresses the issue of elevated sample quantitation limits. In Chapter 5.3.2, RAGS states one can "exclude the samples from the quantitative risk assessment if they" (i.e., referring to elevated SQLs) "caused the calculated concentration (i.e., the concentration calculated according to guidance in Chapter 6) to exceed the maximum detected concentration for a particular data set." The 90% UCLs for all the PAH COPCs exceed their respective maximum detected concentration when the elevated SQLs of 67 mg/kg are retained in the data sets. Therefore, the exclusion of the elevated SQLs is consistent with EPA risk assessment guidance

POPT1S601274

3.2.4 Toxicity Assessment for Total Petroleum Hydrocarbons (TPH)

Determining appropriate toxicity values for TPH (a class of compounds identified as a COI at this site) is difficult because of the characteristics of TPH. TPH are a complex mixture of hundreds or more individual alkanes, cycloalkanes, alkenes, aromatics, and other petroleum substances. For this HHRA, the human health risks associated with TPH were evaluated using an indicator approach. The indicators refer to single compounds within TPH known or believed to be carcinogenic and non carcinogenic and which are evaluated individually. The indicator compounds that were quantitatively evaluated in this HHRA are:

- **Volatiles (BTEX):** benzene, toluene, ethylbenzene, and xylene; and
- **Polynuclear Aromatic Hydrocarbons (PAHs):** anthracene, acenaphthene, acenaphthylene, benzo(a)pyrene, pyrene, naphthalene, chrysene, ideno(1,2,3-cd)pyrene, benzo(g,h,i)perylene, benzo(k)flouranthene, fluoranthene, flourene, phenanthrene, benzo(b)flouranthene, benzo(a)anthracene, and dibenzo(a,h)anthracene.

3.3.2 Risks and Hazards Associated with Current and Future Site Conditions

Risk and hazard estimates for each area are discussed in Sections 3.3.2.1 through 3.3.2.3. As discussed previously, the residential, commercial worker, construction worker, and excavation worker exposure scenarios are evaluated for each area. Risk and hazard estimate calculations for each area, exposure pathway, and receptor are presented in Appendix B (Tables B-1 through B-9). Table 10 presents the totals as a sum of risks and hazards associated with each individual exposure pathway, while Table 11 presents the RME carcinogenic risk estimates as a sum of risks associates with each COPC.

3.3.2.1 Area A Risk and Hazard Estimates

The exposure pathways that were quantitatively evaluated at Area A are soil ingestion, dermal contact with soil, inhalation of volatiles from groundwater, and inhalation of fugitive dust.

Resident. The cumulative RME and CT excess lifetime cancer risks for the residential receptor are estimated to be 2×10^{-4} and 2×10^{-6}, respectively. The RME risk estimate is greater than the OAR 340-122 acceptable level of 1×10^{-5} for cumulative carcinogenic risk, while the CT risk estimate is less than the DEQ acceptable risk level. The primary exposure pathways (RME evaluation) are soil ingestion (risk = 8×10^{-5}) and dermal contact with soil (risk = 8×10^{-5}). COPCs

POPT1S601275

that exceed the DEQ acceptable risk level of 1×10^{-6} for individual carcinogens are benzo(a)pyrene (risk = 9×10^{-5}), arsenic (risk = 5×10^{-5}), benzo(a)anthracene (risk = 1×10^{-5}), dibenz(a,h)anthracene (risk = 8×10^{-6}), benzo(b)fluoranthene (risk = 7×10^{-6}), and indeno(1,2,3-cd)pyrene (risk = 4×10^{-6}).

The cumulative RME and CT HIs for the residential receptor are estimated to be 1.0 and 0.01, respectively. The RME HI is equal to, while the CT HI is less than, the DEQ acceptable HI of 1.0. In addition, both the RME and CT concentrations of lead in surface soil exceeded residential lead PRG.

Commercial Worker. The cumulative RME and CT excess lifetime cancer risks for the commercial worker are estimated to be 1×10^{-5} and 6×10^{-7}, respectively. The RME risk estimate is equal to, while the CT risk estimate is less than, the DEQ acceptable level of 1×10^{-5} for cumulative carcinogenic risk. The primary exposure pathways (RME evaluation) are soil ingestion (risk = 1×10^{-5}) and dermal contact with soil (risk = 3×10^{-6}). Individual COPCs that exceed the DEQ acceptable risk level of 1×10^{-6} for individual carcinogens are benzo(a)pyrene (risk = 7×10^{-6}) and arsenic (risk = 5×10^{-6}).

The cumulative RME and CT HIs for the residential receptor are estimated to be 0.03 and 0.006, respectively. The RME and CT HI are less than the DEQ acceptable HI of 1.0. In addition, the RME concentrations of lead in surface soil exceeded the industrial lead PRG but the CT concentration was acceptable.

Construction Worker. The cumulative RME and CT excess lifetime cancer risks for the construction worker are estimated to be 7×10^{-7} and 1×10^{-7}, respectively. The RME and CT risk estimates are less than the DEQ acceptable risk level for multiple carcinogens. The cumulative RME and CT HIs for the construction worker are estimated to be 0.07 and 0.01, respectively. Both of which are below the acceptable HI of 1.0. In addition, the RME concentrations of lead in total soil exceeded the industrial lead PRG but the CT concentration was acceptable.

Excavation Worker. The cumulative RME and CT excess lifetime cancer risks for the excavation worker are estimated to be 5×10^{-8} and 3×10^{-9}, respectively. The RME and CT risk estimates are less than the DEQ acceptable risk level for multiple carcinogens. The cumulative RME and CT HIs for the residential receptor are estimated to be 4×10^{-3} and 5×10^{-4}, respectively. Both of which are well below the acceptable HI of 1.0. In addition, the RME concentrations of lead in total soil exceeded the industrial lead PRG but the CT concentration was acceptable.

POPT1S601276

3.3.2.2 Area B Risk and Hazard Estimates

The exposure pathways that were quantitatively evaluated at Area B are soil ingestion, dermal contact with soil, and inhalation of fugitive dust. No VOCs were detected in Area B soil or groundwater.

Resident. The cumulative RME and CT excess lifetime cancer risks for the residential receptor are estimated to be 3×10^{-5} and 5×10^{-7}, respectively. The RME risk estimate is greater than, while the CT risk estimate is less than, the acceptable risk level of 1×10^{-5} for cumulative carcinogenic risk. The primary exposure pathways (RME evaluation) are soil ingestion (risk = 2×10^{-5}) and dermal contact with soil (risk = 1×10^{-5}). COPCs that exceed the DEQ acceptable risk level of 1×10^{-6} for individual carcinogens are benzo(a)pyrene (risk = 9×10^{-6}) and arsenic (risk = 2×10^{-5}).

The cumulative RME and CT HIs for the residential receptor are estimated to be 0.4 and 0.01, respectively. Both of which are less than the DEQ acceptable HI of 1.0.

Commercial Worker. The cumulative RME and CT excess lifetime cancer risks for the commercial worker are estimated to be 2×10^{-6} and 3×10^{-7}, respectively. The RME and CT risk estimates are both less than the DEQ acceptable level of 1×10^{-5} for cumulative carcinogenic risk. Arsenic (risk = 2×10^{-6}) is the only individual COPC that exceeds the DEQ acceptable risk level of 1×10^{-6} for individual carcinogens. The cumulative RME and CT HIs for the commercial receptor are estimated to be 0.01 and 0.006, respectively. The RME and CT HI are less than the DEQ acceptable HI of 1.0.

Construction Worker. The cumulative RME and CT excess lifetime cancer risks for the construction worker are estimated to be 1×10^{-6} and 1×10^{-7}, respectively. The RME and CT risk estimates are less than the DEQ acceptable risk level for multiple carcinogens. The cumulative RME and CT HIs for the construction worker are estimated to be 0.04 and 0.01, respectively. Both of which are below the acceptable HI of 1.0.

Excavation Worker. The cumulative RME and CT excess lifetime cancer risks for the excavation worker are estimated to be 1×10^{-7} and 4×10^{-9}, respectively. The RME and CT risk estimates are less than the DEQ acceptable risk level for multiple carcinogens. The cumulative RME and CT HIs for the residential receptor are estimated to be 3×10^{-3} and 4×10^{-4}, respectively. Both of which are well below the acceptable HI of 1.0.

POPT1S601277

3.3.2.3 Area C Risk and Hazard Estimates

The exposure pathways that were quantitatively evaluated at Area C are soil ingestion, dermal contact with soil, and inhalation of fugitive dust. No VOCs were detected in Area C soil or groundwater. Arsenic is the only COPC for Area C.

The cumulative RME and CT excess lifetime cancer risks for all receptors (resident, commercial worker, construction worker, and excavation worker) are less than the acceptable risk level of 1×10^{-5} for cumulative carcinogenic risk, with the exception of the RME residential scenario (risk = 2×10^{-5}). Arsenic has individual cancer risk estimates of 2×10^{-5} and 2×10^{-6} for the RME residential and commercial worker scenarios, respectively. All individual and cumulative hazard estimates are less than the DEQ acceptable HI of 1.0.

3.4 Uncertainty Analysis

It is important to fully specify the assumptions and uncertainties inherent in the risk assessment to place the risk estimates in proper perspective. For this risk assessment, the general sources of uncertainty that are addressed include:

- Data collection and evaluation;
- Exposure assessment;
- Toxicity assessment; and
- Risk characterization.

3.4.1 Data Collection and Evaluation

The identification of the types and numbers of environmental samples, sampling procedures, and sample analysis each contain components that contribute to uncertainties in this risk assessment. For example, it is generally not practical to sample all locations and media at a site. Decisions were made to select a subset of the potential sampling locations and media based upon the anticipated presence of the chemical. These decisions were made with the use of historical and background information of the site and the potential contaminants' chemical and physical properties. Exposure doses for the site that are based on non-random, or hot spot, samples may be overestimated.

POPT1S601278

3.4.2 Exposure Assessment

The exposure estimation methods are subject to varying degrees of uncertainty. The degree of uncertainty generally depends on the amount of site-specific data available. The following sources of uncertainty have been identified.

Exposure Scenario Identification. This HHRA assumes that receptors are limited to residents, commercial workers, construction workers, and excavation workers. If this assumption is incorrect, future risks and hazards could be under- or overestimated.

Exposure Parameters and Assumptions. The standard and site-specific exposure assumptions may or may not be representative of the actual exposure conditions and could under- or overestimate future risks and hazards.

Calculation of Exposure Point Concentrations. The 90% UCL on the arithmetic mean, or the maximum detected concentration, whichever is lower, was used as the exposure point concentration (EPC) in this HHRA. Prior to the calculation of the 90% UCL, each data set was evaluated to determine whether the data were distributed normally or lognormally. As discussed previously, if a data set was found to be neither normal nor lognormal, the data set was evaluated as a lognormal data set. A lognormal distribution is common among environmental data sets. The maximum detected COPC concentrations, especially at Area A, has a significant effect on the EPCs used in this HHRA.

- **Area A.** Carcinogenic PAHs, arsenic, and lead were identified as compounds of concern (COCs) in surface soil, while only lead was identified as a subsurface COC. The surface soil exposure concentrations for cPAHs, arsenic, and lead are driven by the maximum detected concentration of each COC, which was detected in soil sample B-68 (B-94 for dibenz(a,h)anthracene). The second highest cPAH detections were found in soil sample B-94 (detected between 1 and 2 mg/kg). The remaining cPAH detections are less than 0.5 mg/kg, which are consistent with ambient levels of cPAHs in urban areas.

  Arsenic was detected at a concentration of 12.9 mg/kg in sample B-68 and at a concentration of 7.53 mg/kg in sample B-97. All other arsenic detections were less than the Terminal 1 arsenic background level of 5.3 mg/kg (Hahn and Associates, 2001a). Additionally, if the arsenic concentration of 12.9 mg/kg were removed from the Area A surface soil data set, the resulting arithmetic mean concentration of the remaining data would be 2.2 mg/kg.

POPT1S601279

As discussed previously, the maximum detected lead concentration in surface soil at Area A was 6,190 mg/kg. The second highest lead detection was 192 mg/kg, which is below the residential and industrial (or commercial) soil screening levels. Lead is the only COC identified in the HHRA as a subsurface compound of concern (i.e., detected at levels above DEQ acceptable levels).

- **Area B.** Benzo(a)pyrene and arsenic were identified as COCs in surface soil. No subsurface COCs were identified at Area B. The maximum detected concentration of benzo(a)pyrene and the other three cPAHs evaluated are less than 0.2 mg/kg. These levels are consistent with ambient levels of cPAHs in urban areas.

  Arsenic was detected at a maximum concentration of 3.1 mg/kg in surface soil, which is less than the Terminal 1 arsenic background level of 5.3 mg/kg (Hahn and Associates, 2001a).

- **Area C.** Arsenic was identified as a COC in surface soil. No subsurface COCs were identified at AOC C. Arsenic was detected at a maximum concentration of 2.9 mg/kg in surface soil, which is less than the Terminal 1 arsenic background level of 5.3 mg/kg (HAI, 2001a).

Assumption of Steady-State Conditions. The inherent assumption is that future COC concentrations are the same as current concentrations. In general, this assumption overestimates COC concentrations and resulting exposure intakes.

Chemical Characterization. The sampling strategy used in collecting the soil samples that were used in this HHRA was a directed sampling strategy and was approved by DEQ. While there is uncertainity in limited sampling, sampling was conducted in areas where contamination was most likely to exist. There was no reason to believe contamination was present to warrant additional soil or groundwater sampling. Because the potential current and future receptors are assumed to visit the entire site, not just the areas that are contaminated, the exposure point concentrations used likely overestimate potential risks and hazards.

Modeling Procedures. DEQ's Risk-based Decision Making guidance was used to estimate the volatilization from groundwater to indoor and outdoor air. The assumptions used in these models introduce uncertainty to the degree that they do not reflect actual conditions. There is significant uncertainty associated with the volatilization model used to estimate indoor and outdoor air concentrations based on soil and groundwater concentrations. Areas of uncertainty include, but are not limited to:

POPT1S601280

- **COPC Concentration.** The model assumes the COPC concentrations are homogeneous over the entire area being evaluated. Since some COPC concentrations are based on the maximum detected concentration, this is a conservative assumption that is likely to significantly overestimate the amount of contamination present.

- **Building Parameters.** The model uses various building parameters as a basis for the indoor air concentrations such as building volume to area ratio (essentially the height of the building), building air exchange rate (the amount of times the air in the building is replace per second), the foundation crack thickness, and the foundation crack fraction (that is, the fraction of the building floor that contains cracks). Many of these assumptions have a linear effect on the model output (that is, if the air exchange rate is doubled, the indoor air concentration would drop in half). The model also assumes there is no vapor barrier under the foundation and that the building is not under positive pressure. Default building parameters were used in this HHRA.

- **COPC-Specific Parameters.** The model uses various chemical parameters such as diffusion coefficients, Log K_{oc} or Log K_d, Henry's Law Constant, vapor pressure, and solubility. These values can vary considerably in the literature. Default chemical parameters included in the RBDM model were used. These COPC-specific parameters can have a significant effect on the model results, and, therefore, the degree that the parameters used represent actual conditions at the site may lead to an overestimation or underestimation of actual air concentrations.

3.4.3 Toxicity Assessment

Whether verified by consensus among EPA scientists or not, uncertainty is present in the derivation of toxicity factors, and several assumptions are necessary.

Toxicity Assessment for Total Petroleum Hydrocarbons (TPH). Determining appropriate toxicity values for TPH (a class of compounds identified as a COI at this site) is difficult because of the characteristics of TPH. TPH are a complex mixture of hundreds or more individual alkanes, cycloalkanes, alkenes, aromatics, and other petroleum substances. For this HHRA, the human health risks associated with TPH were evaluated using an indicator approach. The indicators refer to single compounds within TPH known or believed to be carcinogenic and non-carcinogenic and which are evaluated individually. The indicator compounds that were quantitatively evaluated in this HHRA are:

- **Volatiles (BTEX):** benzene, toluene, ethylbenzene, and xylene; and

- **Polynuclear Aromatic Hydrocarbons (PAHs):** anthracene, acenaphthene, acenaphthylene, benzo(a)pyrene, pyrene, naphthalene, chrysene, ideno(1,2,3-cd)pyrene, benzo(g,h,i)perylene, benzo(k)flouranthene, fluoranthene, flourene, phenanthrene, benzo(b)flouranthene, benzo(a)anthracene, and dibenzo(a,h)anthracene.

Additionally, the factors used in the derivation of toxicity factors that add uncertainty to the results are presented below.

- **Extrapolation from Animal Studies.** Extrapolating human health risks from animal studies is complicated by physiological and pharmacokinetic differences. Similar toxic effects are not always observed in all species or at similar relative concentrations (when corrected for body weight). These extrapolations may overestimate or underestimate the actual chemical toxicity to humans.

- **High-Dose to Low-Dose Extrapolations.** Toxicity values are generally based on laboratory studies using high chemical exposures. Dose-response trends observed at high doses are generally assumed to be linear at low doses. Because dose-response relationships at low doses are largely unknown, assuming a linear relationship may overestimate or underestimate chemical toxicity at concentrations in the extrapolated range.

- **Population Variability.** Laboratory animal studies generally use animal strains that are genetically similar, yet the human population is genetically diverse. Because methods for estimating toxicity in more susceptible individuals, such as children, are largely undeveloped, such estimates may overestimate or underestimate chemical toxicity.

- **Available Studies.** Not all toxicity values are based on the same amount or quality of research. As new studies are performed and reviewed, toxicity values can change. The less information available on a chemical, the greater the possibility that chemical toxicity will be overestimated or underestimated.

The uncertainties discussed above are addressed when developing RfDs by dividing the no observable adverse effect level (NOAEL) from animal studies by uncertainty factors of up to 10,000.

Uncertainty associated with determining chemical carcinogenicity is reflected in the weight-of-evidence classification groups assigned to carcinogens. In addition, uncertainties are introduced because SFs are derived from the low-dose end of the dose-response curves, and the experimental studies are usually conducted at the high-dose end of the curve. The selected 95% UCL of the slope of the dose-response curve is considered an upper-bound toxicity value.

POPT1S601282

Therefore, it is unlikely that the SFs will underestimate risk. Actual cancer risk may range from a low of zero to the upper limit defined by the model.

Uncertainty is also associated with using oral toxicity factors to evaluate dermal exposures. The use of oral toxicity factors as surrogates is necessary because there are no dermal toxicity factors approved by EPA. Most of the uncertainty exists because it is not known whether the compounds in question exhibit the same toxicity via dermal contact as they do via the oral pathway. Default oral absorption factors were used to adjust the oral toxicity factors so that the absorbed doses calculated for the dermal pathway could be evaluated. The use of the oral absorption factors may bias the risk and hazard estimates high or low.

The use of surrogate toxicity factors for chemicals lacking toxicity factors may under- or overestimates the potential risks or hazards.

3.4.4 Risk Characterization

This HHRA used EPA's standard algorithms to calculate chemical intakes and associated health risks and hazards. There are certain assumptions inherent in the use of these equations that add uncertainty. For example, calculations of carcinogenic risks and non-carcinogenic HIs assume the additivity of toxic effects. This assumption adds uncertainty to the assessment and may result in an overestimation or underestimation of the potential risks, depending on whether synergistic or antagonistic conditions apply. Exposure pathway risks are combined assuming that a single receptor may be exposed to contamination through a selected number of pathways concurrently. This is a conservative estimate that may overestimate risks and hazards. Additionally, the standard algorithms used do not consider certain factors, such as absorption or matrix effects. In cases where these processes are important, the risk estimates may overestimate or underestimate the potential human risks at this site.

