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Montana Risk-Based Corrective Action Guidance for Petroleum Releases

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Risk-Based Corrective Action Guidance for Petroleum Releases

Purpose:	The purpose of this document is to establish a risk-based approach to remediation of releases of petroleum products.
Scope:	This guidance applies to petroleum products, crude oil, and constituents of petroleum products and crude oil released into the environment.

Revision Date	Revision Description
August 2002	Leaching RBSL update
October 2003	Fraction toxicity update
October 2007	Exposure factor, toxicity, and leaching update
September 2009	Fraction toxicity update and removal of soil beneficial use RBSLs
September 2016	Exposure factor, toxicity, leaching, and text update; addition of Tier 2; see Executive Summary
May 2018	January 2017 benzo(a)pyrene toxicity update and May 2017 Montana DEQ-7 update; see Executive Summary
July 2020	Revised naphthalene RBSLs for Direct Contact in Surface Soil
December 2023	See Executive Summary – Overall update for clarity and updated RBSL equation inputs for all compounds
February 2024	RBSL Toxicity values review and update

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DEFINITIONS AND ACRONYMS

1 x 10^{-5} cancer risk – See Carcinogenic Risk

ARM – Administrative Rules of Montana

AST – Aboveground storage tank used to store petroleum. Also see petroleum storage tank definition.

Attenuation – The reduction in concentrations of chemical(s) of concern in the environment with distance and time due to processes such as diffusion, dispersion, absorption, chemical degradation, biodegradation, and so forth.

bgs – Below ground surface

BTEX – Benzene, toluene, ethylbenzene, and xylenes.

Carcinogen – A compound that the EPA has determined causes cancer based on the weight of peer-reviewed scientific evidence. Some carcinogens may also have non-carcinogenic effects.

Carcinogenic Risk - the potential for carcinogenic human health effects to occur from exposure to the chemical(s) of concern. Cumulative cancer risk for carcinogenic compounds in soil may not exceed a 1E-05 target risk.

Chemicals of concern (COC) – Specific petroleum compounds that are identified following the Tier 2 process for evaluation.

Chemical of potential concern (COPC) – Specific petroleum compounds that are identified for further evaluation following the Tier 1 process.

Circular DEQ-7 – The Montana Numeric Water Quality Standards, applicable to state surface water and groundwater, adopted by rule and published by DEQ.

COC – See chemicals of concern.

COPC – See Chemicals of potential concern.

Commercial/industrial property - Property used as a place of business with employees present with no one living on the property.

Complete exposure pathway – An exposure route with an impacted receptor that is associated with a confirmed source of contamination and migration pathway.

Conceptual site model (CSM) - A representation of the type of release and associated movement through the environment of released chemicals that allows assessment of potential and/or actual exposure to contaminants.

Construction scenario - An exposure scenario based on the limited exposure of any individual to surface (0-2 feet below ground surface) and subsurface soils (2-10 feet below ground surface). Construction workers are exposed to both surface and subsurface soils and therefore, exposure is evaluated using data from both surface and subsurface soils.

Corrective action - Actions at a petroleum release that may include, but are not limited to, investigation, site assessment, emergency response, abatement, underground storage tank removal, cleanup, operation and maintenance of equipment, monitoring, reclamation, and termination of the corrective action.

CSM – See conceptual site model.

DAF – See dilution attenuation factor.

DCA 1,2 - See dichloroethane, 1,2.

DEQ - The Montana Department of Environmental Quality.

DEQ-7 - See Circular DEQ-7.

Dibromoethane, 1,2- (also known as Ethylene dibromide - EDB) - Gasoline additive that was used until leaded gasoline was phased out. EDB may still be found in some leaded aviation gasoline.

Dichloroethane, 1,2- (1,2-DCA) - Leaded gasoline additive that was used until leaded gasoline was phased out. 1,2-DCA is still used as an industrial solvent, and it may still be found in some leaded aviation gasoline.

Diesel range organics (DRO) – A lab analysis of petroleum hydrocarbons within the diesel range (C10 to C28). DRO was historically a DEQ-accepted analytical method used to determine if a petroleum release was present at a level significant enough to require cleanup. DEQ ceased using DRO with the first RBCA publication in 1998 and uses Montana EPH instead.

Dilution attenuation factor (DAF) – The ratio of contaminant concentration in soil leachate to the concentration in groundwater at the downgradient edge of the source area (e.g., landfill, impoundment, or contaminated soils). The DAF represents the reduction in concentration of the leachate created by precipitation infiltrating through contaminated soils to the underlying groundwater, where leachate mixes with upgradient groundwater flowing beneath the source area and within the aquifer beneath the source area.

