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8 Risk Calculators

This portion of the guidance provides insights on the use and applicability of electronic calculators for assessing TPH risk and describes various tools available for estimating the potential human health risks associated with TPH-related contamination and calculating generic risk-based screening levels (RBSLs) and site-specific target levels (SSTLs) for use in site management. In general, these electronic calculators can provide (1) the level of risk and exposure based on the known contaminant concentration present at a site ("forward mode"), which is useful for estimating the scope and degree of cleanup required to achieve protective levels, and (2) acceptable contaminant concentration(s) that are estimated to meet a specified level of risk ("backward mode"); most calculators operate in the backward mode. RBSLs and SSTLs are expected to be protective for the general human population, including susceptible groups such as pregnant women and children in residential, commercial/industrial, and in some cases, construction worker scenarios. Calculators for potential impacts to ecological receptors are described in Section 7.

8.1 Calculating TPH Risk

A number of electronic TPH risk calculators are available. The calculators are based on the same simple commonly applied risk equations used for individual chemicals (ASTM 2015b; ITRC 2015; USEPA 1996, 2002, 2004, 2018c). Many TPH risk calculators are available, but they often reflect different policy decisions and incorporate different physical, chemical, and/or toxicity parameter values, which results in different estimated risks, RBSLs, and SSTLs. Most calculators use single surrogate compounds to represent the physical, chemical, and toxicity properties of a given TPH fraction. Other calculators are more broadly based on the properties of various petroleum mixtures.

When present and included in a TPH analysis, petroleum biodegradation products can contribute significantly to bulk TPH concentrations (see Section 4) and cause exceedances of local regulatory TPH screening levels. However, none of the electronic TPH risk calculators are currently set up to directly address the potential risks associated with petroleum biodegradation products. Potential human health risk and health-based RBSLs and SSTLs for biodegradation products could be calculated using the same equations as those for other contaminants *if all necessary physical, chemical, and toxicity properties of the chemicals are known*. It is important to discuss the need for risk estimates, RBSLs, or SSTLs for biodegradation products and the assumptions to be used with local regulatory agencies prior to calculation.

8.1.1 Risk-Based Screening Levels

RBSLs are generic screening-level chemical concentrations in air, water, and/or soil that are expected to be protective of human receptors under most exposure conditions. They are derived equivalent to a specified level of risk (e.g., cancer risk <1E-06 to 1E-04, Hazard Index ≤ 1) and typically incorporate reasonable maximum exposure factors (USEPA 2014), generic site conditions, and very conservative chemical property and toxicity parameters. Many regulatory programs have adopted these standard calculations in developing program-specific generic RBSLs that are then used as regulatory site screening levels. TPH RBSLs developed for different regulatory programs may vary by orders of magnitude, depending on the assumptions used. The States Survey demonstrates the variability in regulatory screening values.

In applying RBSLs at an individual site it is important to make sure that the assumptions that went into the RBSL calculation are consistent with the site's conceptual site model and that the analytical data available for the site are consistent with the RBSL to be applied. For example, USEPA TPH RSLs (USEPA 2018d) have been developed separately for aliphatic and aromatic compounds in three TPH carbon ranges (i.e., low, medium, high). Application of these RBSLs to analytical data that does not represent these fractionated groupings (e.g., total petroleum hydrocarbons [aliphatic low]) is not strictly appropriate and introduces significant uncertainty into the analysis. Practitioners should consult local regulatory agencies prior to selecting RBSLs to be applied at a particular site.

8.1.2 Site-Specific Target Levels

SSTLs are typically based on the same general equations used to develop RBSLs, but they incorporate site-specific exposure assumptions and/or properties of the contaminated media for applicable constituents and exposure pathways, such as soil porosity, soil density, distance to receptors, fraction organic carbon, source-area size, contaminant degradation rate, and

measured petroleum composition. SSCLs provide more accurate estimates of exposure and often serve as site-specific cleanup goals.