4.0 LEVEL 1 SCOPING ECOLOGICAL RISK ASSESSMENT

4.4 Exposure Pathways

Groundwater data collected from push probe explorations as part of the RI suggested the potential for site related contaminants to be present in site groundwater. A groundwater monitoring program was initiated by Hahn and Associates and seven monitoring wells were installed at the T1S Site (Hahn and Associates, 2001b). Because the movement of shallow groundwater at the site has been found to be in the direction of the Willamette River, a modified Level 2 Screening ERA was conducted on the available groundwater monitoring data to

POPT1S601283

determine whether contaminants are present in groundwater at concentrations at levels of potential concern to ecological receptors.

The procedures for conducting a Modified Level 2 Screening ERA were presented in the Risk Assessment Work Plan for this site (Hart Crowser, 2001) and further discussed with DEQ in Port of Portland's Response to Review Comments letter (Port of Portland, November 12, 2001). The available groundwater monitoring data, which consists of two rounds of quarterly groundwater monitoring of the seven monitoring wells placed on this site, were screened against appropriate DEQ Ecological Screening Levels (SLs) to determine whether the detected concentrations of contaminants exceeded the risk based screening levels. The Modified Level 2 Screening of groundwater data is presented in Table 12.

The groundwater monitoring well data from each well were screened against the Freshwater Aquatic SLs. No PAHs or VOCs were detected in groundwater at concentrations exceeding their corresponding SLs. There were two metals (copper and lead in MW-3 in the first round of monitoring and lead in MW-7) for which the total metal concentration exceeded the corresponding SL. The concentrations of total copper and lead in MW-3 in the second round of groundwater monitoring conducted in January 2002 were below SLs for these two metals. In addition, the analysis of the dissolved fraction of copper and lead from monitoring wells MW-3 and MW-7 indicates these metals were not detected in the samples, and there are no detected concentrations of analytes that exceed the SLs. As dissolved metals represent the bioavailable fraction of metals in aqueous media, it is concluded that there are no constituents in groundwater at levels of concern to aquatic ecological receptors.

4.5 Conclusions and Recommendations

In October 2001, Hart Crowser completed a Level 1 Scoping ERA for possible ecological receptors and pathways at the T1S Site. The site visit and historical research did not identify any ecologically important species or habitats present in the upland portion of this site. The site is almost entirely paved or covered by buildings. The absence of upland habitat results in no complete exposure pathways to terrestrial species.

A Modified Level 2 Screening ERA was conducted on the two rounds of groundwater monitoring data that have been collected at this site. There were no detected concentrations of organic constituents in the seven groundwater monitoring wells that exceeded their corresponding Ecological SLs. There were two metals (copper and lead) detected in groundwater that exceeded SLs based on the analysis of unfiltered, total metals, but when the same samples were analyzed for dissolved metals, copper and lead were not detected. The

POPT1S601284

dissolved fraction of metals represents the bioavailable fraction in aqueous environmental media. Therefore, it is concluded that there is no potential for adverse ecological impacts to aquatic ecological receptors from the discharge of groundwater to the Willamette River.

No further ERA activities are warranted at this site.

Potential Human Health Risk from Fish Consumption:

The comments received by Hart Crowser on the Marine Terminal 1 Feasibility Study (DEQ Letter dated May 3, 2002) brought up an issue that we believe is more appropriately addressed in the risk assessment. DEQ requests that the potential ecological and human health risks (i.e., via fish consumption) associated with groundwater discharging to surface water be addressed. The evaluation of potential ecological risks was addressed in the modified Level 2-Screening of the groundwater monitoring well data against the new DEQ Aquatic Ecological Screening Levels in Section 4.4 and Table 12 of Hart Crowser's Terminal 1 South Human Health and Ecological Baseline Risk Assessment. The conclusions of the modified Level 2-Screening of the new groundwater data were consistent with the initial results and indicates that the concentrations of compounds of interest in groundwater are below conservative screening levels and are, therefore, below any levels of concern from the aquatic perspective.

To address the potential human health impacts from groundwater discharges into the Willamette River and subsequent fish ingestion by recreational anglers, the available groundwater monitoring data were screened against existing Surface Water Criteria developed for the protection of human health from the ingestion of fish tissue. The existing groundwater data from the two completed rounds of monitoring and the DEQ and EPA screening levels are attached in the accompanying table to this memorandum

- The existing data were compared against two sets of available Surface Water Quality Criteria based on the protection of human health from the consumption of fish tissue: The DEQ Table 20 values that were developed in 1992 and the EPA recommended National Ambient Water Quality Criteria (AWQC) dated April 1999. Both sets of criteria were evaluated, as the criteria for the primary contaminants of concern found in groundwater at the T1S site (PAHs and arsenic) are significantly different for the Table 20 values versus the more recent EPA recommended AWQC (see Attachment A to this Addendum).
- All VOCs (including chloroform) were either not detected or were detected at concentrations below DEQ's Surface Water Criteria for Fish Consumption (Table 20) in all groundwater samples.

POPT1S601285

- Non-carcinogenic PAHs were either not detected or detected at concentrations below both DEQ's Surface Water Criteria for Fish Consumption (Table 20) and EPA's National Recommended AWQC for Fish Consumption in all groundwater samples.

- For carcinogenic PAHs, the DEQ Table 20 does not provide criteria for individual PAHs but a total PAH criteria of 31.1 mg/L. The more recent EPA Recommended Freshwater AWQC for Fish Consumption, which was updated based on toxicity factors present in the EPA IRIS database in 1998, provides criteria for individual PAHs and is also based on a carcinogenic risk standard of 1×10^{-6}, is equivalent to DEQ's individual carcinogen risk standard. We believe the EPA AWQC are more appropriate for use for screening of potential human health risks from fish consumption as it benefits from more recent toxicity information.

- No carcinogenic PAHs were detected in any of the groundwater monitoring wells. However, the detection limits achieved for these samples were above the EPA AWQC for fish consumption. At the present time, there is no reason to believe that carcinogenic PAHs are present in groundwater at this site. Generally, in risk assessments, a proxy concentration of one half the detection limit is often used to represent contaminant concentrations in situations where the contaminant has been detected in at least one sample. While such an analysis is quite conservative in this situation as carcinogenic PAHs were not detected in any of the groundwater samples, the proxy concentration thus generated is generally 0.050 µg/L, essentially equal to the EPA AWQC of 0.049 µg/L. This increases our confidence that levels of carcinogenic PAHs are not present above levels of concern at this site.

- The total and dissolved levels of arsenic found in the groundwater samples exceed both DEQ and National EPA Recommended criteria, as well as the regional Willamette River watershed background level of 2.0 µg/L. However, for the Ross Island Risk Assessments, Hart Crowser worked with DEQ to establish an alternative Surface Water Criterion for Fish Tissue Consumption of 20.5 µg/L based on the EPA Region 6 Interim Strategy: Arsenic – Freshwater Human Health Criterion for Fish Consumption. This value was accepted by DEQ, and all of the groundwater arsenic data (both dissolved and total) collected at the T1S site are below this alternative criterion. The EPA Region 6 Interim Strategy: Arsenic is provided as Attachment B to this addendum.

The conclusions of the human health fish consumption exposure scenario evaluation is that the concentrations of COIs in groundwater are below conservative screening levels and are, therefore, below any levels of concern from a human health perspective. There appears to be no transport mechanism

POPT1S601286

present at this site that would result in unacceptable concentrations of COIs being transported to the Willamette River.

POPT1S601287

Tables

POPT1S601288

Table 1 - Area A COPC Identification Table
Marine Terminal 1 South Risk Assessment
Portland, Oregon

	Soil (Concentrations in mg/kg)						Groundwater (Concentrations in µg/L)							Multiple Media
	PRG	Cij	Rij	COPC?	Rij/Rj	COPC?	PRG	Cij	Rij	COPC?	Rij/Rj	COPC?	SRij	COPC?
Total Petroleum Hydrocarbons														
Diesel	NA	1.2E+03	--	Yes[1]	--	Yes[1]	NA	4.2E+02	--	Yes[1]	--	Yes[1]	na	No
Oil	NA	1.8E+03	--	Yes[1]	--	Yes[1]	--	ND	--	--	--	--	na	No
Semivolatiles														
Acenaphthene	3.7E+03	6.6E+00	1.8E-03	No	8.9E-06	No	3.7E+02	7.2E-01	1.9E-03	No	6.9E-04	No	3.7E-03	No
Acenaphthylene	3.7E+03	5.6E-01	1.5E-04	No	7.6E-07	No	--	ND	--	--	--	--	1.5E-04	No
Anthracene	2.2E+04	1.1E+01	5.2E-04	No	2.6E-06	No	--	ND	--	--	--	--	5.2E-04	No
Benzo(a)anthracene	6.2E-01	9.4E+00	1.5E+01	Yes	7.6E-02	Yes	--	ND	--	--	--	--	1.5E+01	Yes
Benzo(a)pyrene	6.2E-02	7.1E+00	1.1E+02	Yes	5.7E-01	Yes	--	ND	--	--	--	--	1.1E+02	Yes
Benzo(b)fluoranthene	6.2E-01	4.2E+00	6.8E+00	Yes	3.4E-02	Yes	--	ND	--	--	--	--	6.8E+00	Yes
Benzo(g,h,i)perylene	2.3E+03	3.8E+00	1.6E-03	No	8.2E-06	No	--	ND	--	--	--	--	1.6E-03	No
Benzo(k)fluoranthene	6.2E+00	5.5E+00	8.9E-01	No	4.5E-03	No	--	ND	--	--	--	--	8.9E-01	No
Chrysene	6.2E+01	9.6E+00	1.5E-01	No	7.8E-04	No	--	ND	--	--	--	--	1.5E-01	No
Dibenz(a,h)anthracene	6.2E-02	3.5E+01	5.6E+00	Yes	2.8E-02	No	--	ND	--	--	--	--	5.6E+00	Yes
Fluoranthene	2.3E+03	2.0E+01	8.5E-03	No	4.3E-05	No	--	NE	--	--	--	--	8.5E-03	No
Fluorene	2.6E+03	5.7E+00	2.2E-03	No	1.1E-05	No	--	ND	--	--	--	--	2.2E-03	No
Indeno(1,2,3-cd)pyrene	6.2E-01	3.4E+00	5.5E+00	Yes	2.7E-02	No	--	ND	--	--	--	--	5.5E+00	Yes
Naphthalene	5.6E+01	7.9E+00	1.4E-01	No	7.1E-04	No	6.2E+00	2.9E-01	4.7E-02	No	1.7E-02	No	1.9E-01	No
Phenanthrene	2.2E+04	3.5E+01	1.6E-03	No	8.0E-06	No	1.8E+03	1.3E+00	6.9E-04	No	2.5E-04	No	2.3E-03	No
Pyrene	2.3E+03	2.8E+01	1.2E-02	No	6.0E-05	No	--	NE	--	--	--	--	1.2E-02	No
Metals														
Antimony	3.1E+01	2.0E+01	6.3E-01	No	3.2E-03	No	--	ND	--	--	--	--	6.3E-01	No
Arsenic	3.9E-01	1.3E+01	3.3E+01	Yes	1.7E-01	Yes	--	NE	--	--	--	--	3.3E+01	Yes
Cadmium	3.7E+01	7.4E+00	2.0E-01	No	1.0E-03	No	--	ND	--	--	--	--	2.0E-01	No
Chromium	2.1E+02	4.3E+01	2.1E-01	No	1.0E-03	No	--	ND	--	--	--	--	2.1E-01	No
Copper	2.9E+03	2.9E+02	9.9E-02	No	5.0E-04	No	--	NE	--	--	--	--	9.9E-02	No
Lead	4.0E+02	6.2E+03	1.5E+01	Yes	7.8E-02	Yes	--	NE	--	--	--	--	1.5E+01	Yes
Mercury	2.3E+01	9.7E+00	4.1E-01	No	2.1E-03	No	--	ND	--	--	--	--	4.1E-01	No
Nickel	1.6E+03	6.4E+01	4.0E-02	No	2.0E-04	No	--	ND	--	--	--	--	4.0E-02	No
Thallium	5.2E+00	3.5E+00	6.7E-01	No	3.4E-03	No	--	ND	--	--	--	--	6.7E-01	No
Zinc	2.3E+04	3.0E+02	1.3E-02	No	6.5E-05	No	--	ND	--	--	--	--	1.3E-02	No
Volatiles														
Acetone	1.6E+03	2.2E-01	1.4E-04	No	7.1E-07	No	--	ND	--	--	--	--	1.4E-04	No
2-Butanone	7.3E+03	3.5E-02	4.7E-06	No	2.4E-08	No	--	ND	--	--	--	--	4.7E-06	No
Tetrachloroethene	--	nd	--	No	--	No	1.1E+00	3.1E+00	2.8E+00	Yes	9.8E-01	Yes	2.8E+00	Yes
Rj			2.0E+02						2.8E+00					
Nij			3.0E+01						5.0E+00					
1/Nij			3.3E-02						2.0E-01					

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Notes:
(1) COPC identified based on the presence of TPH in site soils and groundwater. No PRG is available for screening.

Variables:
PRG = EPA Region 9 PRG (residential for soil, tap water for groundwater).
Cij = Maximum detected concentration of compound i in medium j.
Rij = Risk ratio for compound i in medium j (Cij/PRG); compound is a COPC if Rij is greater than 1.
Rj = Sum of risk ratios for medium j.
Nij = Number of compounds i detected in medium j.
Rij/Rj = Compound is a COPC if this ratio is greater than 1/Nij.
SRij = Summary risk ratio for compound i in all media (total Rij across all media); compound is a COPC if SRij is greater than 1.

Acronyms:
NA = Not Available.
ND = Not Detected.
NE = Not Evaluated (only volatile compounds evaluated).
-- = Not Applicable.

Table 2 - Area B COPC Identification Table
Marine Terminal 1 South Risk Assessment
Portland, Oregon

	Soil (Concentrations in mg/kg)						Groundwater (Concentrations in µg/L)							
	PRG	Cij	Rij	COPC?	Rij/Rj	COPC?	PRG	Cij	Rij	COPC?	Rij/Rj	COPC?	SRij	Medium COPC?
Total Petroleum Hydrocarbons														
Diesel	NA	1.2E+03	–	Yes[1]	–	Yes[1]	NA	4.2E+02	–	Yes[1]	–	Yes[1]	na	No
Oil	NA	1.8E+03	–	Yes[1]	–	Yes[1]	–	–	–	–	–	–	na	No
Semivolatiles														
Acenaphthene	3.7E+03	1.1E+02	2.9E-02	No	4.8E-04	No	3.7E+02	7.2E-01	1.9E-03	No	–	–	3.1E-02	No
Acenaphthylene	3.7E+03	2.6E-01	7.1E-05	No	1.2E-06	No	–	ND	–	–	–	–	7.1E-05	No
Anthracene	2.2E+04	6.8E+01	3.1E-03	No	5.2E-05	No	–	ND	–	–	–	–	3.1E-03	No
Benzo(a)anthracene	6.2E-01	1.5E+00	2.4E+00	Yes	4.1E-02	Yes	–	ND	–	–	–	–	2.4E+00	Yes
Benzo(a)pyrene	6.2E-02	2.4E+00	3.8E+01	Yes	6.3E-01	Yes	–	ND	–	–	–	–	3.8E+01	Yes
Benzo(b)fluoranthene	6.2E-01	1.6E+00	2.5E+00	Yes	4.2E-02	Yes	–	ND	–	–	–	–	2.5E+00	Yes
Benzo(g,h,i)perylene	2.3E+03	2.5E+00	1.1E-03	No	1.8E-05	No	–	ND	–	–	–	–	1.1E-03	No
Benzo(k)fluoranthene	6.2E+00	1.1E+00	1.8E-01	No	2.9E-03	No	–	ND	–	–	–	–	1.8E-01	No
Chrysene	6.2E+01	1.9E+00	3.0E-02	No	5.1E-04	No	–	ND	–	–	–	–	3.0E-02	No
Dibenz(a,h)anthracene	6.2E-02	2.5E-01	4.1E+00	Yes	6.8E-02	Yes	–	ND	–	–	–	–	4.1E+00	Yes
Fluoranthene	2.3E+03	2.9E+02	1.2E-01	No	2.1E-03	No	–	NE	–	–	–	–	1.2E-01	No
Fluorene	2.6E+03	1.7E+02	6.7E-02	No	1.1E-03	No	–	ND	–	–	–	–	6.7E-02	No
Indeno(1,2,3-cd)pyrene	6.2E-01	1.6E+00	2.5E+00	Yes	4.2E-02	Yes	–	ND	–	–	–	–	2.5E+00	Yes
Naphthalene	5.6E+01	4.0E+00	7.1E-02	No	1.2E-03	No	6.2E+00	2.9E-01	4.7E-02	No	–	–	1.2E-01	No
Phenanthrene	2.2E+04	7.0E+02	3.2E-02	No	5.3E-04	No	1.8E+03	1.3E+00	6.9E-04	No	–	–	3.3E-02	No
Pyrene	2.3E+03	1.4E+02	6.2E-02	No	1.0E-03	No	–	ND	–	–	–	–	6.2E-02	No
Metals														
Antimony	3.1E+01	7.0E-01	2.3E-02	No	3.8E-04	No	–	ND	–	–	–	–	2.3E-02	No
Arsenic	3.9E-01	3.6E+00	9.2E+00	Yes	1.5E-01	Yes	–	NE	–	–	–	–	9.2E+00	Yes
Beryllium	1.5E+02	2.3E-01	1.5E-03	No	2.6E-05	No	–	ND	–	–	–	–	1.5E-03	No
Cadmium	3.7E+01	1.3E+00	3.6E-02	No	6.1E-04	No	–	ND	–	–	–	–	3.6E-02	No
Chromium	2.1E+02	1.6E+01	7.8E-02	No	1.3E-03	No	–	ND	–	–	–	–	7.8E-02	No
Copper	2.9E+03	2.7E+01	9.3E-03	No	1.6E-04	No	–	NE	–	–	–	–	9.3E-03	No
Lead	4.0E+02	1.2E+02	3.0E-01	No	5.1E-03	No	–	NE	–	–	–	–	3.0E-01	No
Mercury	2.3E+01	1.5E-01	6.2E-03	No	1.0E-04	No	–	ND	–	–	–	–	6.2E-03	No
Nickel	1.6E+03	2.4E+01	1.5E-02	No	2.5E-04	No	–	ND	–	–	–	–	1.5E-02	No
Thallium	5.2E+00	6.1E-02	1.2E-02	No	2.0E-04	No	–	ND	–	–	–	–	1.2E-02	No
Zinc	2.3E+04	1.4E+02	6.1E-03	No	1.0E-04	No	–	ND	–	–	–	–	6.1E-03	No
Volatiles														
Chloroform	–	nd	–	No	–	No	1.6E-01	2.1E+00	1.3E+01	Yes	4.8E+00	Yes	1.3E+01	Yes
Rj			6.0E+01						1.3E+01					
Nij			2.9E+01						5.0E+00					
1/Nij			3.4E-02						2.0E-01					

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Notes:
(1) COPC identified based on the presence of TPH in site soils and groundwater. No PRG is available for screening.