Down Gradient Edge (DGE) - A term established to describe a hypothetical monitoring well that could be constructed at the down gradient edge of the hypothetical contaminated source zone. This hypothetical well is used in the leaching model to calculate the worst-case groundwater contamination created from the hypothetical contaminant source to calculate RBSLs.

DRO - See diesel range organics.

EDB - See ethylene dibromide or 1,2-dibromoethane.

EPA - The United States Environmental Protection Agency.

EPA Provisional Peer-Reviewed Toxicity Values – A toxicity value derived from a review of the relevant literature using EPA methods, sources of data and guidance for value derivation.

EPH - See extractable petroleum hydrocarbons.

Ethylene dibromide (EDB) - See dibromoethane, 1,2.-

Exposure - The contact of a receptor with a chemical of concern.

Exposure pathway - The route a chemical or physical agent takes from a source to an exposed receptor. An exposure pathway describes the mechanism by which an individual or population is exposed to chemicals of concern at or originating from a release. Each exposure pathway includes a source, an exposure point, and an exposure route. If the exposure point differs from the source, a transport/exposure medium (e.g., air) or media (in cases of transfer between media) will also be included. Some examples of complete exposure pathways include, but are not limited to:

- Release of volatile contaminants to soil from a source leading to inhalation of vapors by a person.
- Ingestion or inhalation of contaminated soil particles by a worker during excavation activities or by a resident digging in their yard.
- Release of contaminants to soils that subsequently leach into underlying groundwater that is used for drinking, bathing, etc.
- Inhalation of vapors by a neighbor resulting from the migration of contamination.
- Release of contaminants to groundwater that discharges to wetlands or other surface water bodies and exposes plants and/or ecological receptors.

Exposure route - the manner in which a chemical(s) of concern comes in contact with an organism (for example, ingestion, inhalation, and dermal contact).

Extractable petroleum hydrocarbons (EPH) - A group of petroleum hydrocarbons that includes the petroleum fractions typically found in diesel and other heavier petroleum products that are not analyzed and reported as specific compounds, like naphthalene. EPH is also the analytical method developed by the Massachusetts Department of Environmental Protection to determine the fractional composition of these compounds.

foc –See fraction organic carbon.

Fraction Organic Carbon (foc) – The fraction of organic carbon (%) in the media (soil/water/air) being evaluated.

Gasoline range organics (GRO) - A lab analysis of petroleum hydrocarbons within the gasoline range (C6 to C12). GRO was historically an accepted analytical method used to determine if a petroleum release was present at a level significant enough to require cleanup. DEQ ceased using GRO with the first RBCA publication in 1998 and uses Montana VPH instead.

GRO - See gasoline range organics.

H_2SO_4 – Sulfuric acid

Hazard index (HI) - The sum of hazard quotients for multiple substances and/or multiple exposure pathways. However, this term is not used in this guidance.

Hazard quotient (HQ) - The ratio of the level of exposure of a chemical(s) of concern over a specified time period to a reference dose for that chemical(s) of concern derived for a similar exposure period.

HCl – Hydrochloric acid

HDPE – High-density polyethylene.

HQ – See hazard quotient.

Institutional Controls – A restriction on the use of real property that mitigates the risk posed to public health, safety, and welfare and the environment.

Lead scavengers - Compounds such as 1,2-DCA and EDB added to leaded gasoline to help volatilize or scavenge tetraethyl lead so it would not accumulate in the engine.

MBTEXN - Methyl tertiary-butyl ether, benzene, toluene, ethylbenzene, xylenes, and naphthalene. A set of compounds commonly found in gasoline.

MCA - Montana Code Annotated.

Methyl tertiary-butyl ether (MTBE) - A synthetic chemical formerly (1979 to 2005) added to commercial gasolines as an anti-knock additive or oxygenate.

MTBE - See methyl tertiary-butyl ether.

Non-carcinogen - A compound that the EPA has determined to have toxic effects but has not determined to be a carcinogen. Some carcinogens may also have non-carcinogenic effects.

Owner/Operator -
- Owner 17.56.101 (50) (a) ARM - a person who owns an underground storage tank system used for the storage, use, or dispensing of regulated substances.
- Operator 17.56.101 (47)(a) ARM - a person in control of or having responsibility for the operation, maintenance, or management of an underground storage tank system.

PAHs - See polycyclic aromatic hydrocarbons.

