## APPENDIX 5-I

## FORMAT FOR AN EXPOSURE PATHWAY ASSESSMENT REPORT

Page

**Cover Page**

_____ A. Provide DOH UST facility ID Number

_____ B. Provide facility name and address. If available, provide latitude and longitude coordinates

_____ C. Date report prepared

_____ D. Name, address, and telephone number of person/company preparing report

**Table of Contents**

**1. Executive Summary**

_____ A. Brief summary of the facility and UST history, type and extent of contaminant release, environmental transport and transformation of contaminants, existence of present and future potential receptors and exposure pathways. Conclusions and recommendations should also be summarized.

**2. Introduction/Purpose**

_____ A. Give brief summary of facility and UST release history.

_____ B. State the intent of the report and how it is to be utilized in respect to release response activities at the site.

_____ C. State scope of the report and the extent of its application to the site.

### 3. Characterization Of Contaminants Released

_____ A. Identify chemicals present at the site and provide the maximum concentrations in soil and ground water. Use Tables 5I.3, 5I.4 and 5I.5 provided in the worksheet following this format to summarize information on the chemicals present.

_____ B. Describe full vertical and horizontal extent of contamination. Provide an estimate of volume ($yd^3$) of soil contaminated.

_____ C. Summarize information on chemicals present, integrating chemical properties provided in Tables 5I.1 and 5I.2.

### 4. Characterization Of Exposure Setting

_____ A. Present the characteristics of the physical setting of the site. Use Tables 5I.6, 5I.7, 5I.8 and 5I.9 on the worksheet to identify the pertinent characteristics of the site.

_____ B. Identify the potentially exposed populations. Use Tables 5I.10 and 5I.11 on the worksheet.

_____ C. Summarize the physical setting of the site and surrounding populations and how they will effect potential exposure pathways.

### 5. Identification Of Exposure Pathways

_____ A. Identify the presence of existing and potential exposure pathways at the site without consideration of natural or engineered controls. Use Table 5I.12 on the worksheet to indicate exposure pathways.

_____ B. Identify the effects of natural or engineered controls on existing exposure pathways. Use Table 5I.13 on the worksheet to indicate the effects. Provide information on effectiveness of these controls and include supporting rationale.

_____ C. Summarize all identified exposure pathways and provide rationale for elimination of existing pathways as being of concern to human health and the environment by controls. Potential pathways should have been identified and their management will be addressed in the exposure management plan.

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**6. Identification Of Uncertainties**

_____ A. Summarize the major assumptions of the exposure pathway assessment report. Discuss the uncertainties associated with each assumption and describe how this uncertainty is expected to affect the estimate of exposure.

**7. Summary**

_____ A. Summarize the results of the exposure pathway assessment report. Present conclusions as to the presence or absence of exposure pathways and recommendations for proceeding to either exposure prevention management or other cleanup options.

**8. Worksheet for Exposure Pathway Assessment Report** (see pages 5-I-6 thru 5-I-11)

**9. References**

## Table 5I.1 Contaminant Properties Affecting Subsurface Transport and Fate

| Property | Description |
|---|---|
| Water Solubility | Water solubility governs the extent to which a contaminant will partition into the aqueous phase. More soluble contaminants would be expected to migrate further in the subsurface than less soluble compounds. The greater the water solubility of a compound to migrate with the aqueous advective flow component. Contaminants with high water solubilities are likely to migrate through the vadose zone to ground water. |
| Vapor Pressure | The vapor pressure of a compound provides an indication of the extent to which the compound will volatilize. The tendency of a compound to volatilize will rise proportionately with its vapor pressure. |
| Henry's Law Constant | Henry's Law Constant provides an indication of the extent to which a compound will volatilize from an aqueous solution. Henry's Law Constant is directly proportional to the vapor pressure of the compound and inversely proportional to the water solubility of the compound. The greater the Henry's Law Constant of a compound, the greater will be the tendency of the compound to volatilize from aqueous solution. |
| Density | The density of a compound indicates whether the compound is heavier or lighter than water. Liquid compounds with densities greater than 1.0 g/cc (the density of water) and of only limited water solubility may migrate vertically under the influence of gravity and eventually gravitate to the bottom or other region of an aquifer where an impermeable layer is encountered. Compounds with limited water solubility and with densities less than 1.0 g/cc will tend to float on the water table. |
| Log $K_{ow}$ | The octanol/water partition coefficient is a measure of the extent to which a contaminant partitions between octanol and water. It is the ratio of the concentration of the compound in octanol to the concentration of the compound in water. The $K_{ow}$ provides an indication of the extent to which a compound will adsorb to a soil or an aquifer solid, particularly organic material. The greater the $K_{ow}$ value of a compound, the greater will be its tendency to be adsorbed in the subsurface. |
| Log $K_{oc}$ | The organic carbon partition coefficient is the ratio of the amount of chemical adsorbed per unit weight of organic carbon in the soil to the concentration of the chemical in solution at equilibrium. The $K_{oc}$ is similar to the $K_{ow}$ in that the higher the $K_{oc}$, the more likely a chemical is to bind to soil or sediment than to remain in water. |