Variables:
PRG = EPA Region 9 PRG (residential for soil, tap water for groundwater).
Cij = Maximum detected concentration of compound i in medium j.
Rij = Risk ratio for compound i in medium j (Cij/PRG); compound is a COPC if Rij is greater than 1.
Rj = Sum of risk ratios for medium j.
Nij = Number of compounds i detected in medium j.
Rij/Rj = Compound is a COPC if this ratio is greater than 1/Nij.
SRij = Summary risk ratio for compound i in all media (total Rij across all media); compound is a COPC if Sri is greater than 1.

Acronyms:
NA = Not Available.
ND = Not Detected.
NE = Not Evaluated (only volatile compounds evaluated).
– = Not Applicable.

Table 3 - Area C COPC Identification Table
Marine Terminal 1 South Risk Assessment
Portland, Oregon

	Soil (Concentrations in mgkg)						*Groundwater (Concentrations in µg/L)*							Medium
	PRG	Cij	Rij	COPC?	Rij/Rj	COPC?	PRG	Cij	Rij	COPC?	Rij/Rj	COPC?	SRij	COPC?
Metals														
Arsenic	3.9E-01	1.2E+01	3.0E+01	Yes	9.9E-01	Yes	--	--	--	--	--	--	3.0E+01	Yes
Beryllium	1.5E+02	7.8E-01	5.2E-03	No	1.7E-04	No	--	--	--	--	--	--	5.2E-03	No
Cadmium	3.7E+01	1.3E+00	3.5E-02	No	1.2E-03	No	--	--	--	--	--	--	3.5E-02	No
Chromium	2.1E+02	2.6E+01	1.2E-01	No	4.0E-03	No	--	--	--	--	--	--	1.2E-01	No
Copper	2.9E+03	1.9E+01	6.6E-03	No	2.1E-04	No	--	--	--	--	--	--	6.6E-03	No
Lead	4.0E+02	1.6E+01	3.9E-02	No	1.3E-03	No	--	--	--	--	--	--	3.9E-02	No
Nickel	1.6E+03	1.9E+01	1.2E-02	No	3.9E-04	No	--	--	--	--	--	--	1.2E-02	No
Zinc	2.3E+04	7.7E+01	3.3E-03	No	1.1E-04	No	--	--	--	--	--	--	3.3E-03	No
Rj			3.0E+01						0.0E+00					
Nij			8.0E+00						0.0E+00					
1/Nij			1.3E-01						--					

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Variables:
PRG = EPA Region 9 PRG (residential for soil, tap water for groundwater).
Cij = Maximum detected concentration of compound i in medium j.
Rij = Risk ratio for compound i in medium j (Cij/PRG); compound is a COPC if Rij is greater than 1.
Rj = Sum of risk ratios for medium j.
Nij = Number of compounds i detected in medium j.
Rij/Rj = Compound is a COPC if this ratio is greater than 1/Nij.
SRij = Summary risk ratio for compound i in all media (total Rij across all media); compound is a COPC if Srij is greater than 1.

Acronyms:
-- = Not Applicable.

Table 4 - Exposure Point Concentrations: Soil and Groundwater
Marine Terminal 1 South Risk Assessment
Portland, Oregon

Analyte	Detection Frequency	SQL Range (Min-Max)	Detect Range (Min-Max)	max	Sample ID of Maximum Detection	Distribution	90 % UCL	Arithmetic Mean	EPC RME	EPC CT
AREA A: SURFACE SOIL (0 to 3 feet bgs)										
PAHs in mg/kg										
Benzo(a)anthracene	7/18	0.0134 - 1.0	0.0275 - 9.35	9.35	B-68	Weak Lognormal	2.0E+00	6.7E-01	2.0E+00	6.7E-01
Benzo(a)pyrene	7/18	0.0134 - 1.0	0.0292 - 7.05	7.05	B-68	Weak Lognormal	1.8E+00	5.5E-01	1.8E+00	5.5E-01
Benzo(b)fluoranthene	6/18	0.0134 - 1.0	0.0189 - 4.22	4.22	B-68	Weak Lognormal	1.4E+00	4.0E-01	1.4E+00	4.0E-01
Dibenz(a,h)anthracene	3/18	0.01 - 1.34	0.033 - 0.16	0.16	B-94	Weak Lognormal	1.8E-01	9.0E-02	1.6E-01	9.0E-02
Indeno(1,2,3-cd)pyrene	6/18	0.0134 - 1.0	0.0131 - 3.38	3.38	B-68	Weak Lognormal	7.4E-01	2.8E-01	7.4E-01	2.8E-01
Metals in mg/kg										
Arsenic	7/10	1.0	1.49 - 12.9	12.9	B-68	Lognormal	8.4E+00	3.3E+00	8.4E+00	3.3E+00
Lead	7/12	1.0 - 10.0	9.21 - 6,190	6190	B-68	Lognormal	1.7E+04	5.4E+02	6.2E+03	5.4E+02
TPH in mg/kg										
Diesel Range	5/18	24.4 - 506	36.0 - 653	653	B-68	Assm. Lognormal	1.8E+02	9.7E+01	1.8E+02	9.7E+01
Oil-Range	6/18	50.0 - 61.7	72.1 - 1,300	1300	B-94	Assm. Lognormal	3.8E+02	2.1E+02	3.8E+02	2.1E+02
AREA A: TOTAL SOIL (0 to 15 feet bgs)										
PAHs in mg/kg										
Benzo(a)anthracene	16/41	0.01 - 1.0	0.0203 - 9.35	9.35	B-68	Weak Lognormal	9.4E+00	3.7E-01	9.4E+00	3.7E-01
Benzo(a)pyrene	16/41	0.01 - 1.0	0.0157 - 7.05	7.05	B-68	Weak Lognormal	3.7E-01	3.3E-01	3.7E-01	3.3E-01
Benzo(b)fluoranthene	16/41	0.01 - 1.0	0.018 - 4.22	4.22	B-68	Weak Lognormal	3.4E-01	2.7E-01	3.4E-01	2.7E-01
Dibenz(a,h)anthracene	6/41	0.01 - 1.34	0.015 - 0.35	0.35	B-38	Weak Lognormal	7.0E-02	6.0E-02	7.0E-02	6.0E-02
Indeno(1,2,3-cd)pyrene	14/41	0.01 - 1.0	0.0131 - 3.38	3.38	B-68	Weak Lognormal	2.0E-01	1.8E-01	2.0E-01	1.8E-01
Metals in mg/kg										
Arsenic	12/15	1.0	1.35 - 12.9	12.9	B-68	Lognormal	6.0E+00	3.4E+00	6.0E+00	3.4E+00
Lead	11/18	1.0 - 10.0	2.73 - 6,190	6190	B-68	Lognormal	5.0E+03	4.3E+02	5.0E+03	4.3E+02
TPH in mg/kg										
Diesel Range	11/53	24.4 - 506	25.5 - 1,170	1170	B-102	Assm. Lognormal	8.7E+01	9.6E+01	9.6E+01	9.6E+01
Oil-Range	16/53	50.0 - 69.4	62.0 - 1,760	1760	B-102	Assm. Lognormal	1.8E+02	2.0E+02	2.0E+02	2.0E+02
AREA A: GROUNDWATER										
Tetrachloroethene	2/7	1.0	2.76 - 3.06	2.66	MW-1	Maximum	2.7E+00	1.2E+00	2.7E+00	1.2E+00

Please refer to notes at end of table.

Table 4 - Exposure Point Concentrations: Soil and Groundwater
Marine Terminal 1 South Risk Assessment
Portland, Oregon

Analyte	Detection Frequency	SQL Range (Min-Max)	Detect Range (Min-Max)	max	Sample ID of Maximum Detection	Distribution	90 % UCL	Arithmetic Mean	EPC RME	EPC CT
AREA B: SURFACE SOIL (0 to 3 feet bgs)										
PAHs in mg/kg										
Benzo(a)anthracene	4/7	0.0134 - 0.067	0.0448 - 0.149	0.149	B-87	Lognormal	1.7E-01	6.0E-02	1.5E-01	6.0E-02
Benzo(a)pyrene	4/7	0.0134 - 0.067	0.0501 - 0.188	0.188	B-87	Lognormal	2.1E-01	7.0E-02	1.9E-01	7.0E-02
Benzo(b)fluoranthene	4/7	0.0134 - 0.067	0.0402 - 0.134	0.134	B-64/B-64a	Lognormal	1.8E-01	6.0E-02	1.3E-01	6.0E-02
Indeno(1,2,3-cd)pyrene	4/7	0.0134 - 0.067	0.0281 - 0.117	0.117	B-64/B-64a	Lognormal	1.4E-01	5.0E-02	1.2E-01	5.0E-02
Metals in mg/kg										
Arsenic	4/4	--	2.6 - 3.1	3.1	B-31	NA	3.1E+00	2.9E+00	3.1E+00	2.9E+00
TPH in mg/kg										
Oil-Range	4/9	50.0	1,170 - 6,030	6030	B-5	Weak Lognormal	1.6E+05	1.2E+03	6.0E+03	1.2E+03
AREA B: TOTAL SOIL (0 to 15 feet bgs)										
PAHs in mg/kg										
Benzo(a)anthracene	13/18	0.0134 - 1.68	0.02 - 1.51	1.51	B-92	Lognormal	1.7E+00	4.0E-01	1.5E+00	4.0E-01
Benzo(a)pyrene	13/18	0.0134 - 1.68	0.0246 - 2.35	2.35	B-92	Lognormal	2.1E+00	4.7E-01	2.1E+00	4.7E-01
Benzo(b)fluoranthene	13/18	0.0134 - 1.68	0.0215 - 1.54	1.54	B-92	Lognormal	1.4E+00	3.7E-01	1.4E+00	3.7E-01
Dibenz(a,h)anthracene	4/18	0.0134 - 1.68	0.0839 - 0.253	0.253	B-92	Lognormal	2.3E-01	1.1E-01	2.3E-01	1.1E-01
Indeno(1,2,3-cd)pyrene	13/18	0.0134 - 1.68	0.0193 - 1.56	1.56	B-92	Lognormal	9.0E-01	2.9E-01	9.0E-01	2.9E-01
Metals in mg/kg										
Arsenic	6/6	--	2.05 - 3.6	3.6	B-63/B-63a	Lognormal	3.3E+00	2.9E+00	3.3E+00	2.9E+00
TPH in mg/kg										
Diesel Range	5/30	20.8 - 2,500	29.0 - 3,440	3440	B-63/B-63a	Assm. Lognormal	4.8E+02	2.7E+02	4.8E+02	2.7E+02
Oil-Range	16/30	50.0 - 52.1	62.7 - 20,700	20700	B-65/B-65a	Assm. Lognormal	6.8E+03	1.7E+03	6.8E+03	1.7E+03
AREA B: GROUNDWATER										
Chloroform	1/7	1.0	2.09	2.09	MW-5	Maximum	2.1E+00	7.3E-01	2.1E+00	7.3E-01
AREA C: SURFACE SOIL (0 to 3 feet bgs)										
Metals in mg/kg										
Arsenic	1/1	--	2.9	2.9	B-32	NA	2.9E+00	2.9E+00	2.9E+00	2.9E+00
AREA C: TOTAL SOIL (0 to 15 feet bgs)										
Metals in mg/kg										
Arsenic	3/3	--	2.72 - 11.8	11.8	B-3	NA	1.2E+01	5.8E+00	1.2E+01	5.8E+00

F:\DATA\Jobs\Port of Portland\15191-01 T-1 Risk Assessment\TablesTable 4, EPC

Notes:

Acronyms and Abbreviations:

EPC = Exposure point concentration.
PAHs = Polynuclear aromatic hydrocarbons.
RME = Reasonable maximum exposure.
TPH = Total petroleum hydrocarbons.
UCL = Upper confidence limit on the mean.
VOCs = Volatile organic compounds.
CT = Central Tendency.
SQL = Standard quantification limit.
NA = Not applicable.

Table 5 - Exposure Dose Equations and Exposure Factor Values: Soil Ingestion
Marine Terminal 1 South Risk Assessment
Portland, Oregon

$$LADD^{a}(mg/kg\text{-}d) = \frac{C_{soil} \times IRS \times CF \times EF \times ED}{BW \times At_{carc}}$$

$$ADD^{b}(mg/kg\text{-}d) = \frac{C_{soil} \times IRS \times CF \times EF \times ED}{BW \times At_{non}}$$

EXPOSURE FACTOR (units)	RME[e] Value	CT[f] Value
C_{soil} = Chemical concentration in soil (mg/kg)	UCL_{90}[c]	Arithmetic Mean
CF = Conversion factor (kg/mg)	10^{-6}	10^{-6}
IRS = Incidental Soil Ingestion Rate (mg/d)		
Commercial Worker	100[d]	50[d]
Utility/Excavation Worker	480[d]	100[d]
Construction Worker	330[g]	100[h]
Resident – Adult	100[d]	50[d]
Resident – Child	400[d]	100[d]
EF = Exposure frequency (days/year)		
Commercial Worker	250[d]	250[d]
Utility/Excavation Worker	9[d]	9[d]
Construction Worker	250[g]	250[h]
Resident – Adult/Child	350[d]	40[d]
ED = Exposure duration (year)		
Commercial Worker	25[d]	6[d]
Utility/Excavation Worker	1[d]	0.5[d]
Construction Worker	1[g]	0.5[h]
Resident – Adult	30[d]	9[d]
Resident – Child	6[d]	6[d]
BW = Body weight (kg)		
Adult	70[d]	70[d]
Child	15[d]	15[d]
AT_{carc} = Averaging time for carcinogens (days)	25,550[d]	25,550[d]
AT_{non} = Averaging time for noncarcinogens (days)	ED (years) x 365 days/year	ED (years) x 365 days/year

F:\DATA\Jobs\Port of Portland\15191-01 T-1 Risk Assessment\Tables\Table5Soil-Ing(T1)

Notes:

(a) Lifetime average daily dose, the intake value used to evaluate potential carcinogenic effects. For the residential evaluation, the adult and child intakes will be combined as recommended in Appendix A, Section A.0 of DEQ guidance (2000).
(b) Average daily dose, the intake value used to evaluate potential noncarcinogenic effects.
(c) An upper one-sided 90 percent confidence limit of the mean or the maximum concentration (whichever is lower) used for the RME.
(d) DEQ (December 2000).
(e) Reasonable maximum exposure.
(f) Central Tendency.
(g) EPA 2001.
(h) Values consistent with development of Utility/Excavation Worker CT Values.

Table 6 - Exposure Dose Equations and Exposure Factor Values: Dermal Contact with Soil
Marine Terminal 1 South Risk Assessment
Portland, Oregon

$$LADD^{a}\ (mg/kg\text{-}d) = \frac{C_{soil} \times AF \times SA \times DAF \times EF \times ED \times CF}{BW \times At_{carc}}$$

$$ADD^{b}\ (mg/kg\text{-}d) = \frac{C_{soil} \times AF \times SA \times DAF \times EF \times ED \times CF}{BW \times At_{non}}$$

Exposure Factor (units)			RME[e] Value	CT[f] Value
C_{soil}	=	Chemical concentration in soil (mg/kg)	UCL_{90}[c]	Arithmetic Mean
AF	=	Soil-to-skin adherence factor (mg/cm^2-event)		
		Commercial Worker	0.08[d]	0.08[d]
		Utility/Excavation Worker	1.0[d]	0.3[d]
		Construction Worker	0.3[h]	0.3[g]
		Resident – Adult	0.08[d]	0.08[d]
		Resident – Child	1.0[d]	0.3[d]
SA	=	Skin surface area (cm^2/day)		
		Commercial Worker	4100[d]	3200[d]
		Utility/Excavation Worker	4100[d]	3200[d]
		Construction Worker	3300[h]	3200[g]
		Resident – Adult	6900[d]	5200[d]
		Resident – Child	5000[d]	4500[d]
DAF	=	Dermal absorption factor (unitless)	Chemical-specific	Chemical-specific
EF	=	Exposure frequency (days/year)		
		Commercial Worker	250[d]	250[d]
		Utility/Excavation Worker	9[d]	9[d]
		Construction Worker	250[h]	250[h]
		Resident – Adult/Child	350[d]	40[d]
ED	=	Exposure duration (years)		
		Commercial Worker	25[d]	6[d]
		Utility/Excavation Worker	1[d]	0.5[d]
		Construction Worker	1[h]	0.5[i]
		Resident – Adult	30[d]	9[d]
		Resident – Child	6[d]	6[d]
CF	=	Conversion factor (kg/mg)	10^{-6}	10^{-6}
BW	=	Body weight (kg)		
		Adult	70[d]	70[d]
		Child	15[d]	15[d]
AT_{carc}	=	Averaging time for carcinogens (days)	25,550[d]	25,550[d]
AT_{non}	=	Averaging time for noncarcinogens (days)	ED (years) x 365 days/year[d]	ED (years) x 365 days/year[d]

F:\DATA\Jobs\Port of Portland\15191-01 T-1 Risk Assessment\Tables\Table6Derm(T1)

Notes:
(a) Lifetime absorbed daily dose, intake value used to evaluate potential carcinogenic effects. For the residential evaluation, the adult and child intakes will be combined as recommended in Appendix A, Section A.0 of DEQ guidance (2000).
(b) Absorbed daily dose, intake value used to evaluate potential noncarcinogenic effects.
(c) An upper one-sided 90 percent confidence limit of the mean or the maximum concentration (whichever is lower) was used for the RME.
(d) DEQ (December 2000).
(e) Reasonable maximum exposure.
(f) Central Tendency.
(g) Equal to DEQ Utility/Excavation Worker Values.
(h) EPA 2001
(i) Values consistent with development of Utility/Excavation Worker CT Values.

Table 7 - Exposure Dose Equations and Exposure Factor Values: Inhalation of Volatiles
Marine Terminal 1 South Risk Assessment
Portland, Oregon

$$LADD^{a}\ (mg/kg\text{-}d) = \frac{C_{air} \times IR \times EF \times ED}{BW \times At_{carc}}$$

$$ADD^{b}\ (mg/kg\text{-}d) = \frac{C_{air} \times IR \times EF \times ED}{BW \times At_{non}}$$

Exposure Factor (units)	RME[f] Value	CT[g] Value
C_{air}[d] = Chemical concentration in air (mg/m^3)	UCL_{90}[c]	Arithmetic Mean
IR = Inhalation rate (m^3/day)		
Commercial Worker	15.2[e]	15.2[e]
Utility/Excavation Worker	15.2[e]	15.2[e]
Construction Worker	20[i]	15.2[h]
Resident – Adult	15.2[e]	15.2[e]
Resident – Child	8.3[e]	8.3[e]
EF = Exposure frequency (days/year)		
Commercial Worker	250[e]	250[e]
Utility/Excavation Worker	9[e]	9[e]
Construction Worker	250[i]	250[i]
Resident – Adult/Child	350[e]	350[e]
ED = Exposure duration (years)		
Commercial Worker	25[e]	6[e]
Utility/Excavation Worker	1[e]	0.5[e]
Construction Worker	1[i]	0.5[i]
Resident – Adult	30[e]	9[e]
Resident – Child	6[e]	6[e]
BW = Body weight (kg)		
Adult	70[e]	70[e]
Child	15[e]	15[e]
AT_{carc} = Averaging time for carcinogens (days)	25,550[e]	25,550[e]
At_{non} = Averaging time for noncarcinogens (days)	ED (years) x 365 days/year	ED (years) x 365 days/year

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Notes:
(a) Lifetime average daily dose, intake value used to evaluate potential carcinogenic effects. For the residential evaluation, the adult and child intakes will be combined as recommended in Appendix A, Section A.0 of DEQ guidance (2000).
(b) Average daily dose, intake value used to evaluate potential noncarcinogenic effects.
(c) Upper one-sided 90 percent confidence limit of the mean or the maximum concentration (whichever is lower) was used for the RME.
(d) C_{air} was derived from soil and groundwater concentrations using models discussed in DEQ guidance (1999 and 2000).
(e) DEQ (December 2000).
(f) Reasonable maximum exposure.
(g) Central Tendency.
(h) Equal to DEQ Utility/Excavation Worker Values.
(i) EPA 2001
(j) Values consistent with development of Utility/Excavation Worker CT Values.