8.1.3 Parameters Necessary for Calculating TPH RBSLs and SSTLs

TPH RBSLs and SSTLs often vary among agencies and calculators because of differences in how TPH fractions are defined, as well as differences in the assumed values for physical, chemical, toxicity, and exposure parameters. Lists of TPH fraction chemical and toxicity parameter values can be found in TPHCWG (1997a, 1997b) guidance and in several state regulatory programs, including those developed by Alaska DEC [ADEC] (2016) and Texas CEQ [TCEQ] (2017b). Comprehensive lists of exposure parameters can be found in USEPA (2011, 2018b, 2018d) guidance. Because of the variability of parameter values used by different regulatory programs, practitioners should consult their local regulatory program for guidance in assigning values. Whenever site-specific parameters are available, they should be used to provide the most accurate exposure and risk estimates.

Examples of parameters that often differ among risk calculators include:

- TPH fractions. For example, some calculators include a >C6–C7 aromatic fraction, while others do not because they routinely analyze the individual chemicals in that fraction (e.g., benzene, toluene).
- Hydrogeologic parameters: e.g., soil type, porosity, fraction organic carbon (f_{oc}), and moisture content.
- Chemical-specific properties: e.g., Henry's law constant, solubility, assumed air and water diffusion coefficients.
- Exposure parameters: e.g., soil ingestion rate, exposure duration, exposure frequency.
- Toxicity values: Some calculators use values corresponding to the most toxic chemical assumed to be present in a given TPH fraction, while others use compounds or complex mixtures that are considered to be more representative of the chemicals present in a fraction.

8.1.4 Exposure Pathways

Electronic calculators developed by different agencies may include all or a subset of the following human exposure pathways:

- Air inhalation
- Water ingestion
- Groundwater volatilizing through soil to indoor air
- Groundwater volatilizing through soil to outdoor/ambient air
- Soil leaching to groundwater for ingestion
- Subsurface soil volatilizing to indoor air/enclosed space
- Subsurface soil volatilizing to outdoor/ambient air
- Surface soil ingestion, particulate inhalation, and dermal contact

The selection of the appropriate pathways to consider at any particular site should be consistent with its conceptual site model. For example, calculations for vapor intrusion to indoor air may not be necessary if buildings do not currently exist at a site and future development of enclosed structures will be restricted, or if any existing or expected future structures "screen out," as described in ITRC PVI and USEPA PVI guidances.

8.2 Electronic TPH Risk Calculators

Many regulatory programs and other organizations have constructed electronic calculators and spreadsheet tools for estimating levels of risk (forward mode) and/or calculating TPH RBSLs and SSTLs (backward mode). Table 8-1 shows calculators developed by 11 regulatory or other agencies, compares some of the most important features for evaluating TPH risk, and summarizes the main benefits and limitations of each calculator. The majority are simple spreadsheets and not expert systems that guide the user through the risk assessment process. The most useful calculators are those that calculate risk, RBSLs, and/or SSTLs for a large number of exposure pathways and permit adjustment of many site- and chemical-specific parameters that are influential in risk assessments. Practitioners can use this table to help select a risk calculator that best matches a site's conceptual site model and includes parameters that best match required regulatory conditions. Most state programs and the USEPA calculator can be used or downloaded at no cost.

Seven of the calculators were developed specifically for use in a particular state, and assumptions incorporated into these tools may limit their potential usefulness for application outside of the state. Three calculators (API TPH spreadsheet (API 2008), RBCA Toolkit (GSI 2018), and RISC5 software (Spence, Walden, and Roy 2017)) are more flexible, allowing TPH

fractions to be defined by the user and the input variables modified. These calculators also have the advantage that they include an unsaturated zone leaching model along with a groundwater transport model. Most of the other calculators use a leaching model based on the very conservative approach presented in the USEPA Soil Screening Guidance (USEPA 2002) and in ASTM guidance (ASTM 2015b) in which the unsaturated zone source is assumed to be just above the water table and the groundwater model consists only of a mixing zone in groundwater directly beneath the source.

One of the most important features of a TPH calculator is whether the model can account for the presence of NAPL (or "four-phase partitioning"). Many calculators (such as the USEPA RSL calculator) assume three-phase partitioning, in which it is assumed that all of a contaminant is found either adsorbed to soil, in the vapor phase, or in the dissolved phase. For petroleum hydrocarbons it is common to have a fourth, oil, phase into which chemicals also partition. If this fourth phase is not considered, the amount of the contaminant in the other three phases will be overestimated (often greatly overestimated). Therefore, any TPH model that estimates the presence of petroleum hydrocarbons in the vapor phase (for volatilization to indoor or outdoor air) or dissolved phase (for leaching to groundwater) should account for the presence of NAPL. This is typically done by incorporating Raoult's law into the models to limit the TPH concentrations in those phases. The benefits/limitations columns in Table 8-1 indicate whether the calculators account for the presence of NAPL and include four-phase partitioning.