## Table 5I.2 Chemical Properties of Contaminants*

| CHEMICAL (Organics) | Water Solubility (mg/l) | Vapor Pressure (mmHg) | Henry's Law Constant (atm-$m^3$/mol) | Density (g/cc) | Log $K_{ow}$ | Log $K_{oc}$ |
|---|---|---|---|---|---|---|
| Benzene | $1.78x10^{-3}$ | 0.76 | $5.43x10^{-3}$ | 0.8765 | 2.13 | 1.81 |
| Ethylbenzene | $1.52x10^{-2}$ | 7.0 | $7.9x10^{-3}$ | 0.867 | 3.15 | 2.83 |
| Toluene | $5.15x10^{-2}$ | 0.22 | $6.61x10^{-3}$ | 0.8669 | 2.73 | 2.41 |
| Benzo(a)pyrene | $3.8x10^{-3}$ | $5.49x10^{-9}$ | $1.8x10^{-5}$ | nd | 6.06 | 6.74 |
| Acenapthene | 3.88 | $2.31x10^{-2}$ | $1.20x10^{-3}$ | 1.225 | 3.92 | 3.7 |
| Fluoranthene | 0.265 | $1x10^{-6}$ | $6.5x10^{-6}$ | 1.252 | 4.90 | 4.58 |
| Napthalene | 0.31 | 0.2336 | $1.27x10^{-3}$ | 1.162 | 3.30 | 3.11 |
| Aroclor 1242 | 0.45 | $4.06x10^{-4}$ | $3.4x10^{-4}$ | 1.385 | 5.58 | 5 |
| Aroclor 1254 | $1.2x10^{-2}$ | $7.71x10^{-5}$ | $2.8x10^{-4}$ | 1.538 | 6.03 | 5.72 |
| Aroclor 1260 | $2.7x10^{-3}$ | $4.05x10^{-5}$ | $3.4x10^{-4}$ | 1.44 | 7.15 | 6.83 |
| 1,1,1 Trichloro-ethane | $9.5x10^{-2}$ | $1x10^{-2}$ | $2.76x10^{-3}$ | 1.325 | 2.49 | 2.18 |
| Tetrachloro-ethylene | $1.5x10^{-2}$ | 0.14 | $2.27x10^{-2}$ | 1.625 | 3.14 | 2.82 |

| CHEMICAL (Inorganics) | PROPERTIES |
|---|---|
| Lead (total) | Adsorption behavior correlates with cation exchange capacity (CEC) of soil and aquifer material. Adsorption/precipitation increases with increasing pH with most Pb precipitating out at pH>6. |
| Cadmium (total) | Adsorption behavior correlates with cation exchange capacity (CEC) of soil and aquifer material.Adsorption/precipitation increases with increasing pH with most Cd precipitating out at pH>6. |
| Chromium (total) | May occur in more than one oxidation state in subsurface. Trivalent form (Cr III) is dominant under pH and redox conditions generally present in subsurface. Cr III may be converted to highly mobile and toxic hexavalent form (Cr VI) under oxidizing conditions. Cr III is readily adsorbed in the subsurface while Cr VI is not. |

* U.S. EPA. 1990. Subsurface Contamination Guide. EPA/540/2-90/011. Office of Emergency and Remedial Response, Washington, D.C.

## WORKSHEET FOR EXPOSURE PATHWAY ASSESSMENT REPORT

Use this worksheet to provide DOH with information needed to assess existing potential exposure pathways at a site due to a release. Include this worksheet along with written supporting rationale for claims made and recommendations for further action at the site. If parts are non-applicable or unknown, indicate by a "NA" or "UNK" respectively.