Table 8 - Exposure Dose Equations and Exposure Factor Values:
Inhalation of Dust
Marine Terminal 1 South Risk Assessment
Portland, Oregon

$$LADD^{a}\ (mg/kg\text{-}d) = \frac{PM_{10} \times IR \times EF \times ED}{BW \times At_{carc}}$$

$$ADD^{b}\ (mg/kg\text{-}d) = \frac{PM_{10} \times IR \times EF \times ED}{BW \times At_{non}}$$

Exposure Factor (units)	RME[f] Value	CT[g] Value
PM_{10}[d] = Respirable particulate concentration in air (mg/m^3)	UCL_{90}[c]	Arithmetic Mean
IR = Inhalation rate (m^3/day)		
Commercial Worker	15.2[e]	15.2[e]
Utility/Excavation Worker	15.2[e]	15.2[e]
Construction Worker	20[i]	15.2[h]
Resident – Adult	15.2[e]	15.2[e]
Resident – Child	8.3[e]	8.3[e]
EF = Exposure frequency (days/year)		
Commercial Worker	250[e]	250[e]
Utility/Excavation Worker	9[e]	9[e]
Construction Worker	250[i]	250[j]
Resident – Adult/Child	350[e]	350[e]
ED = Exposure duration (years)		
Commercial Worker	25[e]	6[e]
Utility/Excavation Worker	1[e]	0.5[e]
Construction Worker	1[i]	0.5[j]
Resident – Adult	30[e]	9[e]
Resident – Child	6[e]	6[e]
BW = Body weight (kg)		
Adult	70[e]	70[e]
Child	15[e]	15[e]
AT_{carc} = Averaging time for carcinogens (days)	25,550[e]	25,550[e]
At_{non} = Averaging time for noncarcinogens (days)	ED (years) x 365 days/year	ED (years) x 365 days/year

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Notes:
(a) Lifetime average daily dose, intake value used to evaluate potential carcinogenic effects. For the residential evaluation, the adult and child intakes will be combined as recommended in Appendix A, Section A.0 of DEQ guidance (2000).
(b) Average daily dose, intake value used to evaluate potential noncarcinogenic effects.
(c) Upper one-sided 90 percent confidence limit of the mean or the maximum concentration (whichever is lower) was used for the RME.
(d) PM_{10} was derived using the Particulate Emission Factor equation presented in DEQ guidance (2000).
(e) DEQ (December 2000).
(f) Reasonable maximum exposure.
(g) Central Tendency.
(h) Equal to DEQ Utility/Excavation Worker Values.
(i) EPA 2001
(j) Values consistent with development of Utility/Excavation Worker CT Values.

Table 9 - Human Health Toxicity Assessment
Marine Terminal 1 South Risk Assessment
Portland, Oregon

Noncarcinogenic Toxicity Values

Compound of Potential Concern	Oral RfD Citation	Oral RfD in mg/kg-day	Critical Effect	Uncertainty Factor	Inhalation RfD Citation	Inhalation RfD in mg/kg-day	Critical Effect	Uncertainty Factor
Volatile Organics								
Chloroform	NA	NA	NA	NA	NCEA	8.60E-05	NA	NA
Tetrachloroethene	NA	NA	NA	NA	NCEA/ODEQ	8.40E-02	NA	NA
Metals								
Arsenic	IRIS	3.00E-04	Hyperpigmentation, keratosis and possible vascular complications	3	NA	NA	NA	NA

Carcinogenic Toxicity Values

Compound of Potential Concern	Oral CSF Citation	Oral CSF in $(mg/kg\text{-}day)^{-1}$	Type of Cancer	Slope Factor/ Unit Risk: Weight of Evidence	Inhalation CSF Citation	Inhalation CSF in $(mg/kg\text{-}day)^{-1}$	Type of Cancer	Weight of Evidence
Volatile Organics								
Chloroform	NA	NA	NA	NA	IRIS	0.081	Hepatocellular Carcinoma	B2
Tetrachloroethene	NCEA	0.052	NA	NA	NCEA/ODEQ	2.6E-03	NA	C-B2
Semivolatile Organics								
Benzo(a)anthracene	IRIS	7.3E-01	see Benzo(a)pyrene	B2	NCEA	3.1E-01	NA	NA
Benzo(a)pyrene	IRIS	7.3E+00	Stomach, larynx, and esophagus	B2	NCEA	3.1E+00	NA	NA
Benzo(b)fluoranthene	IRIS	7.3E-01	see Benzo(a)pyrene	B2	NCEA	3.1E-01	NA	NA
Dibenz(a,h)anthracene	IRIS	7.3E+00	see Benzo(a)pyrene	B2	NCEA	3.1E+00	NA	NA
Indeno(1,2,3-cd)pyrene	IRIS	7.3E-01	see Benzo(a)pyrene	B2	NCEA	3.1E-01	NA	NA
Metals								
Arsenic	IRIS	1.5E+00	Skin	A	IRIS	1.5E+01	Lung	A

F:\DATA\Jobs\Port of Portland\15191-01 T-1 Risk Assessment\Tables\Table 9 Toxicity Data

Notes:
IRIS = Integrated Risk Information System (On-line Database).
NCEA = National Center for Environmental Assessment (EPA, 2000a).
ODEQ = Oregon Department of Environmental Quality (DEQ, 2001b).
NA = Not Available or Not Applicable.
RfD = Reference Dose.
CSF = Carcinogenic slope factor.
A = Human Carcinogen.
B2 = Probable human carcinogen - based on sufficient evidence of carcinogenicity in animals.

Table 10 - Risk and Hazard Summary: By Exposure Pathway
Marine Terminal 1 South Risk Assessment
Portland, Oregon

		RME Cancer Risk					RME Hazard Index				
SubArea	Exposure Scenario	Ingestion	Dermal	Inhalation of Volatiles	Inhalation of Dust	TOTAL	Ingestion	Dermal	Inhalation of Volatiles	Inhalation of Dust	TOTAL
Area A	Resident	8.E-05	8.E-05	4.E-09	3.E-08	**2.E-04**	7.E-01	3.E-01	8.E-05	0.E+00	**1.E+00**
	Commercial Worker	1.E-05	3.E-06	5.E-10	5.E-09	**1.E-05**	3.E-02	3.E-03	5.E-06	0.E+00	**3.E-02**
	Excavation Worker	5.E-08	3.E-08	9.E-14	5.E-12	**8.E-08**	3.E-03	9.E-04	3.E-08	0.E+00	**4.E-03**
	Construction Worker	6.E-07	1.E-07	3.E-12	2.E-10	**7.E-07**	6.E-02	6.E-03	1.E-06	0.E+00	**7.E-02**
Area B	Resident	2.E-05	1.E-05	3.E-08	9.E-09	**3.E-05**	3.E-01	1.E-01	2.E-02	0.E+00	**4.E-01**
	Commercial Worker	2.E-06	4.E-07	1.E-10	2.E-09	**2.E-06**	1.E-02	1.E-03	1.E-06	0.E+00	**1.E-02**
	Excavation Worker	6.E-08	6.E-08	3.E-14	3.E-12	**1.E-07**	2.E-03	5.E-04	1.E-08	0.E+00	**3.E-03**
	Construction Worker	1.E-06	4.E-07	1.E-12	1.E-10	**1.E-06**	4.E-02	3.E-03	4.E-07	0.E+00	**4.E-02**
Area C	Resident	1.E-05	4.E-06	NA	8.E-09	**2.E-05**	2.E-01	9.E-02	NA	0.E+00	**3.E-01**
	Commercial Worker	2.E-06	1.E-07	NA	2.E-09	**2.E-06**	9.E-03	9.E-04	NA	0.E+00	**1.E-02**
	Excavation Worker	4.E-08	1.E-08	NA	1.E-11	**5.E-08**	7.E-03	2.E-03	NA	0.E+00	**9.E-03**
	Construction Worker	8.E-07	8.E-08	NA	4.E-10	**9.E-07**	1.E-01	1.E-02	NA	0.E+00	**1.E-01**

		CT Cancer Risk					CT Hazard Index				
SubArea	Exposure Scenario	Ingestion	Dermal	Inhalation of Volatiles	Inhalation of Dust	TOTAL	Ingestion	Dermal	Inhalation of Volatiles	Inhalation of Dust	TOTAL
Area A	Resident	7.E-07	8.E-07	7.E-10	2.E-09	**2.E-06**	8.E-03	3.E-03	3.E-05	0.E+00	**1.E-02**
	Commercial Worker	4.E-07	2.E-07	6.E-11	5.E-10	**6.E-07**	5.E-03	8.E-04	2.E-06	0.E+00	**6.E-03**
	Excavation Worker	2.E-09	1.E-09	2.E-14	2.E-12	**3.E-09**	4.E-04	1.E-04	1.E-08	0.E+00	**5.E-04**
	Construction Worker	6.E-08	4.E-08	6.E-13	4.E-11	**1.E-07**	1.E-02	3.E-03	4.E-07	0.E+00	**1.E-02**
Area B	Resident	3.E-07	2.E-07	4.E-09	2.E-09	**5.E-07**	7.E-03	3.E-03	6.E-03	0.E+00	**2.E-02**
	Commercial Worker	2.E-07	5.E-08	1.E-11	4.E-10	**3.E-07**	5.E-03	7.E-04	4.E-07	0.E+00	**6.E-03**
	Excavation Worker	2.E-09	2.E-09	5.E-15	1.E-12	**4.E-09**	3.E-04	1.E-04	4.E-09	0.E+00	**4.E-04**
	Construction Worker	7.E-08	5.E-08	2.E-13	4.E-11	**1.E-07**	9.E-03	3.E-03	1.E-07	0.E+00	**1.E-02**
Area C	Resident	3.E-07	1.E-07	NA	2.E-09	**4.E-07**	7.E-03	3.E-03	NA	0.E+00	**1.E-02**
	Commercial Worker	2.E-07	3.E-08	NA	4.E-10	**2.E-07**	5.E-03	7.E-04	NA	0.E+00	**6.E-03**
	Excavation Worker	2.E-09	6.E-10	NA	3.E-12	**3.E-09**	7.E-04	2.E-04	NA	0.E+00	**9.E-04**
	Construction Worker	6.E-08	2.E-08	NA	7.E-11	**8.E-08**	2.E-02	5.E-03	NA	0.E+00	**2.E-02**

F:\DATA\Jobs\Port of Portland\15191-01 T-1 Risk Assessment\Tables\Table 10 and 11 Risk Sum

Note:
1. Shaded boxes indicate exposure scenaros that exceed DEQ's acceptable risk targets.

Table 11 - RME Risk Summary: By COPC
Marine Terminal 1 South Risk Assessment
Portland, Oregon

SubArea	Exposure Scenario	COPC	RME Cancer Risk				
			Ingestion	Dermal	Inhalation of Volatiles	Inhalation of Dust	TOTAL
Area A	Resident	Benzo(a)anthracene	4.E-06	6.E-06	na	1.E-10	1.E-05
		Benzo(a)pyrene	4.E-05	5.E-05	na	1.E-09	9.E-05
		Benzo(b)fluoranthene	3.E-06	4.E-06	na	8.E-11	7.E-06
		Dibenz(a,h)anthracene	3.E-06	5.E-06	na	1.E-10	8.E-06
		Indeno(1,2,3-cd)pyrene	1.E-06	2.E-06	na	4.E-11	4.E-06
		Arsenic	3.E-05	1.E-05	na	2.E-08	5.E-05
		Tetrachloroethene	na	na	4.E-09	na	4.E-09
		TOTAL	**8.E-05**	**8.E-05**	**4.E-09**	**3.E-08**	**2.E-04**
	Commercial Worker	Benzo(a)anthracene	5.E-07	2.E-07	na	3.E-11	7.E-07
		Benzo(a)pyrene	5.E-06	2.E-06	na	2.E-10	7.E-06
		Benzo(b)fluoranthene	4.E-07	2.E-07	na	2.E-11	5.E-07
		Dibenz(a,h)anthracene	4.E-07	2.E-07	na	2.E-11	6.E-07
		Indeno(1,2,3-cd)pyrene	2.E-07	8.E-08	na	9.E-12	3.E-07
		Arsenic	4.E-06	4.E-07	na	5.E-09	5.E-06
		Tetrachloroethene	na	na	6.E-10	na	6.E-10
		TOTAL	**1.E-05**	**3.E-06**	**6.E-10**	**5.E-09**	**1.E-05**
Area B	Resident	Benzo(a)anthracene	3.E-07	4.E-07	na	9.E-12	7.E-07
		Benzo(a)pyrene	4.E-06	5.E-06	na	1.E-10	9.E-06
		Benzo(b)fluoranthene	3.E-07	4.E-07	na	8.E-12	6.E-07
		Indeno(1,2,3-cd)pyrene	2.E-07	3.E-07	na	7.E-12	6.E-07
		Arsenic	1.E-05	4.E-06	na	9.E-09	1.E-05
		Chloroform	na	na	3.E-08	na	3.E-08
		TOTAL	**2.E-05**	**1.E-05**	**na**	**9.E-09**	**3.E-05**
	Commercial Worker	Benzo(a)anthracene	4.E-08	2.E-08	na	2.E-12	5.E-08
		Benzo(a)pyrene	5.E-07	2.E-07	na	2.E-11	7.E-07
		Benzo(b)fluoranthene	3.E-08	1.E-08	na	2.E-12	5.E-08
		Indeno(1,2,3-cd)pyrene	3.E-08	1.E-08	na	2.E-12	4.E-08
		Arsenic	2.E-06	2.E-07	na	2.E-09	2.E-06
		TOTAL	**2.E-06**	**4.E-07**	**na**	**2.E-09**	**3.E-06**
Area C	Resident	Arsenic	1.E-05	4.E-06	na	8.E-09	2.E-05
	Commercial Worker	Arsenic	2.E-06	2.E-07	na	2.E-09	2.E-06

F:\DATA\Jobs\Port of Portland\15191-01 T-1 Risk Assessment\Tables\Table 10 and 11 Risk Sum

Note:
1. Shaded boxes indicate COPC that exceeds DEQ acceptable risk target.

Table 12 - Modified Level 2 Screening of Groundwater Results
Marine Terminal 1 South Risk Assessment
Portland, Oregon

Station Sampling Date	MW-1 10/01/2001	MW-1 1/18/2002	MW-2 10/01/2001	MW-2 1/18/2002	MW-3 9/28/2001	MW-3 1/18/2002	MW-4 9/28/2001	MW-4 1/17/2002	MW-5 9/28/2001	MW-5 1/18/2002	MW-6 9/28/2001	MW-6 1/17/2002	MW-7 10/01/2001	MW-7 1/17/2002	DEQ SBV Aquatic
Total Metals in µg/L															
Arsenic	2.01	1.2	12.8	10.8	14	3.92	6.45	9.23	12.1	1.56	2.72	1.16	1.38	1.32	150
Cadmium	1 U	NA	NA	NA	NA	NA	1 U	NA	NA	NA	NA	NA	NA	NA	2.2
Chromium	3.25	2.52	NA	1.89	NA	1.56	5.12	2.26	NA	1.31	NA	2.81	NA	1.69	74
Copper	4.74	2.04	2 U	2 U	102	2.29	4.48	2 U	2.95	2 U	2.51	3.31	2 U	2 U	9
Lead	1.16	1 U	1 U	1 U	38.2	1 U	2.49	1 U	1.46	1 U	1 U	1.86	4.5	3.94	2.5
Mercury	0.2 U	NA	NA	NA	NA	NA	0.2 U	NA	NA	NA	NA	NA	NA	NA	0.77
Nickel	5.25	NA	NA	NA	NA	NA	3.86	NA	NA	NA	NA	NA	NA	NA	52
Silver	1 U	NA	NA	NA	NA	NA	1 U	NA	NA	NA	NA	NA	NA	NA	0.12
Zinc	10.6	NA	NA	NA	NA	NA	9.06	NA	NA	NA	NA	NA	11.6	NA	120
Dissolved Metals in µg/L															
Arsenic	1 U	1 U	14.5	11	11	4.28	6.51	9.93	11.3	1.6	3.65	1 U	1 U	1.42	150
Chromium	NA	1.43	NA	1.05	NA	1.2	NA	1.14	NA	1 U	NA	1.06	NA	1.3	74
Copper	2.29	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	9
Lead	1.37	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	2.5
PAHs in µg/L															
Benzo(a)anthracene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.027
Benzo(a)pyrene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.014
Benzo(b)fluoranthene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	–
Benzo(k)fluoranthene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	–
Chrysene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	–
Dibenz(ah)anthracene	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	–
Indeno(1,2,3-cd)pyrene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	–
Acenaphthene	0.1 U	0.1 U	0.121	0.104	0.192	0.125	0.72	0.115	0.448	0.277	0.1 U	0.1 U	0.1 U	0.1 U	520
Acenaphthylene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	–
Anthracene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	13
Benzo(ghi)perylene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	–
Fluoranthene	0.1 U	0.1 U	0.119	0.107	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	6.2
Fluorene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	3.9
Naphthalene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.291	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	620
Phenanthrene	0.1 U	0.1 U	1.25	0.555	0.138	0.175	0.576	0.608	1.16	0.32	0.1 U	0.1 U	0.153	0.102	6.3
Pyrene	0.1 U	0.1 U	0.564	0.23	0.1 U	0.119	0.123	0.205	0.172	0.1 U	0.1 U	0.1 U	0.153	0.113	–
Total PAHs	0.2 U	0.2 U	2.054	0.996	0.33	0.419	1.71	0.928	1.78	0.597	0.2 U	0.2 U	0.306	0.215	–
Volatiles in µg/L															
Benzene	1 U	1 U	NA	1 U	NA	NA	1 U	NA	NA	1 U	NA	1 U	NA	1 U	130
Chloroform	NA	NA	NA	1 U	NA	1 U	NA	NA	NA	2.09	NA	NA	NA	1 U	1,240
DEHP	10 U	NA	10 U	NA	NA	NA	NA	NA	NA	NA	NA	NA	10 U	NA	3
Ethylbenzene	1 U	1 U	NA	1 U	NA	NA	1 U	NA	NA	1 U	NA	1 U	NA	1 U	7.3
PCE	2.76	3.06	NA	1 U	NA	1 U	1 U	NA	NA	NA	NA	NA	NA	1 U	840
Toluene	1 U	1 U	NA	1 U	NA	NA	1 U	NA	NA	1 U	NA	1 U	NA	1 U	9.8
Total xylenes	1 U	2 U	NA	2 U	NA	NA	1 U	NA	NA	2 U	NA	2 U	NA	2 U	13

F:\DATA\Jobs\Port of Portland\15791-01\T-1 Risk Assessment\Tables\Tables 12-15

Notes:
1. U = Not Detected at Reported Detection Limit.
2. NA = Not Analyzed.
3. Shading Denotes Analyte Exceeding Ecological Screening Levels.
4. DEQ Ecological Screening Levels - Freshwater Value for Aquatic Organisms (DEQ December 2001).