Table 8-1. Comparison of TPH electronic risk calculators

Calculator Source	**Description/Main Benefits**	**Main Limitations**	**Calculates Level of Risk (Forward Mode)**	**Calculates RBSLs/SSTLs Exposure Pathways (Backward Mode)**	**Allows Modifications to Exposure,Chemical, Toxicity Properties**	**TPH Fractions and COPCs**
Alaska Petroleum Cleanup Level Calculator (Online Hydrocarbon Method 3 Calculator) (ADEC 2016)	• Online calculator used to implement "Method 3" and calculate SSTLs for "gross TPH fractions," such as total GRO, DRO, RRO or GRO, DRO, RRO aliphatics and aromatics • Can change default soil parameters	• Does not account for delineation of multiple TPH fractions within GRO, DRO, or RRO • Leaching model assumes impacted soil in contact with GW and that GW is unimpacted • Does not account for presence of NAPL	No	Yes Soil (ing) Soil (inh of outdoor air) Soil (leaching to GW) GW	No	• 6 TPH fractions or • 3 total fractions (GRO, DRO, RRO) • 150 individual compounds
Alaska Hydrocarbon Risk Calculator (ADEC)	• Excel Spreadsheet. Fairly complex algorithms • Wide variety of exposure pathways • Accounts for presence of NAPL	• No true unsaturated zone or GW transport models	Yes	Yes Soil (ing) Soil (inh of indoor and outdoor air) Soil (leaching to GW) GW (ing)	No	• 16 TPH fractions • 150 individual compounds

Calculator Source	Description/Main Benefits	Main Limitations	Calculates Level of Risk (Forward Mode)	Calculates RBSLs/SSTLs Exposure Pathways (Backward Mode)	Allows Modifications to Exposure,Chemical, Toxicity Properties	TPH Fractions and COPCs
API TPH Risk-Based Cleanup Levels Spreadsheet (API 2008)	• Excel spreadsheet. • Based on original TPHCWG fractionation scheme. • Contains true unsaturated zone and groundwater transport models. • Contains a large database with TPH fractionation data for crude oils from around the world (and a few refined products). • Accounts for presence of NAPL	• Does not calculate GW RBSLs	No	Yes Soil (ing, inh, dermal) Soil (leaching to GW and GW ing) Soil (inh of outdoor air)	Yes	• 12 TPH fractions • BTEXN • PAHs
Hawaii DOH 2017 (HIDOH 2017)			No	Soil	Yes	• 3 TPH fractions
Maine Excel Risk Calculators for soil, indoor air, groundwater (MEDEP 2016)	• Excel spreadsheet	• Cannot modify any inputs • Cannot view default values or algorithms used	Yes	Yes Soil (ing, inh, dermal) GW (ing) Indoor air (inh)	No	• 6 fractions • numerous individual compounds
Massachusetts EPH Calculator 2017	• Excel spreadsheet		Yes	Soil Water	Yes	• 6 TPH fractions
New Jersey EPH Calculator (NJDEP 2017a)	• Excel Spreadsheet for “Non-#2 fuel oil/diesel oil” petroleum mixtures	• Not to be used for #2 fuel oil/diesel or lighter, more volatile mixtures (gasoline, kerosene, jet fuel, mineral spirits) • Cannot view default values or algorithms used • Pathways considered are not described • Unclear whether accounts for NAPL	No	Yes Soil (pathways not described)	No	• 8 TPH fractions