## I. CHARACTERIZATION OF CONTAMINANTS RELEASED

### Table 5I.3 Nature of Release

| SUBSTANCE | VOLUME RELEASED |
|---|---|
| Unleaded Gasoline | |
| Leaded Gasoline | |
| Diesel | |
| Jet Fuel | |
| Kerosene | |
| Fuel Oil | |
| Waste Oil | |
| Unknown | |

### Table 5I.4 Identification of Maximum Concentrations of Chemicals Present in Soil

| **SOIL** | Unleaded Gasoline | Leaded Gasoline | Diesel | Jet Fuel | Kerosene | Fuel Oil | Waste Oil | Unknown |
|---|---|---|---|---|---|---|---|---|
| Benzene | | | | | | | | |
| Toluene | | | | | | | | |
| Ethylbenzene | | | | | | | | |
| Acenaphthalene | | | | | | | | |
| Fluoranthene | | | | | | | | |
| Benzo(a)pyrene | | | | | | | | |
| Polychlorinated biphenyls | | | | | | | | |
| 1,1,1-Trichloroethane | | | | | | | | |
| Tetrachloro-ethylene | | | | | | | | |
| Total Lead | | | | | | | | |
| Total Cadmium | | | | | | | | |
| Total Chromium | | | | | | | | |
| Other | | | | | | | | |

**Table 5I.5 Identification of Maximum Concentrations of Chemicals Present in Water**

| WATER | Unleaded Gasoline | Leaded Gasoline | Diesel | Jet Fuel | Kerosene | Fuel Oil | Waste Oil | Unknown |
|---|---|---|---|---|---|---|---|---|
| Benzene | | | | | | | | |
| Toluene | | | | | | | | |
| Ethyl-Benzene | | | | | | | | |
| Acenaphthalene | | | | | | | | |
| Naphthalene | | | | | | | | |
| Fluoranthene | | | | | | | | |
| Benzo(a)pyrene | | | | | | | | |
| Polychlorinated biphenyls | | | | | | | | |
| 1,1,1-Trichloroethane | | | | | | | | |
| Tetrachloro-ethylene | | | | | | | | |
| Total Lead | | | | | | | | |
| Total Cadmium | | | | | | | | |
| Total Chromium | | | | | | | | |
| Other | | | | | | | | |

## II. CHARACTERIZATION OF EXPOSURE SETTING

A. Provide annual net precipitation for site. Determine monthly precipitation and monthly evapotransportation to determine net precipitation by using local measured monthly averages or use monthly averages from the National Oceanographic and Atmospheric Administration. It is not intended for consultants/contractors to collect field measurements, use of credible references and estimates based on available information is sufficient.

**Table 5I.6 Net Precipitation**

| ANNUAL NET PRECIPITATION (INCHES) | |
|---|---|
| GREATER THAN 0 TO 5 | |
| GREATER THAN 5 TO 15 | |
| GREATER THAN 15 TO 30 | |
| GREATER THAN 30 | |

B. Identify all aquifers underlying the site (i.e. brackish, fresh, perched) and provide depth to each aquifer. Measure depth to aquifer by determining the depth from the lowest known point of contamination at the site to the top of the aquifer being evaluated.

**Table 5I.7 Depth to Aquifer(s)**

| DEPTH TO AQUIFER (FEET) | AQUIFER TYPE | | |
|---|---|---|---|
| | | | |
| LESS THAN OR EQUAL TO 25 | | | |
| GREATER THAN 25 TO 250 | | | |
| GREATER THAN 250 | | | |

C. Evaluate the geologic materials in the interval between the lowest known point of contaminant at the site and the top of the aquifer being evaluated. Use of credible references to identify the geologic materials is sufficient. Identify the type of material present on the table below. Only consider layers at least 3 feet thick. The assigned hydraulic conductivities provided can be used, or can be determined by in-situ or laboratory tests for identified layers. Provide documentation of these tests if done.

**Table 5I.8 Type of Geologic Material**

| TYPE OF MATERIAL | PRESENCE | ASSIGNED HYDRAULIC CONDUCTIVITY (CM/SEC) |
|---|---|---|
| CLAY; low permeability till (compact unfractured till), shale, unfractured metamorphic and igneous rocks | | $10^{-8}$ |
| SILT; loesses, silty clays, sediments that are predominantly silts, moderately permeable till (fine-grained, unconsolidated till or compact till with some fractures), low permeability limestones and dolomites, low permeability sandstone, low permeability fractured igneous and metamorphic rocks | | $10^{-6}$ |
| SANDS; sandy silts, sediments that are predominantly sand, highly permeable till (coarse-grained, unconsolidated or compact and highly fractured), peat, moderately permeable limestones and dolomites, moderately permeable sandstone, moderately permeable fractured igneous and metamorphic rocks | | $10^{-4}$ |
| GRAVEL; clean sand, highly permeable fractured igneous and metamorphic rocks, permeable basalt | | $10^{-2}$ |

D. Select from the previously identified geologic material the layer(s) with the lowest hydraulic conductivity as the layer(s) will be a controlling factor in migration of the contaminants present.