ATTACHMENT A
HUMAN HEALTH SCREENING FOR FISH CONSUMPTION

POPT1S601302

Attachment A - Human Health Screening for Fish Consumption; Analytical Results for Groundwater Samples
Marine Terminal 1 South Risk Assessment
Portland, Oregon

Sample ID	5106-011001-108	5106-011001-109	5106-020118-109	5106-020118-110	5106-011001-107	5106-020118-107	5106-020118-108	5106-010926-103	5106-020118-106
Station	MW-1	MW-1 (Dup)	MW-1	MW-1 (dup)	MW-2	MW-2	MW-2 (dup)	MW-3	MW-3
Sampling Date	10/01/2001	10/01/2001	1/18/2002	1/18/2002	10/01/2001	1/18/2002	1/18/2002	9/26/2001	1/18/2002
Depth in Feet	17 - 32	17 - 32	17 - 32	17 - 32	17 - 32	17 - 32	17-32	17 - 32	17 - 32
Total Suspended Solids	36	35	57		55	19	29	720	15
Total Metals in µg/L									
Arsenic	2.01	1.00	1.2		2.8	10.8	10.9	14	3.92
Cadmium	1 U	1 U							
Chromium	3.25	2.65	2.52			1.89	1.49		1.56
Copper	4.74	3.88	2.04		2 U	2 U	2 U	40.2	2.29
Lead	1.16	1 U	1 U		1 U	1 U	1 U	35.2	1 U
Mercury	0.2 U	0.2 U							
Nickel	5.25	4.49							
Silver	1 U	1 U							
Zinc	10.6	8.43							
Dissolved Metals in µg/L									
Arsenic	1 U	1 U	1 U		1.5	11	11.9	10	1.28
Chromium			1.43			1.05	1.35		1.2
Copper	2.29	2.03	2 U		2 U	2 U	2 U	2 U	2 U
Lead	1.37	1 U	1 U		1 U	1 U	1 U	1 U	1 U
PAHs in µg/L									
Benzo(a)anthracene	0.1 U	0.1 U	0.1 U		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Benzo(a)pyrene	0.1 U	0.1 U	0.1 U		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Benzo(b)fluoranthene	0.1 U	0.1 U	0.1 U		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Benzo(k)fluoranthene	0.1 U	0.1 U	0.1 U		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Chrysene	0.1 U	0.1 U	0.1 U		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Dibenz(ah)anthracene	0.2 U	0.2 U	0.2 U		0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
Indeno(1,2,3-cd)pyrene	0.1 U	0.1 U	0.1 U		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Acenaphthene	0.1 U	0.1 U	0.1 U		0.121	0.104	0.11	0.192	0.125
Acenaphthylene	0.1 U	0.1 U	0.1 U		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Anthracene	0.1 U	0.1 U	0.1 U		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Benzo(ghi)perylene	0.1 U	0.1 U	0.1 U		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Fluoranthene	0.1 U	0.1 U	0.1 U		0.119	0.107	0.108	0.1 U	0.1 U
Fluorene	0.1 U	0.1 U	0.1 U		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Naphthalene	0.1 U	0.1 U	0.1 U		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Phenanthrene	0.1 U	0.1 U	0.1 U		1.25	0.555	0.62	0.138	0.175
Pyrene	0.1 U	0.1 U	0.1 U		0.564	0.23	0.251	0.1 U	0.119
Total PAHs	0.2 U	0.2 U	0.2 U		2.054	0.996	1.089	0.33	0.419
TPH in µg/L									
Diesel	416.2	338.2					250 U		
Oil	500 U	ND					500 U		
Volatiles in µg/L									
Benzene	1 U	1 U	1 U	1 U		1 U	1 U		
Chloroform						1 U			1 U
DEHP	10 U	10 U			10 U				
Ethylbenzene	1 U	1 U	1 U	1 U		1 U	1 U		
Naphthalene			2 U	2 U		2 U	2 U		
PCE	2.76	3.29	3.06	2.62		1 U			1 U
Toluene	1 U	1 U	1 U	1 U		1 U	1 U		
Total xylenes	1 U	1 U	2 U	2 U		2 U	2 U		

Please refer to notes at end of table.

Attachment A - Human Health Screening for Fish Consumption; Analytical Results for Groundwater Samples
Marine Terminal 1 South Risk Assessment
Portland, Oregon

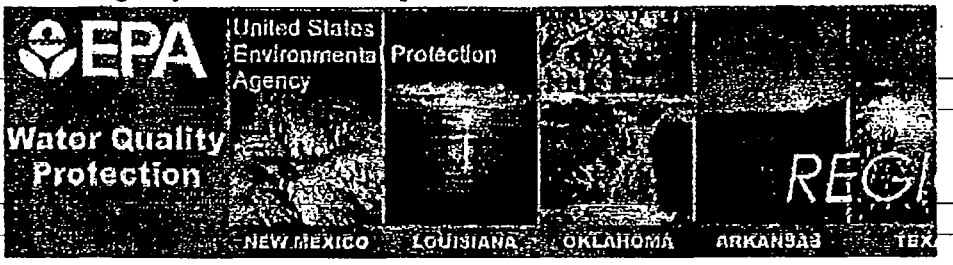
Sample ID	5106-010928-104	5106-020117-104	5106-010928-102	5106-020118-105	5106-010928-105	5106-020117-102	5106-011001-108	5106-020117-103	DEQ	EPA
Station	MW-4	MW-4	MW-5	MW-5	MW-6	MW-6	MW-7	MW-7	WQ Criteria	National
Sampling Date	9/28/2001	1/17/2002	9/28/2001	1/18/2002	9/28/2001	1/17/2002	10/01/2001	1/17/2002	(Fish Consumtion Only)	AWQC
Depth in Feet	17 - 32	17 - 32	19 - 34	19 - 34	17 - 32	17 - 32	17 - 32	17 - 32	Table 20	(Fish Consumtion Only)
Total Suspended Solids	130	40	108	17	50	30	20 U	12		
Total Metals in µg/L										
Arsenic	0.45	0.23	1.21	1.55	2.72	0.18	1.38	1.32	0.0175	0.14
Cadmium	1 U									
Chromium	5.12	2.26		1.31		2.81		1.69	3,433,000	
Copper	4.48	2 U	2.95	2 U	2.51	3.31	2 U	2 U		
Lead	2.49	1 U	1.46	1 U	1 U	1.86	4.47	3.94		
Mercury	0.2 U								0.146	
Nickel	3.86								100	
Silver	1 U									
Zinc	9.08						11.6			
Dissolved Metals in µg/L										
Arsenic	0.51	0.93	1.13	1.6	3.65	1 U	1 U	1.42	0.0175	0.14
Chromium		1.14		1 U		1.06		1.3	3,433,000	
Copper	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U		
Lead	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U		
PAHs in µg/L										
Benzo(a)anthracene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U		0.049
Benzo(a)pyrene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U		0.049
Benzo(b)fluoranthene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U		0.049
Benzo(k)fluoranthene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U		0.049
Chrysene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U		0.049
Dibenz(ah)anthracene	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U		0.049
Indeno(1,2,3-cd)pyrene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U		0.049
Acenaphthene	0.72	0.115	0.448	0.277	0.1 U	0.1 U	0.1 U	0.1 U		2,700
Acenaphthylene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U		
Anthracene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U		110,000
Benzo(ghi)perylene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U		
Fluoranthene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	54	370
Fluorene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U		14,000
Naphthalene	0.281	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U		
Phenanthrene	0.576	0.608	1.16	0.32	0.1 U	0.1 U	0.153	0.102		
Pyrene	0.123	0.205	0.172	0.1 U	0.1 U	0.1 U	0.153	0.113		11,000
Total PAHs	1.71	0.928	1.78	0.597	0.2 U	0.2 U	0.306	0.215		
TPH in µg/L										
Diesel	250 U			250 U						
Oil	500 U			500 U						
Volatiles in µg/L										
Benzene	1 U			1 U		1 U		1 U	40	
Chloroform				2.09				1 U	15.7	
DEHP							10 U			
Ethylbenzene	1 U			1 U		1 U		1 U	3,280	
Naphthalene				2 U		2 U		2 U		
PCE	1 U							1 U	8.85	
Toluene	1 U			1 U		1 U		1 U	424,000	
Total xylenes	1 U			2 U		2 U		2 U		

DATA\Joint Port of Portland\15191-01 T-1 Risk Assessment\Attachment A\Attachment A Tables

Notes:
1. Shaded boxes indicate exceedance of regulatory criterion.
2. U = Not Detected at Reported Detection Limit.

ATTACHMENT B
EPA ALTERNATIVE FRESHWATER ARSENIC CRITERION

POPT1S601305



Region 6 Interim Strategy: Arsenic - Freshwater Human Health Criterion for Fish Consumption

General Information
Regulatory History
Purpose of Arsenic Interim Strategy
Criteria Development for Office of Water
Bioconcentration Factor
Inorganic Arsenic and Organic Arsenic
EPA Region 6 Recommended Criteria
References
Appendix A: Agency RFD and Cancer Assessment Process and Integrated Risk Information System (IRIS)
Appendix B: Health Effects of Arsenic

General Information

Arsenic is a ubiquitous, naturally-occurring element. Increased levels of arsenic in water and soil can be found in certain areas of the country as a result of leaching from rock into ground water, and possible geothermal activity. In addition, nonferrous mining and smelting operations, refining operations and now discontinued pesticide manufacturing facilities may add to increased levels of arsenic in water. Only very limited quantities of arsenic-containing pesticides are still manufactured and used under strict limitations in the U.S. They represent a minimal source of arsenic exposure.

Arsenic may exist in both an organic and inorganic form, either in the trivalent or pentavalent state. The inorganic form is associated with the toxicity described in this risk characterization. Arsenic usually occurs in waters as inorganic oxides in the pentavalent form. Trivalent forms of arsenic (inorganic and organic) are more toxic to humans and aquatic organisms and are usually only present under anaerobic conditions.

oxidation
trivalent----------›pentavalent

forms<----------forms
reduction

Sources of human exposure to arsenic compounds may include air, soil, water and food. Dietary sources may include dairy products, meat, poultry and fish, fruits and vegetable and grain products. Water quality criteria may be established to protect consumption of water and/or fish.

Regulatory History

The Environmental Protection Agency (EPA) Office of Water has established guidance or regulations for arsenic under the Clean Water Act (CWA) and the Safe Drinking Water Act (SDWA). Under the CWA, a water quality criterion for arsenic - fish consumption was established at 0.14 ug/L in 1992 using the hazard assessment in EPA's Integrated Risk Information System (IRIS) database according to the current methodology for developing ambient water quality criteria for human health. The criterion for water + fish consumption is 0.018 ug/L. [For further information concerning IRIS, see Appendix A]. These arsenic water quality criteria represent a one in one million (10-6) cancer risk level for arsenic exposures.

EPA Office of Water also has a drinking water standard, or maximum contaminant level (MCL) issued under the SDWA of 50 ug/L. This level was developed in the mid-1940s by the Public Health Service and is not based on a risk assessment as we know it. Since the SDWA was passed in 1974, EPA Office of Water has been in the process of reevaluating the MCL. More recent data and analyses raise questions about the adequacy of the current MCL to protect human health "with a margin of safety." In addition, EPA Office of Water has been in the process of developing a drinking water health advisory, which is a non-regulatory guidance document, since 1985. Both the MCL revision and health advisory have yet to be completed due to continuing uncertainties associated with the risk. The Safe Drinking Water Act Amendments of 1996 mandates that a revised regulation for arsenic be proposed by January 1, 2000. The 1996 amendments also require that EPA develop a comprehensive plan for study of health risks to support the revised MCL within 180 days of enactment of the amendments.

Purpose of Arsenic Interim Strategy

As discussed above, there is currently no agreement between the recommended criteria developed pursuant to the CWA and the MCL developed pursuant to the SDWA. There are also questions concerning the toxicity database used in developing the cancer potency slope. While these issues need resolution and are being addressed by EPA Headquarters, the purpose of this strategy is to determine a reasonable approach to interpreting the arsenic criterion recommended to protect human health via the exposure route of consuming fish. The confusion over the appropriate criterion for freshwater fish consumption arose

POPT1S601307

during the promulgation of the National Toxics Rule. In 1991, EPA proposed the National Toxics Rule in the Federal Register. EPA received two comments (# 68 and # 74) which expressed concern over the different forms of arsenic in fish and the degree of carcinogenicity of different forms of arsenic. In the final National Toxics Rule, issued December 22, 1992, a footnote was added to the human health criteria for arsenic (fish consumption only and water and fish consumption) that stated EPA's criteria apply only to the inorganic form of arsenic (EPA, 1992). Criteria based on inorganic arsenic are difficult to regulate and require additional resources for water quality analyses. States continue to use arsenic in criteria and implementation without recognizing that most of the arsenic is in the organic form in freshwater finfish. Since most of the arsenic present in finfish is in the organic form, criteria can be modified to reflect this.

While there may be several approaches to account for the different forms of arsenic in finfish, Region 6 recommends that States and Tribes adopt an arsenic criterion based upon the inorganic fraction that would be found in edible fish tissue (no Region 6 State or Tribe is in the National Toxics Rule for arsenic). This approach does not reevaluate the toxicity information, but looks at bioconcentration of inorganic arsenic from the water body into freshwater finfish. The strategy can be used by any State or Tribe in Region 6 that is adopting a risk-based criterion to protect human health from consuming inorganic arsenic found in finfish.

Criteria Development for Office of Water

The EPA Office of Water develops drinking water criteria or regulatory levels to protect human health under the CWA and the SDWA. Criteria developed under the CWA are developed to restore and maintain the chemical, physical, and biological integrity of all navigable waters. States may adopt these criteria in developing their State water quality standards or develop their own criteria.

Under the SDWA, criteria are referred to as Maximum Contaminant Level Goals (MCLGs) and are developed as non-enforceable health goals that are protective of adverse health effects and incorporate a margin of safety. Maximum Contaminant Levels (MCLs) are enforceable standards and are based on risk characterization. Factors such as analytical methods, technology and costs, economic impact and regulatory impact may also be used in the development of MCLs. MCLs apply to the concentration of a contaminant at the tap. States must adopt Federal drinking water standards (MCLs) or develop more stringent levels in a certain time period following promulgation of a drinking water standard.

The methodology to develop criteria for each program has evolved separately and incorporates different policies and assumptions. As a result, criteria for the same contaminant under the CWA and the

POPT1S601308

SDWA can be different, even though they protect human health through drinking water exposures. Information on arsenic and the uncertainties with the human health arsenic criteria are found in Appendix B. The following equation was used to develop human health criteria for fish consumption under the CWA:

$$\text{Criterion} = \frac{RF \times BW}{q1^*[BCF \times FC]}$$

where: RF = risk factor (dimensionless)
BW = body weight (kg)
q1* = cancer potency factor (mg/kg/day)-1
BCF = bioconcentration factor (L/kg)
FC = fish consumption rate (kg/day)

Bioconcentration Factor

The amount of pollutant that will accumulate in fish/shellfish is important to estimate since this route of exposure is potentially significant to human populations. Bioaccumulation occurs both through uptake across the gill membranes and other external body surfaces (bioconcentration) and through ingestion of contaminated food (biomagnification). Arsenic does not appear to progressively accumulate through the food chain (Callahan et al., 1979 and EPA, 1982, 1983 in ATSDR, 1993). EPA generally recommends that fish fillets be used to measure chemical contamination as this is portion consumed by humans (EPA, 1989). In cases where whole fish is consumed by certain subpopulations or where toxicity to wildlife is of concern, measurements from whole fish are more appropriate (EPA, 1995).

EPA's current bioconcentration factor (BCF) for arsenic is found in Ambient Water Quality Criteria for Arsenic (EPA, 1980). The BCF was calculated from the geometric mean (weighted with consumption rates) of two species. Data from the eastern oyster (BCF=350, 112 day test) and bluegill (BCF=4, 28 day test) resulted in a BCF for arsenic of 44. The criteria document also stated that BCFs of 0 were obtained from tests with rainbow trout. The data for the rainbow trout was not used in the calculation of the BCF. EPA Region 6 believes that the use of the eastern oyster data most likely overestimates the health risks associated with freshwater finfish consumption.

The BCF from the bluegill test was obtained from whole body measurements, while the BCF for the eastern oyster was measured using soft parts. BCFs for muscle tissue, the edible portion, should be lower than results obtained with whole fish (Stephan, 1993). Literature also supports this theory. Azcue and Dixon (1994) measured arsenic in four tissues of the rock bass. The highest concentration was found in bone and scales, followed by (in decreasing concentration), intestines

POPT1S601309

and contents, muscle and liver. A BCF of 0.71 was calculated using the mean concentration for muscle tissue (0.04 mg/kg) divided by the concentration in water (0.056 mg/L). In comparison, a BCF of 2.3 was calculated from the mean whole-body concentration of rock bass (0.128 mg/kg). So, the BCF based on the whole fish tissue was 3 times greater than the BCF based on muscle tissue.

A draft version of the Great Lakes Initiative proposed a BCF of 1 (Stephan, 1993). The Final Water Quality Guidance for the Great Lakes Initiative, Federal Register March 23, 1995, pp 15366 - 15425, did not contain human health criteria for arsenic. Additional information presented below indicates that the bioconcentration factor for arsenic in freshwater fish is considerably lower than the BCF of 44.

- The 1984 criteria document for arsenic (EPA, 1985) contains BCFs for fish. The BCFs were calculated from whole body measurements and range from 0 to 4 (EPA, 1985). Results for invertebrates ranged from 0 to 17. Data for the eastern oyster and the bluegill were the only measurements from Table 5 used to calculate the current BCF of 44 (EPA, 1980).

- Lacayo et al. (1992) measured total arsenic in water, fish and sediments in a lake in Nicaragua. Raw data was not available in this study, tissue concentrations were reported in ranges. BCFs were calculated by averaging the high end of the ranges (BCF = 12.6), the midpoint of the ranges (BCF = 6.3) and the low end of the ranges (BCF = 0.53).

- Marine organisms, particularly crustaceans and mollusks, appear to contain higher arsenic concentrations than freshwater fish (Cullen, 1989).

States and Tribes may wish to use data from whole body measurements for derivation of BAF rather than fish fillets if subpopulations exist which consume skin, heads or other parts of the fish. Differences in cooking preparation may affect the bioavailablity of contaminents.

A water quality study in the Middle Rio Grande is currently underway with the City of Albuquerque, the Pueblo of Isleta, the New Mexico Environment Department, the U.S. Geological Survey and EPA Region 6. One of the objectives of the project is to calculate a site-specific bio-accumulation factor for arsenic based on fish species in the middle Rio Grande. A joint report from the study cooperators is scheduled to be released by the participants in 1997. EPA Region 6's Interim Arsenic Strategy may be amended following completion of this study. In the meantime, Region 6 recommends that a BCF of 1, as proposed during the Great Lakes Initiative, be used in the calculation of human health criteria.

Inorganic Arsenic and Organic Arsenic

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As discussed under General Information, arsenic may be present in surface and groundwater as inorganic or organic compounds. Fish tissue also contains inorganic and organic compounds. Most analyses of arsenic related to fish consumption have focused on marine organisms and have determined that arsenic in marine organisms is primarily present as organic compounds (arsenobetaine and arsenocholine, in certain species). Various articles have noted that absence of arsenic related food poisonings from seafood throughout history (Kaise et al. 1985, Yamauchi et al., 1986, Edmonds and Francesconi, 1993). Several studies have measured inorganic arsenic in freshwater fish and other food groups and were reviewed during development of the Interim Strategy.