Calculator Source	Description/Main Benefits	Main Limitations	Calculates Level of Risk (Forward Mode)	Calculates RBSLs/SSTLs Exposure Pathways (Backward Mode)	Allows Modifications to Exposure,Chemical, Toxicity Properties	TPH Fractions and COPCs
Oregon Calculating Risk-Based Concentrations (RBC) for Total Petroleum Hydrocarbons (ORDEQ 2011)	• Excel spreadsheet • Site-specific information can be used • Includes subchronic toxicity for construction scenarios • Accounts for presence of NAPL	• Cannot modify toxicity values or fraction names • For leaching to GW, source is assumed to be in contact with GW • No unsaturated zone or GW transport models	No	Yes Soil (ing, inh, dermal) Soil (inh outdoor air) Soil (leaching to GW and GW ing) GW (ing) GW (ing and inh of volatiles) GW (inh outdoor air) GW (inh indoor air) GW (dermal, inh of volatiles for excavations)	Yes	• 12 TPH fractions • BTEXN • n-hexane • 1,2,4-trimethylbenzene • 1,3,5-trimethylbenzene
RBCA Toolkit	• Spreadsheet application that walks user through generic and/or site-specific risk evaluations • Includes the original TPHCWG fractions· Accounts for NAPL • Can model downgradient GW receptors • Includes numerous built-in fate and transport model options plus option to import attenuation factors from external models	• Must purchase software	No	Yes Soil (ing, inh, dermal) Soil (leaching to GW and GW ing) Soil (leaching to GW and migration to SW) Soil (inh outdoor and indoor air) GW (ing, inh outdoor and indoor air, migration to SW)	Yes	• 13 default TPH fractions • > 600 individual constituents

Calculator Source	Description/Main Benefits	Main Limitations	Calculates Level of Risk (Forward Mode)	Calculates RBSLs/SSTLs Exposure Pathways (Backward Mode)	Allows Modifications to Exposure,Chemical, Toxicity Properties	TPH Fractions and COPCs
RISC5	• Expert software program that walks the user through the risk evaluation • Includes the original TPHCWG TPH fractions • Accounts for presence of NAPL • Can model downgradient GW receptors	• Must purchase software	Yes	Yes Soil (ing, inh, dermal) Soil (leaching to GW and GW ing) Soil (inh indoor air) Soil (leaching to GW and migration to SW) GW (ing, inh, dermal)	Yes	• 13 TPH fractions • > 200 individual constituents
Texas TPH Protective Concentration Levels (PCLs) Calculators (TCEQ 2017b)	• Excel spreadsheet • Calculates overall protective concentration limits for TPH based on site-specific TPH mixture	• Must be used with TX fractionated analytical method	No	Yes Soil (ing, leaching to GW, volatilization) GW (ing, non-ing, volatilization)	No	• 13 TPH fractions
USEPA RSL Calculator (USEPA 2018c)	• Online calculator • Includes several exposure scenarios • Includes subchronic exposure option • Allows calculations for alternate target risk levels • Allows site-specific inputs for many variables	• Calculates fractionated TPH risks only; does not calculate overall TPH risks • Does not account for presence of NAPL	Yes	Yes Soil (ing, inh outdoor air, dermal) Tapwater (ing) Air (inh)	Yes	• 6 TPH fractions (carbon ranges low, medium, high)
Utah Cleanup Level Calculator (UDEQ 2015)	• Excel spreadsheet • Calculates site-specific cleanup levels • Allows calculations for alternate target risk levels • Allows site-specific inputs for many variables	• Used to calculate TPH fraction cleanup levels only; cannot calculate overall TPH screening/cleanup level • Unclear whether it accounts for presence of NAPL	No	Yes Soil (ing, inh, dermal) Soil (leaching to GW and GW ing) Soil (inh outdoor and indoor air) GW (ing, inh outdoor and indoor air) Air (inh)	Yes	• 10 TPH fractions • BTEXN • PAHs

Calculator Source	Description/Main Benefits	Main Limitations	Calculates Level of Risk (Forward Mode)	Calculates RBSLs/SSTLs Exposure Pathways (Backward Mode)	Allows Modifications to Exposure,Chemical, Toxicity Properties	TPH Fractions and COPCs
Washington Calculator (WADOE 2015)			No	Yes	Yes	• TPH gasoline, diesel, heavy oil (carbon ranges not specified)

COPCs = chemicals of potential concern; DRO = diesel range organics; GRO = gasoline range organics; GW = groundwater; ing = ingestion; inh = inhalation; RRO = residual range organics; SW = surface water