**Table 5I.9 Thickness of Lowest Hydraulic Conductivity Layer(s)**

| HYDRAULIC CONDUCTIVITY | THICKNESS OF LAYER | | | |
|---|---|---|---|---|
| | Greater than 3 to 5 | 5 to 100 | 100 to 500 | Greater than 500 |
| Greater then or equal to $10^{-3}$ | | | | |
| $10^{-3}$ to $10^{-5}$ | | | | |
| $10^{-5}$ to $10^{-7}$ | | | | |
| Less than $10^{-7}$ | | | | |

E. Identify potentially exposed receptors to the released contaminants (without consideration of engineered or natural controls). Mark if receptor is present on the table below.

**Table 5I.10 Potentially Exposed Populations**

| HUMAN POPULATION COUNTS* | DISTANCE FROM RELEASE IN MILES | | | | | |
|---|---|---|---|---|---|---|
| | 0-1/4 | 1/4-1/2 | 1/2-1 | 1-2 | 2-3 | 3-4 |
| Residents | | | | | | |
| Workers | | | | | | |
| GROUND WATER WELLS | | | | | | |
| Drinking | | | | | | |
| Industrial | | | | | | |
| Agriculture | | | | | | |
| SURFACE WATERS | | | | | | |
| Rivers, Streams and Canals | | | | | | |
| Lakes and Reservoirs | | | | | | |
| Bays, Estuaries and Oceans | | | | | | |
| SENSITIVE ECOLOGICAL RECEPTORS** | | | | | | |
| Flora | | | | | | |
| Fauna | | | | | | |

* Human population counts can be provided by giving ranges (0, 1 to 100, 101 to 1,000, Greater than 1,000).

** Identify presence of sensitive ecological receptors using descriptions provided in Table 5F.11 Those receptors identified on Table 5F.11 should be reflected in Table 5F.10

F. This table is meant to serve as guidance for sensitive ecological receptors (flora and fauna) to identify, it is not all-encompassing. If sensitive ecological receptors are present, accompanying text should describe them in greater detail.

**Table 5I.11 Sensitive Ecological Receptors**

| | |
|---|---|
| Critical habitat for Federal designated endangered or threatened species | |
| Marine Sanctuary | |
| National Park | |
| Designated Federal Wilderness Area | |
| National Monument | |
| National Seashore Recreational Area | |
| Habitat known to be used by Federal or State designated or proposed endangered or threatened species | |
| National Estuarine Research Reserves | |
| National or State Wildlife Refuge | |
| Spawning areas critical for the maintenance of fish/shellfish species | |
| National Preserve | |
| Federal designated Scenic or Wild river | |
| State land designated for wildlife or game management | |
| State designated Natural Areas | |
| Marine Life Conservation District | |
| Fishery Management Area | |
| Natural Area Reserve | |
| Conservation Land Use District Protective Subzone | |
| Other areas important to maintenance of unique biotic communities | |
| | |
| | |
| | |
| | |

## III. IDENTIFICATION OF EXPOSURE PATHWAYS

A. Identify existing and potential exposure pathways (without consideration of engineered or natural controls).

**Table 5I.12 Exposure Pathways**

| Routes of Exposure | Receptors for Exposure Routes | | |
|---|---|---|---|
| | Human | Flora | Fauna |
| Oral-Water | | | |
| Oral-Soils | | | |
| Dermal-Water | | | |
| Dermal-Soils | | | |
| Inhalation-Volatilization from water | | | |
| Inhalation-Volatilization from soils | | | |

B. Identify where natural or engineered controls effect the existing exposure pathways identified above.

**Table 5I.13 Effects of Natural or Engineered Controls on Exposure Pathways**

| Natural Controls | Oral-Water | Oral-Soils | Dermal-Water | Dermal-Soils | Inhalation-Volatilization from water | Inhalation-Volatilization from soils |
|---|---|---|---|---|---|---|
| 1. | | | | | | |
| 2. | | | | | | |
| 3. | | | | | | |
| 4. | | | | | | |
| Engineered Controls | | | | | | |
| 1. | | | | | | |
| 2. | | | | | | |
| 3. | | | | | | |
| 4. | | | | | | |