- According to Weiler (1987), studies performed by the Canadian Ministry of the Environment measured 10% of total arsenic in freshwater fish as inorganic.

- Lawrence et al. (1986) measured organic arsenic in fish and shellfish. Organic arsenic ranged from 71% to 85% of total arsenic in freshwater fish. The organic compound obtained from this analysis was not identified; however, it was more hydrophilic than arsenobetaine, which may mean that it is absorbed and excreted rapidly. In marine fish and shell fish, the organic portion of total arsenic ranged from 74-91%.

- Analysis of six species of freshwater fish in the Lower Columbia River measured 0.1 to 27% of total arsenic present as inorganic arsenic (Tetra Tech, 1996).

The organic forms are considered much less toxic, but data are insufficient to characterize the risk. Edmonds and Francesconi (1993) reported that, to the best of their knowledge, there is no evidence to indicate the demethylation of arsenic (organic inorganic) in animals. Several studies have examined the effects of organic arsenic in animals and humans. Four articles are summarized below.

- Kaise et al. (1985) administered arsenobetaine (organic) and arsenic trioxide (inorganic) to mice. No deaths or abnormal effects were observed in mice that received arsenobetaine, therefore, the lethal dose (LD50) of arsenobetaine was more than the maximum dose of 10 g/kg. The LD50 of arsenic trioxide was 0.0345 g/kg. Arsenobetaine was also measured in urine and was found to be unchanged from the form ingested. 46.4 % of the administered arsenobetaine was excreted within 48 hours.

- Yamauchi et al. (1986) administered arsenobetaine to hamsters to determine the metabolism and excretion using trimethylarsenic (TMA) organic compound. Inorganic arsenic, TMA, methylarsonic acid (MAA) and dimethylarsinic acid (DMAA) were measured after 1 hr, 6 hrs, 12 hrs, 24 hrs, 72 hrs

POPT1S601311

and 120 hrs in the following tissues: brain, hair, kidney, liver, lung, muscle, skin and spleen. MAA and DMAA were not detected in organ and tissues. Also, the concentration of inorganic arsenic in tissues and organs remained similar to the control group, which suggests that arsenobetaine is not converted in vivo into other arsenic compounds. After 120 hrs of administration of arsenobetaine, 90.5% of arsenic had been excreted in urine.

- Brown et al. (1990) conducted an experiment in which volunteers were fed codfish with radioactive labeled arsenobetaine. In all six subjects, less than 1% of the labeled arsenobetaine remained in the body after 24 days (92% was eliminated within 8 days).

- Tam et al. (1982) fed flounder containing approximately 50 ug/g of arsenic to fifteen individuals. Urine and fecal samples were collected prior to ingestion of the flounder and for the following 8 days. An average of 76.26% (range 60.8% - 86.2%) was excreted in urine within 8 days. In contrast, only 0.33% of the arsenic was measured in feces.

The joint study of the Middle Rio Grande is measuring inorganic and organic arsenic in fish. The results of these analyses may also be used to amend EPA Region 6's Strategy. Although most literature reported inorganic arsenic as less than 10%, the data was either unpublished or did not list individual species. Therefore, EPA Region 6 recommends that a conservative estimate of 30% inorganic arsenic from Lawrence et. al (1986), be used in the calculation of the arsenic human health criterion.

EPA Region 6 Recommended Criteria

Based on the above information, EPA Region 6 recommends that human health criterion for freshwater fish consumption be calculated by the formula presented below. The criterion can be further modified by changing the assumed values for body weight, fish consumption, or risk factor as designated in State or Tribal Water Quality Standards. The value of 6.5 g/day for fish consumption is based on market survey data gathered in 1973-1974. EPA is evaluating more recent surveys for revision of the default value. Guidance on developing site-specific surveys to determine fish consumption is available from EPA.

$$\text{Criterion} = \frac{RF \times BW}{q1^{*}[BCF \times FC \times I]}$$

$$\begin{matrix} 0.0205\ \text{mg/L} \\ \text{or} \\ 20.5\ \text{ug/L} \end{matrix} = \frac{10\text{-}6 \times 70\ \text{kg}}{1.75\ (\text{mg/kg/day})^{-1}[1\ \text{L/kg} \times 0.0065\ \text{kg/day} \times .30]}$$

where: 10^{-6} RF = risk factor
70 kg BW = body weight
1.75 mg/kg/day q1* = cancer potency factor
1 L/kg BCF = bioconcentration factor
0.0065 kg/day FC = fish consumption rate
0.30 I = percent of total arsenic in fish tissue that is inorganic

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POPT1S601313

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Appendix A: Agency RFD and Cancer Assessment Process, and Integrated Risk Information System (IRIS)

For chemicals suspected of being carcinogenic to humans, the risk assessment consists of the weight of evidence of carcinogenicity in humans, using bioassays in animals and human epidemiology studies and other pertinent information such as mutagenicity studies. The objectives of the assessment are to determine the level or strength of evidence that the substance is a carcinogen and to provide an upperbound estimate of the possible risk of human exposure to the substance in drinking water. Substances are placed in one of five categories reflecting weight of evidence:

Group A - Human carcinogen based on sufficient information in human studies;

Group B - Probable human carcinogen based on limited evidence in

human (Group B1), or sufficient evidence in animals in the absence of human information (Group B2);

Group C - Possible human carcinogen based on limited evidence of carcinogenicity in animals in the absence of human data.

Group D - Not classifiable based on lack of data or inadequate evidence in animal studies;

Group E - No evidence of carcinogenicity in humans.

If toxicological evidence leads to the classification of a contaminant as a carcinogen, mathematical models are used to estimate an upperbound excess cancer risk associated with lifetime exposure through drinking water. Several models are available to extrapolate data. EPA generally uses the linearized multistage (LMS) model which fits linear dose-response curves to low doses. It is consistent with a no-threshold model of carcinogenesis, ie., exposure to even a very small amount of the substance theoretically produces a finite increased risk of cancer. The LMS model uses dose response data from an appropriate study to calculate a carcinogenic potency factor (q1*) which is then used to determine concentrations of water that are associated with the theoretical upperbound excess lifetime cancer risk of one in ten thousand (10-4) to one in one million (10-6).

The risk assessment for noncancer health effects can be characterized by the reference dose (RfD). The oral RfD (in mg/kg/d) is an estimate, with an uncertainty spanning perhaps an order of magnitude, of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious health effects during a lifetime. The RfD is derived from a no- or lowest observed adverse effect level (called the NOAEL or LOAEL, respectively) that has been identified from appropriate studies in humans or animals. The NOAEL or LOAEL is divided by an uncertainty factor(s) to derive the RfD. Although the RfD is expressed as a single number, it is actually a range with an inherent uncertainty of an order of magnitude.

Uncertainty factors are used to estimate the comparable no- effect level for a large heterogeneous human population. The use of uncertainty factors accounts for several data gaps including intra- and interspecies differences in response to toxicity, the small number of animals tested compared to the size of the population, sensitive subpopulations and the possibility of synergistic action between chemicals. Uncertainty factors may vary from 1 to 30,000. There is very little confidence in an assessment where the uncertainty factor is greater than 3,000.

Appendix B: Health Effects of Arsenic

In evaluating the risks posed by arsenic exposure, risk analysts are fortunate to have a large human database. Humans appear to be more

sensitive to the carcinogenic effects of arsenic than animals. Ingestion of arsenic contaminated water and soil can result in both carcinogenic and noncarcinogenic health effects.

Carcinogenic Effects:

A number of epidemiology studies have been conducted which report an increased incidence of skin cancer in exposed populations. Studies have been conducted in Taiwan, Mexico, Chile, Hungary, and Argentina. The studies conducted outside of Taiwan evaluated populations much smaller in size than the Taiwan study. The Taiwan study also reported a weak association between arsenic ingestion and increased incidence of internal cancers such as cancers of the liver, bladder, kidney, and lung. Studies conducted in the US have not demonstrated an association between arsenic in drinking water and skin cancer. While there was no demonstrated elevated cancer incidence in these U.S. populations, the population sizes studied were too small and/or the lengths of exposure time too short to expect to see an effect.

The largest epidemiology study is the Taiwan study (Tseng etc al., 1968), which also serves as the basis for the EPA risk assessments for arsenic discussed below. In this study, an increased prevalence of skin cancer was observed in 40,000 Taiwanese consuming arsenic contaminated drinking water (0.05 to >1 mg/L) from artesian wells as compared with 7,500 residents of Taiwan or Matsu consuming "arsenic - free" (0-0.017 mg/L) drinking water. The number of people with skin cancer was reported to increase in association with increasing concentrations in the water they consumed.

Related to carcinogenicity, arsenic is a genotoxic agent that induces chromosomal aberrations, micronuclei and sister chromatid exchange in mammalian cells and neoplastic transformations in Syrian hamster embryo cells. Arsenic does not cause cancer in experimental animals. Thus, no animal model is available for studying arsenic-induced cancer.

EPA and other organizations such as the International Agency for Research on Cancer (IARC) have classified arsenic as a human carcinogen. (See Appendix A for further discussion of cancer hazard assessment.) This classification is based on sufficient evidence of carcinogenicity from human data involving occupational and drinking water exposures. EPA used the evidence of skin cancer reported in the Taiwan study as the basis for the arsenic hazard and dose response assessment. Using a time- and dose- dependent multistage model which assumes that any exposure to a compound such as arsenic could result in a cancer response, the cancer potency (q1*) estimated for ingested arsenic is 1.75 mg/kg/day. This potency can then be used to estimate concentrations of arsenic in water associated with an increased cancer risk of one in ten thousand (10-4) to one in one

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million (10-6):

10-4 = 1.8 ug/L
10-5 = 0.18 ug/L
10-6 = 0.018 ug/L

Although this assessment has been adopted by the Agency and extensively peer reviewed, there are a number of issues and uncertainties that make the skin cancer risk assessment conclusions incomplete and uncertain (see Issues and Uncertainties below) and thus, complicate risk management decisions.

Noncarcinogenic Effects:

In addition to the cancer effects observed in epidemiological studies, arsenic exposure has also been reported to result in adverse health effects other than cancer in human and animal studies. Dermal changes including variations in skin pigments, thickening of the skin (e.g.,hyperkeratosis)and ulcerations, peripheral neurotoxicity, peripheral vascular effects, cardiac effects, gastrointestinal and liver effects, and diabetes have been observed.

Acute high-dose oral exposure (e.g., poisonings) to arsenic typically leads to gastrointestinal irritation accompanied by difficulty in swallowing, thirst, abnormally low blood pressure, and convulsions.

The most common signs of long-term arsenic exposure from drinking water are dermal changes such as variations in skin pigments, hyperkeratoses, and ulcerations. Blackfoot disease, a peripheral vascular disease, has been associated with chronic arsenic exposure in Taiwan; however, the exact etiologic mechanism is unknown. Studies in Canada and US report neurological effects after chronic exposure from drinking water containing arsenic. Enlargement of the liver was observed in populations in India that were exposed to arsenic in drinking water. An association between ingested arsenic and ischemic heart disease (low oxygen supply to the heart muscle)and diabetes mellitus (hyperglycemia or diabetes) have been reported in the area of Taiwan where Blackfoot disease is endemic.

There is no clear consensus among Agency scientists on the reference dose (RfD) workgroup to estimate and oral RfD. Applying the Agency's RfD methodology (see Appendix A for further discussion on RfDs), the EPA Risk Assessment Council determined that strong scientific arguments could be made for various values within a factor of 2 or 3 of the currently recommended RfD value, i.e., 0.1 to 0.8 ug/kg/d. The Taiwan data are used to estimate the RfD of 0.3 ug/kg/d, at which no adverse effects (hyperpigmentation, keratosis and possible vascular complications) were observed. It should be noted, however, that the RfD methodology, by definition, assumes that for each estimate there is an inherent uncertainty spanning perhaps an order of

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magnitude. The arsenic summary on IRIS is the first to articulate this point.

Issues and Uncertainties:

As noted above, there are a number of issues and uncertainties associated with the cancer and noncancer health effects and subsequent risk assessment for arsenic. Some of these relate to arsenic in general and some are specific to use of the Taiwan study to quantify the risk.

General:

1. Arsenic may be either inorganic or organic. The inorganic form is associated with the health effects described above. The organic form, which is often found in fish and some seafoods, appears to be less toxic.

2. The typical US diet contains 10 - 20 ug inorganic arsenic/day.

3. Arguments have been made that arsenic is an essential element (NRC, 1989) with a nutritional requirement of 12 - 25 ug/d (Uthus, 1994). Studies in rats, hamsters, minipigs, goats and chicks indicate that it is essential for normal growth and development.

4. Recent human data from dialysis patients suggest that patients with lower serum levels of arsenic are more susceptible to CNS and vascular disease and cancer (Mayer et al., 1993). However, more studies are needed in this area.

5. Arsenic can be detoxified at low exposure levels. Genetic, dietary or other lifestyle factors may enhance or inhibit potential arsenic detoxification processes in humans. Preliminary studies in Mexico indicate that people chronically exposed to high concentrations of arsenic (>400 ug/L) will metabolize it differently than those exposed to low levels (<20 ug/L).

6. The available ecologic-type epidemiology studies do not determine a cause and effect relationship between arsenic exposure in drinking water and skin cancer. In addition, lack of an animal model also precludes use of a controlled laboratory experiment to make such a determination.

7. Unlike many other types of cancer, skin cancer is treatable.

8. Considering the genotoxicity data (chromosomal and DNA changes), exposure information, lack of animal cancer data and incidence of skin cancer, the multistage model may not be the appropriate model for estimating cancer potency. Available data can be used to support a plausible threshold (there is a dose below which a cancer effect would not occur) model.

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Taiwan Study:

1. Arsenic concentrations consumed by Taiwanese are not known. In the Taiwan study, arsenic concentrations are determined by village, some of which contained more than one well. One measurement was taken from each well, with the results averaged to estimate arsenic concentrations for the village. Thus, individual doses can not be determined.

2. There is some question about the analytical method used in the Taiwan study to measure arsenic levels in water. A recent analysis of the method used (Nataleson, spectrophotometry with molybdenum blue) demonstrated that it is only sensitive in the 50 to 100 ug/L. Reported concentrations less than that are not accurate. This directly impacts the risk estimates discussed above.

3. The water consumed in Taiwan contained other possible cancer causing substances in addition to arsenic.

4. The nutritional status of the Taiwanese is not known. In general, their diets tended to be deficient in protein. This may compromise their ability to detoxify arsenic. In addition, there were other sources of arsenic in the Taiwanese diet such as sweet potatoes and rice. There have been studies linking poor nutrition, eg, sweet potato consumption, with increased risk from drinking water containing high arsenic levels.

5. EPA scientists have attempted for more than a decade to obtain the original data to assess quality and accuracy of the reported results with no success. Thus, reliance is placed on published results only.

History of Risk Management Guidance:

Risk assessors and managers have been evaluating the problem of arsenic for a long time. In the Office of Water, this issue has continued for over 20 years. In 1988, the Agency's Risk Assessment Forum published a book "Special Report on Ingested Inorganic Arsenic: Skin Cancer; Nutritional Essentiality." This book articulated Agency risk assessment conclusions concerning carcinogenicity and essentiality. It was reviewed by the Agency's Science Advisory Board and endorsed by the Risk Assessment Council. As a result of the issues and uncertainties associated with arsenic risk estimation as discussed in the book, Lee Thomas, EPA Administrator, issues guidance to risk managers on use of the cancer risk estimates to assist with decision-making. Concerning the cancer hazard assessment, the memo stated:

> "in reaching risk management decisions in specific situations, risk managers must recognize and consider the qualities and uncertainties of risk estimates. The uncertainties associated with inorganic arsenic are such that estimates could be modified downwards as much as an order of magnitude, relative to risk

POPT1S601320

estimates associated with most other carcinogens. In such instances, the management document must clearly articulate this fact and state the factors that influenced such a decision."

When the Risk Assessment Council reached a decision on the RfD, guidance to risk managers state "Risk managers should recognize the considerable flexibility afforded them in formulating regulatory decisions when uncertainty and lack of clear consensus are taken into account."

Back to Water Quality Standards Program Page

Appendix A

APPENDIX A
SOIL AND GROUNDWATER ANALYTICAL DATA USED FOR THE RISK ASSESSMENTS

POPT1S601323

Table A-3 - Analytical Results for Groundwater Samples
Marine Terminal 1 South Risk Assessment
Portland, Oregon

Sample ID	5106-011001-108	5106-011001-109	5106-020118-109	5106-020118-110	5106-011001-107	5106-020118-107	5106-020118-108	5106-010928-103	5106-020118-106	5106-010928-104
Station	MW-1	MW-1 (Dup)	MW-1	MW-1 (dup)	MW-2	MW-2	MW-2 (dup)	MW-3	MW-3	MW-4
Sampling Date	10/01/2001	10/01/2001	1/18/2002	1/18/2002	10/01/2001	1/18/2002	1/18/2002	9/28/2001	1/18/2002	9/28/2001
Depth in Feet	17 - 32	17 - 32	17 - 32	17 - 32	17 - 32	17 - 32	17-32	17 - 32	17 - 32	17 - 32
Total Suspended Solids	38	35	57		55	19	29	720	15	130
Total Metals in µg/L										
Arsenic	2.01	1.06	1.2		12.8	10.8	10.8	14	3.92	6.45
Cadmium	1 U	1 U								1 U
Chromium	3.25	2.65	2.52			1.89	1.49		1.58	5.12
Copper	4.74	3.88	2.04		2 U	2 U	2 U	40.2	2.29	4.48
Lead	1.16	1 U	1 U		1 U	1 U	1 U	38.2	1 U	2.49
Mercury	0.2 U	0.2 U								0.2 U
Nickel	5.25	4.49								3.86
Silver	1 U	1 U								1 U
Zinc	10.6	8.43								9.06
Dissolved Metals in µg/L										
Arsenic	1 U	1 U	1 U		14.5	11	11.3	11	4.28	6.51
Chromium			1.43			1.05	1.35		1.2	
Copper	2.29	2.03	2 U		2 U	2 U	2 U	2 U	2 U	2 U
Lead	1.37	1 U	1 U		1 U	1 U	1 U	1 U	1 U	1 U
PAHs in µg/L										
Benzo(a)anthracene	0.1 U	0.1 U	0.1 U		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Benzo(a)pyrene	0.1 U	0.1 U	0.1 U		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Benzo(b)fluoranthene	0.1 U	0.1 U	0.1 U		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Benzo(k)fluoranthene	0.1 U	0.1 U	0.1 U		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Chrysene	0.1 U	0.1 U	0.1 U		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Dibenz(ah)anthracene	0.2 U	0.2 U	0.2 U		0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
Indeno(1,2,3-cd)pyrene	0.1 U	0.1 U	0.1 U		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Acenaphthene	0.1 U	0.1 U	0.1 U		0.121	0.104	0.11	0.192	0.125	0.72
Acenaphthylene	0.1 U	0.1 U	0.1 U		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Anthracene	0.1 U	0.1 U	0.1 U		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Benzo(ghi)perylene	0.1 U	0.1 U	0.1 U		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Fluoranthene	0.1 U	0.1 U	0.1 U		0.118	0.107	0.108	0.1 U	0.1 U	0.1 U
Fluorene	0.1 U	0.1 U	0.1 U		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Naphthalene	0.1 U	0.1 U	0.1 U		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.291
Phenanthrene	0.1 U	0.1 U	0.1 U		1.25	0.555	0.62	0.138	0.175	0.576
Pyrene	0.1 U	0.1 U	0.1 U		0.564	0.23	0.251	0.1 U	0.119	0.123
Total PAHs	0.2 U	0.2 U	0.2 U		2.054	0.998	1.099	0.33	0.419	1.71
TPH in µg/L										
Diesel	416.2	338.2					250 U			250 U
Oil	500 U	ND					500 U			500 U
Volatiles in µg/L										
Benzene	1 U	1 U	1 U	1 U		1 U	1 U			1 U
Chloroform						1 U			1 U	
DEHP	10 U	10 U			10 U					
Ethylbenzene	1 U	1 U	1 U	1 U		1 U	1 U			1 U
Naphthalene			2 U	2 U		2 U	2 U			
PCE	2.76	3.29	3.06	2.62		1 U			1 U	1 U
Toluene	1 U	1 U	1 U	1 U		1 U	1 U			1 U
Total xylenes	1 U	1 U	2 U	2 U		2 U	2 U			1 U

Please refer to note at end of table.

Table A-3 - Analytical Results for Groundwater Samples
Marine Terminal 1 South Risk Assessment
Portland, Oregon

Sample ID	5106-020117-104	5106-010928-102	5106-020118-105	5106-010928-105	5106-020117-102	5106-011001-108	5106-020117-103
Station	MW-4	MW-5	MW-5	MW-5	MW-6	MW-7	MW-7
Sampling Date	1/17/2002	9/28/2001	1/18/2002	9/28/2001	1/17/2002	10/01/2001	1/17/2002
Depth in Feet	17 - 32	19 - 34	19 - 34	17 - 32	17 - 32	17 - 32	17 - 32
Total Suspended Solids	40	108	17	50	30	20 U	12
Total Metals in µg/L							
Arsenic	9.23	12.1	1.56	2.72	1.16	1.38	1.32
Cadmium							
Chromium	2.26		1.31		2.81		1.69
Copper	2 U	2.95	2 U	2.51	3.31	2 U	2 U
Lead	1 U	1.46	1 U	1 U	1.86	4.47	3.94
Mercury							
Nickel							
Silver							
Zinc						11.6	
Dissolved Metals in µg/L							
Arsenic	9.93	11.3	1.6	3.65	1 U	1 U	1.42
Chromium	1.14		1 U		1.06		1.3
Copper	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Lead	1 U	1 U	1 U	1 U	1 U	1 U	1 U
PAHs in µg/L							
Benzo(a)anthracene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Benzo(a)pyrene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Benzo(b)fluoranthene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Benzo(k)fluoranthene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Chrysene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Dibenz(an)anthracene	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
Indeno(1,2,3-cd)pyrene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Acenaphthene	0.115	0.448	0.277	0.1 U	0.1 U	0.1 U	0.1 U
Acenaphthylene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Anthracene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Benzo(ghi)perylene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Fluoranthene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Fluorene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Naphthalene	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Phenanthrene	0.808	1.16	0.32	0.1 U	0.1 U	0.153	0.102
Pyrene	0.205	0.172	0.1 U	0.1 U	0.1 U	0.153	0.113
Total PAHs	0.928	1.76	0.597	0.2 U	0.2 U	0.306	0.215
TPH in µg/L							
Diesel			250 U				
Oil			500 U				
Volatiles in µg/L							
Benzene			1 U		1 U		1 U
Chloroform			2.09				1 U
DEHP						10 U	
Ethylbenzene			1 U		1 U		1 U
Naphthalene			2 U		2 U		2 U
PCE							1 U
Toluene			1 U		1 U		1 U
Total xylenes			2 U		2 U		2 U

DATA\Jobs\Port of Portland\15191-01 T-1 Risk Assessment\Addendum\Addendum Tables

Note:
1. U = Not Detected at Reported Detection Limit.

Appendix B

APPENDIX B
HUMAN HEALTH RISK ASSESSMENT TABLES

POPT1S601327

Table B-3 - Area A Risk Calculations
Soil Ingestion, Excavation Worker
Marine Terminal 1 South Risk Assessment
Portland, Oregon

Compounds of Potential Concern	Soil EPC in mg/kg		Hazard Intake in mg/kg-day		Hazard Quotient		Cancer Intake in mg/kg-day		Cancer Risk	
	RME	CT	RME	CT	RME	CT	RME	CT	RME	CT
PAHs										
Benzo(a)anthracene	9.4E+00	3.7E-01	1.6E-06	1.3E-08	--	--	2.3E-08	9.3E-11	1.6E-08	6.8E-11
Benzo(a)pyrene	3.7E-01	3.3E-01	6.3E-08	1.2E-08	--	--	8.9E-10	8.3E-11	6.5E-09	6.1E-10
Benzo(b)fluoranthene	3.4E-01	2.7E-01	5.7E-08	9.5E-09	--	--	8.2E-10	6.8E-11	6.0E-10	5.0E-11
Dibenz(a,h)anthracene	7.0E-02	6.0E-02	1.2E-08	2.1E-09	--	--	1.7E-10	1.5E-11	1.2E-09	1.1E-10
Indeno(1,2,3-cd)pyrene	2.0E-01	1.8E-01	3.4E-08	6.3E-09	--	--	4.8E-10	4.5E-11	3.5E-10	3.3E-11
Metals										
Arsenic	6.0E+00	3.4E+00	1.0E-06	1.2E-07	3.4E-03	4.0E-04	1.4E-08	8.6E-10	2.2E-08	1.3E-09
			TOTAL HAZARD INDEX		3.E-03	4.E-04	TOTAL CANCER RISK		5.E-08	2.E-09

Notes:
RME = Reasonable Maximum Exposure.
CT = Central Tendency.
EPC = Exposure Point Concentration.

Table B-3 - Area A Risk Calculations
Dermal Contact with Soil, Excavation Worker
Marine Terminal 1 South Risk Assessment
Portland, Oregon

Compounds of Potential Concern	ABS	Soil EPC in mg/kg		Hazard Intake in mg/kg-day		Hazard Quotient		Cancer Intake in mg/kg-day		Cancer Risk	
		RME	CT	RME	CT	RME	CT	RME	CT	RME	CT
PAHs											
Benzo(a)anthracene	0.13	9.4E+00	3.7E-01	1.8E-06	1.6E-08	--	--	2.5E-08	1.2E-10	1.8E-08	8.5E-11
Benzo(a)pyrene	0.13	3.7E-01	3.3E-01	6.9E-08	1.5E-08	--	--	9.9E-10	1.0E-10	7.2E-09	7.6E-10
Benzo(b)fluoranthene	0.13	3.4E-01	2.7E-01	6.4E-08	1.2E-08	--	--	9.1E-10	8.5E-11	6.7E-10	6.2E-11
Dibenz(a,h)anthracene	0.13	7.0E-02	6.0E-02	1.3E-08	2.6E-09	--	--	1.9E-10	1.9E-11	1.4E-09	1.4E-10
Indeno(1,2,3-cd)pyrene	0.13	2.0E-01	1.8E-01	3.8E-08	7.9E-09	--	--	5.4E-10	5.7E-11	3.9E-10	4.1E-11
Metals											
Arsenic	0.03	6.0E+00	3.4E+00	2.6E-07	3.4E-08	8.7E-04	1.1E-04	3.7E-09	2.5E-10	5.6E-09	3.7E-10
				TOTAL HAZARD INDEX		9.E-04	1.E-04	TOTAL CANCER RISK		3.E-08	1.E-09

Notes:
ABS = Dermal Absorption Factor (EPA, 1998).
RME = Reasonable Maximum Exposure.
CT = Central Tendency.
EPC = Exposure Point Concentration.

Table B-3 - Area A Risk Calculations
Vapor Inhalation (Outdoor Air), Excavation Worker
Marine Terminal 1 South Risk Assessment
Portland, Oregon

Compounds of Potential Concern	Indoor Air EPC in mg/m³		Hazard Intake in mg/kg-day		Hazard Quotient		Cancer Intake in mg/kg-day		Cancer Risk	
	RME	CT	RME	CT	RME	CT	RME	CT	RME	CT
Volatile Organic Compounds										
Tetrachloroethene	6.1E-07	2.7E-07	3.3E-09	1.4E-09	3.0E-08	1.3E-08	4.7E-11	1.0E-11	9.3E-14	2.1E-14
			TOTAL HAZARD INDEX		3.E-08	1.E-08	TOTAL CANCER RISK		9.E-14	2.E-14

Notes:
Indoor Air EPC modeled from maximum detected groundwater concentration using DEQ's RBDM Guidance (DEQ, 2001b).
Outdoor Air not evaluated since indoor air risks and hazards were acceptable.
RME = Reasonable Maximum Exposure.
CT = Central Tendency.
EPC = Exposure Point Concentration.

Table B-3 - Area A Risk Calculations
Fugitive Dust Inhalation (Outdoor Air), Excavation Worker
Marine Terminal 1 South Risk Assessment
Portland, Oregon

Compounds of Potential Concern	Soil EPC in mg/kg		PEF in m^3/kg	Outdoor Air EPC in mg/m^3		Hazard Intake in mg/kg-day		Hazard Quotient		Cancer Intake in mg/kg-day		Cancer Risk	
	RME	CT		RME	CT	RME	CT	RME	CT	RME	CT	RME	CT
PAHs													
Benzo(a)anthracene	9.4E+00	3.7E-01	1.32E+09	7.1E-09	2.8E-10	3.8E-11	1.5E-12	--	--	5.4E-13	1.1E-14	1.7E-13	3.3E-15
Benzo(a)pyrene	3.7E-01	3.3E-01	1.32E+09	2.8E-10	2.5E-10	1.5E-12	1.3E-12	--	--	2.1E-14	9.6E-15	6.6E-14	3.0E-14
Benzo(b)fluoranthene	3.4E-01	2.7E-01	1.32E+09	2.6E-10	2.0E-10	1.4E-12	1.1E-12	--	--	2.0E-14	7.8E-15	6.1E-15	2.4E-15
Dibenz(a,h)anthracene	7.0E-02	6.0E-02	1.32E+09	5.3E-11	4.5E-11	2.8E-13	2.4E-13	--	--	4.1E-15	1.7E-15	1.3E-14	5.4E-15
Indeno(1,2,3-cd)pyrene	2.0E-01	1.8E-01	1.32E+09	1.5E-10	1.4E-10	8.1E-13	7.3E-13	--	--	1.2E-14	5.2E-15	3.6E-15	1.6E-15
Metals													
Arsenic	6.0E+00	3.4E+00	1.32E+09	4.5E-09	2.6E-09	2.4E-11	1.4E-11	--	--	3.5E-13	9.9E-14	5.2E-12	1.5E-12
						TOTAL HAZARD INDEX		0.E+00	0.E+00	TOTAL CANCER RISK		5.E-12	2.E-12

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Notes:
Outdoor Air EPC = Soil EPC (See Table 4)/PEF.
PEF = Particulate Emission Factor.
RME = Reasonable Maximum Exposure.
CT = Central Tendency.
EPC = Exposure Point Concentration.

Table B-3a - Area A Risk Calculations
Soil Ingestion, Construction Worker
Marine Terminal 1 South Risk Assessment
Portland, Oregon

Compounds of Potential Concern	Soil EPC in mg/kg		Hazard Intake in mg/kg-day		Hazard Quotient		Cancer Intake in mg/kg-day		Cancer Risk	
	RME	CT	RME	CT	RME	CT	RME	CT	RME	CT
PAHs										
Benzo(a)anthracene	9.4E+00	3.7E-01	3.0E-05	3.6E-07	--	--	4.3E-07	2.6E-09	3.1E-07	1.9E-09
Benzo(a)pyrene	3.7E-01	3.3E-01	1.2E-06	3.2E-07	--	--	1.7E-08	2.3E-09	1.2E-07	1.7E-08
Benzo(b)fluoranthene	3.4E-01	2.7E-01	1.1E-06	2.6E-07	--	--	1.6E-08	1.9E-09	1.1E-08	1.4E-09
Dibenz(a,h)anthracene	7.0E-02	6.0E-02	2.3E-07	5.9E-08	--	--	3.2E-09	4.2E-10	2.4E-08	3.1E-09
Indeno(1,2,3-cd)pyrene	2.0E-01	1.8E-01	6.5E-07	1.8E-07	--	--	9.2E-09	1.3E-09	6.7E-09	9.2E-10
Metals										
Arsenic	6.0E+00	3.4E+00	1.9E-05	3.3E-06	6.5E-02	1.1E-02	2.8E-07	2.4E-08	4.2E-07	3.6E-08
			TOTAL HAZARD INDEX		6.E-02	1.E-02	TOTAL CANCER RISK		9.E-07	6.E-08

Notes:
RME = Reasonable Maximum Exposure.
CT = Central Tendency.
EPC = Exposure Point Concentration.

Table B-3a - Area A Risk Calculations
Dermal Contact with Soil, Construction Worker
Marine Terminal 1 South Risk Assessment
Portland, Oregon

Compounds of Potential Concern	ABS	Soil EPC in mg/kg		Hazard Intake in mg/kg-day		Hazard Quotient		Cancer Intake in mg/kg-day		Cancer Risk	
		RME	CT	RME	CT	RME	CT	RME	CT	RME	CT
PAHs											
Benzo(a)anthracene	0.13	9.4E+00	3.7E-01	1.2E-05	4.5E-07	--	--	1.7E-07	3.2E-09	1.2E-07	2.4E-09
Benzo(a)pyrene	0.13	3.7E-01	3.3E-01	4.7E-07	4.0E-07	--	--	6.7E-09	2.9E-09	4.9E-08	2.1E-08
Benzo(b)fluoranthene	0.13	3.4E-01	2.7E-01	4.3E-07	3.3E-07	--	--	6.1E-09	2.4E-09	4.5E-09	1.7E-09
Dibenz(a,h)anthracene	0.13	7.0E-02	6.0E-02	8.8E-08	7.3E-08	--	--	1.3E-09	5.2E-10	9.2E-09	3.8E-09
Indeno(1,2,3-cd)pyrene	0.13	2.0E-01	1.8E-01	2.5E-07	2.2E-07	--	--	3.6E-09	1.6E-09	2.6E-09	1.1E-09
Metals											
Arsenic	0.03	6.0E+00	3.4E+00	1.7E-06	9.6E-07	5.8E-03	3.2E-03	2.5E-08	6.8E-09	3.7E-08	1.0E-08
				TOTAL HAZARD INDEX		6.E-03	3.E-03	TOTAL CANCER RISK		2.E-07	4.E-08

Notes:
ABS = Dermal Absorption Factor (EPA, 1998).
RME = Reasonable Maximum Exposure.
CT = Central Tendency.
EPC = Exposure Point Concentration.

Table B-3a - Area A Risk Calculations
Vapor Inhalation (Outdoor Air), Construction Worker
Marine Terminal 1 South Risk Assessment
Portland, Oregon

Compounds of Potential Concern	Indoor Air EPC in mg/m³		Hazard Intake in mg/kg-day		Hazard Quotient		Cancer Intake in mg/kg-day		Cancer Risk	
	RME	CT	RME	CT	RME	CT	RME	CT	RME	CT
Volatile Organic Compounds										
Tetrachloroethene	6.1E-07	2.7E-07	1.2E-07	4.0E-08	1.1E-06	3.7E-07	1.7E-09	2.9E-10	3.4E-12	5.7E-13
			TOTAL HAZARD INDEX		1.E-06	4.E-07	TOTAL CANCER RISK		3.E-12	6.E-13

Notes:
Indoor Air EPC modeled from maximum detected groundwater concentration using DEQ's RBDM Guidance (DEQ, 2001b).
Outdoor Air not evaluated since indoor air risks and hazards were acceptable.
RME = Reasonable Maximum Exposure.
CT = Central Tendency.
EPC = Exposure Point Concentration.

Table B-3a - Area A Risk Calculations
Fugitive Dust Inhalation (Outdoor Air), Construction Worker
Marine Terminal 1 South Risk Assessment
Portland, Oregon

Compounds of Potential Concern	PEF in m^3/kg	Outdoor Air EPC in mg/m^3		Hazard Intake in mg/kg-day		Hazard Quotient		Cancer Intake in mg/kg-day		Cancer Risk	
		RME	CT	RME	CT	RME	CT	RME	CT	RME	CT
PAHs											
Benzo(a)anthracene	1.32E+09	7.1E-09	2.8E-10	1.4E-09	4.2E-11	--	--	2.0E-11	3.0E-13	6.1E-12	9.2E-14
Benzo(a)pyrene	1.32E+09	2.8E-10	2.5E-10	5.5E-11	3.7E-11	--	--	7.8E-13	2.7E-13	2.4E-12	8.2E-13
Benzo(b)fluoranthene	1.32E+09	2.6E-10	2.0E-10	5.0E-11	3.0E-11	--	--	7.2E-13	2.2E-13	2.2E-13	6.7E-14
Dibenz(a,h)anthracene	1.32E+09	5.3E-11	4.5E-11	1.0E-11	6.8E-12	--	--	1.5E-13	4.8E-14	4.6E-13	1.5E-13
Indeno(1,2,3-cd)pyrene	1.32E+09	1.5E-10	1.4E-10	3.0E-11	2.0E-11	--	--	4.2E-13	1.4E-13	1.3E-13	4.5E-14
Metals											
Arsenic	1.32E+09	4.5E-09	2.6E-09	8.9E-10	3.8E-10	--	--	1.3E-11	2.7E-12	1.9E-10	4.1E-11
				TOTAL HAZARD INDEX		0.E+00	0.E+00	TOTAL CANCER RISK		2.E-10	4.E-11

F:\DATA\Jobs\Port of Portland\15191-01 T-1 Risk Assessment\Appendices\Appendix B Tables\B-3

Notes:
Outdoor Air EPC = Soil EPC (See Table 4)/PEF.
PEF = Particulate Emission Factor.
RME = Reasonable Maximum Exposure.
CT = Central Tendency.
EPC = Exposure Point Concentration.

Table B-6a - Area B Risk Calculations
Soil Ingestion, Construction Worker
Marine Terminal 1 South Risk Assessment
Portland, Oregon

Compounds of Potential Concern	Soil EPC in mg/kg		Hazard Intake in mg/kg-day		Hazard Quotient		Cancer Intake in mg/kg-day		Cancer Risk	
	RME	CT	RME	CT	RME	CT	RME	CT	RME	CT
PAHs										
Benzo(a)anthracene	1.5E+00	4.0E-01	4.8E-06	3.9E-07	--	--	6.9E-08	2.8E-09	5.1E-08	2.0E-09
Benzo(a)pyrene	2.1E+00	4.7E-01	6.8E-06	4.6E-07	--	--	9.7E-08	3.3E-09	7.1E-07	2.4E-08
Benzo(b)fluoranthene	1.4E+00	3.7E-01	4.5E-06	3.6E-07	--	--	6.5E-08	2.6E-09	4.7E-08	1.9E-09
Dibenz(a,h)anthracene	2.3E-01	1.1E-01	7.4E-07	1.1E-07	--	--	1.1E-08	7.7E-10	7.7E-08	5.6E-09
Indeno(1,2,3-cd)pyrene	9.0E-01	2.9E-01	2.9E-06	2.8E-07	--	--	4.2E-08	2.0E-09	3.0E-08	1.5E-09
Metals										
Arsenic	3.3E+00	2.9E+00	1.1E-05	2.8E-06	3.6E-02	9.5E-03	1.5E-07	2.0E-08	2.3E-07	3.0E-08
			TOTAL HAZARD INDEX		4.E-02	9.E-03	TOTAL CANCER RISK		1.E-06	7.E-08

Notes:
RME = Reasonable Maximum Exposure.
CT = Central Tendency.
EPC = Exposure Point Concentration.

Table B-6a - Area B Risk Calculations
Dermal Contact with Soil, Construction Worker
Marine Terminal 1 South Risk Assessment
Portland, Oregon

Compounds of Potential Concern	ABS	Soil EPC in mg/kg		Hazard Intake in mg/kg-day		Hazard Quotient		Cancer Intake in mg/kg-day		Cancer Risk	
		RME	CT	RME	CT	RME	CT	RME	CT	RME	CT
PAHs											
Benzo(a)anthracene	0.13	1.5E+00	4.0E-01	1.9E-06	4.9E-07	--	--	2.7E-08	3.5E-09	2.0E-08	2.5E-09
Benzo(a)pyrene	0.13	2.1E+00	4.7E-01	2.6E-06	5.7E-07	--	--	3.8E-08	4.1E-09	2.8E-07	3.0E-08
Benzo(b)fluoranthene	0.13	1.4E+00	3.7E-01	1.8E-06	4.5E-07	--	--	2.5E-08	3.2E-09	1.8E-08	2.4E-09
Dibenz(a,h)anthracene	0.13	2.3E-01	1.1E-01	2.9E-07	1.3E-07	--	--	4.1E-09	9.6E-10	3.0E-08	7.0E-09
Indeno(1,2,3-cd)pyrene	0.13	9.0E-01	2.9E-01	1.1E-06	3.5E-07	--	--	1.6E-08	2.5E-09	1.2E-08	1.8E-09
Metals											
Arsenic	0.03	3.3E+00	2.9E+00	9.6E-07	8.2E-07	3.2E-03	2.7E-03	1.4E-08	5.8E-09	2.1E-08	8.8E-09
				TOTAL HAZARD INDEX		3.E-03	3.E-03	TOTAL CANCER RISK		4.E-07	5.E-08

Notes:
ABS = Dermal Absorption Factor (EPA, 1998).
RME = Reasonable Maximum Exposure.
CT = Central Tendency.
EPC = Exposure Point Concentration.

Table B-6a - Area B Risk Calculations
Vapor Inhalation (Outdoor Air), Construction Worker
Marine Terminal 1 South Risk Assessment
Portland, Oregon

	Indoor Air EPC in mg/m³		Hazard Intake in mg/kg-day		Hazard Quotient		Cancer Intake in mg/kg-day		Cancer Risk	
Compounds of Potential Concern	RME	CT	RME	CT	RME	CT	RME	CT	RME	CT
Volatile Organic Compounds										
Chloroform	2.0E-07	7.1E-08	3.9E-08	1.1E-08	3.6E-07	9.6E-08	5.6E-10	7.5E-11	1.1E-12	1.5E-13
			TOTAL HAZARD INDEX		4.E-07	1.E-07	TOTAL CANCER RISK		1.E-12	2.E-13

Notes:
Indoor Air EPC modeled from maximum detected groundwater concentration using DEQ's RBDM Guidance (DEQ, 2001b).
Outdoor Air not evaluated since indoor air risks and hazards were acceptable.
RME = Reasonable Maximum Exposure.
CT = Central Tendency.
EPC = Exposure Point Concentration.

Table B-6a - Area B Risk Calculations
Fugitive Dust Inhalation (Outdoor Air), Construction Worker
Marine Terminal 1 South Risk Assessment
Portland, Oregon

Compounds of Potential Concern	PEF in m^3/kg	Outdoor Air EPC in mg/m^3		Hazard Intake in mg/kg-day		Hazard Quotient		Cancer Intake in mg/kg-day		Cancer Risk	
		RME	CT	RME	CT	RME	CT	RME	CT	RME	CT
PAHs											
Benzo(a)anthracene	1.32E+09	1.1E-09	3.0E-10	2.2E-10	4.5E-11	--	--	3.2E-12	3.2E-13	9.8E-13	1.0E-13
Benzo(a)pyrene	1.32E+09	1.6E-09	3.6E-10	3.1E-10	5.3E-11	--	--	4.4E-12	3.8E-13	1.4E-11	1.2E-12
Benzo(b)fluoranthene	1.32E+09	1.1E-09	2.8E-10	2.1E-10	4.2E-11	--	--	3.0E-12	3.0E-13	9.2E-13	9.2E-14
Dibenz(a,h)anthracene	1.32E+09	1.7E-10	8.3E-11	3.4E-11	1.2E-11	--	--	4.9E-13	8.9E-14	1.5E-12	2.7E-13
Indeno(1,2,3-cd)pyrene	1.32E+09	6.8E-10	2.2E-10	1.3E-10	3.3E-11	--	--	1.9E-12	2.3E-13	5.9E-13	7.2E-14
Metals											
Arsenic	1.32E+09	2.5E-09	2.2E-09	4.9E-10	3.3E-10	--	--	7.0E-12	2.3E-12	1.0E-10	3.5E-11
				TOTAL HAZARD INDEX		0.E+00	0.E+00	TOTAL CANCER RISK		1.E-10	4.E-11

F:\DATA\Jobs\Port of Portland\15191-01 T-1 Risk Assessment\Appendices\Appendix B Tables\B-3

Notes:
Outdoor Air EPC = Soil EPC (See Table 4)/PEF.
PEF = Particulate Emission Factor.
RME = Reasonable Maximum Exposure.
CT = Central Tendency.
EPC = Exposure Point Concentration.

Table B-9a - Area C Risk Calculations
Soil Ingestion, Construction Worker
Marine Terminal 1 South Risk Assessment
Portland, Oregon

Compounds of Potential Concern	Soil EPC in mg/kg		Hazard Intake in mg/kg-day		Hazard Quotient		Cancer Intake in mg/kg-day		Cancer Risk	
	RME	CT	RME	CT	RME	CT	RME	CT	RME	CT
Metals										
Arsenic	1.2E+01	5.8E+00	3.9E-05	5.7E-06	1.3E-01	1.9E-02	5.5E-07	4.1E-08	8.3E-07	6.1E-08
			TOTAL HAZARD INDEX		1.E-01	2.E-02	TOTAL CANCER RISK		8.E-07	6.E-08

Notes:
RME = Reasonable Maximum Exposure.
CT = Central Tendency.
EPC = Exposure Point Concentration.

Table B-9a - Area C Risk Calculations
Dermal Contact with Soil, Construction Worker
Marine Terminal 1 South Risk Assessment
Portland, Oregon

Compounds of Potential Concern	ABS	Soil EPC in mg/kg		Hazard Intake in mg/kg-day		Hazard Quotient		Cancer Intake in mg/kg-day		Cancer Risk	
		RME	CT	RME	CT	RME	CT	RME	CT	RME	CT
Metals											
Arsenic	0.03	1.2E+01	5.8E+00	3.5E-06	1.6E-06	1.2E-02	5.4E-03	5.0E-08	1.2E-08	7.5E-08	1.8E-08
				TOTAL HAZARD INDEX		1.E-02	5.E-03	TOTAL CANCER RISK		7.E-08	2.E-08

Notes:
ABS = Dermal Absorption Factor (EPA, 1998).
RME = Reasonable Maximum Exposure.
CT = Central Tendency.
EPC = Exposure Point Concentration.

Table B-9a - Area C Risk Calculations
Fugitive Dust Inhalation (Outdoor Air), Construction Worker
Marine Terminal 1 South Risk Assessment
Portland, Oregon

Compounds of Potential Concern	PEF in m^3/kg	Outdoor Air EPC in mg/m^3		Hazard Intake in mg/kg-day		Hazard Quotient		Cancer Intake in mg/kg-day		Cancer Risk	
		RME	CT	RME	CT	RME	CT	RME	CT	RME	CT
Metals											
Arsenic	1.32E+09	9.1E-09	4.4E-09	1.8E-09	6.5E-10	--	--	2.5E-11	4.7E-12	3.8E-10	7.0E-11
				TOTAL HAZARD INDEX		**0.E+00**	**0.E+00**	**TOTAL CANCER RISK**		**4.E-10**	**7.E-11**

F:\DATA\Jobs\Port of Portland\15191-01 T-1 Risk Assessment\Appendicies\Appendix B Tables\B-3

Notes:
Outdoor Air EPC = Soil EPC (See Table 4)/PEF.
PEF = Particulate Emission Factor.
RME = Reasonable Maximum Exposure.
CT = Central Tendency.
EPC = Exposure Point Concentration.

Appendix D

APPENDIX D
DEQ ECOLOGICAL SCOPING CHECKLIST

POPT1S601344

ATTACHMENT 1
Ecological Scoping Checklist

Site Name	Terminal 1 South
Date of Site Visit	October 2, 2001
Site Location	2100 NW Front Avenue along the Willamette River in Portland, Oregon
Site Visit Conducted by	Keith A. Kroeger

Part ❶

CONTAMINANTS OF INTEREST Types, Classes, Or Specific Hazardous Substances ‡ Known Or Suspected	Onsite	Adjacent to or in locality of the facility †
Total Petroleum Hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), and metals.	X	

‡ As defined by OAR 340-122-115(30) † As defined by OAR 340-122-115(34)

Part ❷

OBSERVED IMPACTS ASSOCIATED WITH THE SITE	Finding
Onsite vegetation (None, Limited, Extensive)	N
Vegetation in the locality of the site (None, Limited, Extensive)	N
Onsite wildlife such as macroinvertebrates, reptiles, amphibians, birds, mammals, other (None, Limited, Extensive)	N
Wildlife such as macroinvertebrates, reptiles, amphibians, birds, mammals, other in the locality of the site (None, Limited, Extensive)	N
Other readily observable impacts (None, Discuss below)	N
Discussion:	

ATTACHMENT 1
Ecological Scoping Checklist (cont'd)

Part ❸

SPECIFIC EVALUATION OF ECOLOGICAL RECEPTORS / HABITAT	Finding
Terrestrial - Wooded	
Percentage of site that is wooded	0
Dominant vegetation type (Evergreen, Deciduous, Mixed)	P *
Prominent tree size at breast height, i.e., four feet (<6", 6" to 12", >12")	
Evidence / observation of wildlife (Macroinvertebrates, Reptiles, Amphibians, Birds, Mammals, Other)	
Terrestrial - Scrub/Shrub/Grasses	
Percentage of site that is scrub/shrub	<1%
Dominant vegetation type (Scrub, Shrub, Grasses, Other)	Weed
Prominent height of vegetation (<2', 2' to 5', >5')	<2'
Density of vegetation (Dense, Patchy, Sparse)	S
Evidence / observation of wildlife (Macroinvertebrates, Reptiles, Amphibians, Birds, Mammals, Other)	B
Terrestrial - Ruderal	
Percentage of site that is ruderal	99%
Dominant vegetation type (Landscaped, Agriculture, Bare ground)	B (paved)
Prominent height of vegetation (0', >0' to <2', 2' to 5', >5')	0'
Density of vegetation (Dense, Patchy, Sparse)	S
Evidence / observation of wildlife (Macroinvertebrates, Reptiles, Amphibians, Birds, Mammals, Other)	B
Aquatic - Non-flowing (lentic)	
Percentage of site that is covered by lakes or ponds	0%
Type of water bodies (Lakes, Ponds, Vernal pools, Impoundments, Lagoon, Reservoir, Canal)	
Size (acres), average depth (feet), trophic status of water bodies	
Source water (River, Stream, Groundwater, Industrial discharge, Surface water runoff)	
Water discharge point (None, River, Stream, Groundwater, Wetlands impoundment)	
Nature of bottom (Muddy, Rocky, Sand, Concrete, Other)	
Vegetation present (Submerged, Emergent, Floating)	
Obvious wetlands present (Yes / No)	
Evidence / observation of wildlife (Macroinvertebrates, Reptiles, Amphibians, Birds, Mammals, Other)	
Aquatic - Flowing (lotic)	
Percentage of site that is covered by rivers, streams (brooks, creeks), intermittent streams, dry wash, arroyo, ditches, or channel waterway	0%
Type of water bodies (Rivers, Streams, Intermittent Streams, Dry wash, Arroyo, Ditches, Channel waterway)	
Size (acres), average depth (feet), approximate flow rate (cfs) of water bodies	
Bank environment (cover: Vegetated, Bare / slope: Steep, Gradual / height (in feet))	
Source water (River, Stream, Groundwater, Industrial discharge, Surface water runoff)	
Tidal influence (Yes / No)	
Water discharge point (None, River, Stream, Groundwater, Wetlands impoundment)	
Nature of bottom (Muddy, Rocky, Sand, Concrete, Other)	

SPECIFIC EVALUATION OF ECOLOGICAL RECEPTORS / HABITAT	Finding
~~Vegetation present (Submerged, Emergent, Floating)~~	
~~Obvious wetlands present (Yes / No)~~	
Evidence / observation of wildlife (Macroinvertebrates, Reptiles, Amphibians, Birds, Mammals, Other)	
Aquatic - Wetlands	
Obvious or designated wetlands present (Yes / No)	N
Wetlands suspected as site is/has (Adjacent to water body, in Floodplain, Standing water, Dark wet soils, Mud cracks, Debris line, Water marks)	
~~Vegetation present (Submerged, Emergent, Scrub/shrub, Wooded)~~	
Size (acres) and depth (feet) of suspected wetlands	
Source water (River, Stream, Groundwater, Industrial discharge, Surface water runoff)	
~~Water discharge point (None, River, Stream, Groundwater, Impoundment)~~	
Tidal influence (Yes / No)	
Evidence / observation of wildlife (Macroinvertebrates, Reptiles, Amphibians, Birds, Mammals, Other)	

* P: Photographic documentation of these features is highly recommended.

Part ❹

~~ECOLOGICALLY IMPORTANT SPECIES / HABITATS OBSERVED~~
Terminal 1 South is located adjacent to the Willamette River, which is habitat for Coastal cutthroat trout (proposed threatened), Coho salmon (candidate), Steelhead (threatened), and Chinook salmon (threatened).

ATTACHMENT 2
Evaluation of Receptor-Pathway Interactions

EVALUATION OF RECEPTOR-PATHWAY INTERACTIONS	Y	N	U
Are hazardous substances present or potentially present in surface waters?		N	
AND			
Are ecologically important species or habitats present?	Y		
AND			
Could hazardous substances reach these receptors via surface water?		N	
When answering the above questions, consider the following:			
• Known or suspected presence of hazardous substances in surface waters.			
• Ability of hazardous substances to migrate to surface waters.			
• Terrestrial organisms may be dermally exposed to water-borne contaminants as a result of wading or swimming in contaminated waters. Aquatic receptors may be exposed through osmotic exchange, respiration or ventilation of surface waters.			
• Contaminants may be taken-up by terrestrial plants whose roots are in contact with surface waters.			
• Terrestrial receptors may ingest water-borne contaminants if contaminated surface waters are used as a drinking water source.			
Are hazardous substances present or potentially present in groundwater?	Y		
AND			
Are ecologically important species or habitats present?	Y		
AND			
Could hazardous substances reach these receptors via groundwater?			U
When answering the above questions, consider the following:			
• Known or suspected presence of hazardous substances in groundwater.			
• Ability of hazardous substances to migrate to groundwater.			
• Potential for hazardous substances to migrate via groundwater and discharge into habitats and/or surface waters.			
• Contaminants may be taken-up by terrestrial and rooted aquatic plants whose roots are in contact with groundwater present within the root zone (~1m depth).			
• Terrestrial wildlife receptors generally will not contact groundwater unless it is discharged to the surface.			

"Y" = yes; "N" = No, "U" = Unknown (counts as a "Y")

ATTACHMENT 2
Evaluation of Receptor-Pathway Interactions (cont'd)

EVALUATION OF RECEPTOR-PATHWAY INTERACTIONS	Y	N	U
Are hazardous substances present or potentially present in sediments?		N	
AND			
Are ecologically important species or habitats present?	Y		
AND			
Could hazardous substances reach these receptors via contact with sediments?		N	
When answering the above questions, consider the following:			
• Known or suspected presence of hazardous substances in sediment.			
• Ability of hazardous substances to leach or erode from surface soils and be carried into sediment via surface runoff.			
• Potential for contaminated groundwater to upwell through, and deposit contaminants in, sediments.			
• If sediments are present in an area that is only periodically inundated with water, terrestrial species may be dermally exposed during dry periods. Aquatic receptors may be directly exposed to sediments or may be exposed through osmotic exchange, respiration or ventilation of sediment pore waters.			
• Terrestrial plants may be exposed to sediment in an area that is only periodically inundated with water.			
• If sediments are present in an area that is only periodically inundated with water, terrestrial species may have direct access to sediments for the purposes of incidental ingestion. Aquatic receptors may regularly or incidentally ingest sediment while foraging.			
Are hazardous substances present or potentially present in prey or food items of ecologically important receptors?		N	
AND			
Are ecologically important species or habitats present?	Y		
AND			
Could hazardous substances reach these receptors via consumption of food items?		N	
When answering the above questions, consider the following:			
• Higher trophic level terrestrial and aquatic consumers and predators may be exposed through consumption of contaminated food sources.			
• In general, organic contaminants with log $K_{ow} > 3.5$ may accumulate in terrestrial mammals and those with a log $K_{ow} > 5$ may accumulate in aquatic vertebrates.			

"Y" = yes; "N" = No, "U" = Unknown (counts as a "Y")

ATTACHMENT 2
Evaluation of Receptor-Pathway Interactions (cont'd)

EVALUATION OF RECEPTOR-PATHWAY INTERACTIONS	Y	N	U
Are hazardous substances present or potentially present in surficial soils?	Y		
AND			
Are ecologically important species or habitats present?		N	
AND			
Could hazardous substances reach these receptors via incidental ingestion of or dermal contact with surficial soils?		N	
When answering the above questions, consider the following: • Known or suspected presence of hazardous substances in surficial (~1m depth) soils. • Ability of hazardous substances to migrate to surficial soils. • Significant exposure via dermal contact would generally be limited to organic contaminants which are lipophilic and can cross epidermal barriers. • Exposure of terrestrial plants to contaminants present in particulates deposited on leaf and stem surfaces by rain striking contaminated soils (i.e., rain splash). • Contaminants in bulk soil may partition into soil solution, making them available to roots. • Incidental ingestion of contaminated soil could occur while animals grub for food resident in the soil, feed on plant matter covered with contaminated soil or while grooming themselves clean of soil.			
Are hazardous substances present or potentially present in soils?	Y		
AND			
Are ecologically important species or habitats present?		N	
AND			
Could hazardous substances reach these receptors via vapors or fugitive dust carried in surface air or confined in burrows?		N	
When answering the above questions, consider the following: • Volatility of the hazardous substance (volatile chemicals generally have Henry's Law constant > 10^{-5} atm-m^3/mol and molecular weight < 200 g/mol). • Exposure via inhalation is most important to organisms that burrow in contaminated soils, given the limited amounts of air present to dilute vapors and an absence of air movement to disperse gases. • Exposure via inhalation of fugitive dust is particularly applicable to ground-dwelling species that could be exposed to dust disturbed by their foraging or burrowing activities or by wind movement. • Foliar uptake of organic vapors would be limited to those contaminants with relatively high vapor pressures. • Exposure of terrestrial plants to contaminants present in particulates deposited on leaf and stem surfaces.			

"Y" = yes; "N" = No, "U" = Unknown (counts as a "Y")