Petroleum or petroleum product - Crude oil or any fraction of crude oil that is liquid at standard conditions of temperature and pressure (60 degrees Fahrenheit and 14.7 pounds per square inch absolute) such as gasoline, fuel oil, diesel oil, lubricating oil, hydraulic fluids, oil sludge, or refuse, and any other petroleum related product or waste or fraction of the product or waste. The definition also includes additives that may be blended with the product to enhance its properties as a fuel or lubricant. Specific legal definitions relevant to the investigation of petroleum products may be found at § 75-10-302, MCA and § 75-10-701, MCA.

Petroleum release - A release of petroleum product into the environment, with "release" defined below.

Petroleum storage tank (PST) - A tank that contains or contained petroleum or petroleum products and that is: an underground storage tank defined in 75-11-503, MCA; a storage tank that is situated in an underground area, such as a basement, cellar, mine, drift, shaft, or tunnel; an aboveground storage tank (AST) with a capacity less than 30,000 gallons; including aboveground or underground pipes associated with these tanks. The definition of PST excludes pipelines regulated by the Natural Gas Pipeline Safety Act of 1968 (49 U.S.C. 1671, et seq.), the Hazardous Liquid Pipeline Safety Act of 1979 (49 U.S.C. 2001, et seq.), and comparable state laws, if the facility is intrastate (see § 75-11-302(21), MCA).

Polycyclic aromatic hydrocarbons (PAHs) - A group of petroleum hydrocarbons that includes several semi-volatile compounds typically found in petroleum products, especially petroleum products that are heavier than diesel (Also referred to as polynuclear aromatic hydrocarbons).

ppb – Parts per billion.

ppm – Parts per million.

PPRTV – EPA Provisional Peer-Reviewed Toxicity Values

PST – See petroleum storage tank.

PTCS – Petroleum Tank Cleanup Section

RBCA - See risk-based corrective action.

RBSL - See risk-based screening level.

RCRA – See Resource Conservation and Recovery Act.

RCRA metals - A group of eight heavy metals that are listed and monitored by RCRA because they are considered toxic even at low concentrations. These metals include arsenic (As), barium (Ba), cadmium (Cd), chromium (Cr), lead (Pb), mercury (Hg), selenium (Se), and silver (Ag). If metals analysis is required at your site, communicate with the corresponding regulatory program to ensure analytical data is screened appropriately

Reasonably anticipated future uses – Reasonably anticipated future uses are those potential uses that may be possible for that property in the future. The assumptions regarding future land or resource use are regulatory determinations made by and/or in conjunction with the DEQ program overseeing the release and these determinations are generally made before cleanup actions are taken. **Receptor** - Any person, plant, or animal that is or could potentially be adversely affected by a petroleum release.

Regional Screening Levels (RSL) – Risk-based screening levels published by the EPA to screen chemicals at contaminated sites. RSLs are calculated using the latest toxicity values, default exposure assumptions and physical and chemical properties and are updated semi-annually.

Release - Any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing of petroleum or a petroleum product into the environment.

Remediation/Remedial Action – Activities conducted to protect human health and the environment. An encompassing term including investigation, cleanup, monitoring, and resolving (closing) a confirmed petroleum release.

Remedial Investigation (RI) - The purpose of the RI is to collect data to characterize the nature and extent of contamination that will allow for the development of cleanup levels and evaluation of effective remedial alternatives that address human health and environmental risks. For more information see the 2017 PTCS RI Guidance.

Remediation phases – investigation, cleanup, compliance monitoring, and resolution stages of remedial action for a petroleum release.

Residential property - Any property used as a temporary or permanent place of residence. Residential properties also used for businesses are considered residential (e.g., a farm or ranch or a gas station with an on-site residence). Residential properties that include other uses not defined here are evaluated on a case-by-case basis.

Resolved petroleum release – A categorization status used for petroleum releases meaning that DEQ has determined all cleanup requirements have been met and the conditions at the site ensure present and long-term protection of human health, safety and the environment as defined in §75-11-521(5), MCA (also called "closed"). For the purposes of this document, "resolved" can also refer to a suspected petroleum release that DEQ has determined did not release petroleum into the environment exceeding applicable RBSLs.

Resource Conservation and Recovery Act – The federal law that creates the framework for the proper management of hazardous and non-hazardous solid waste. The law describes the waste management program mandated by Congress that gave EPA authority to develop the RCRA program. RCRA includes regulations associated with underground storage tanks.

Responsible Party – General term used to represent the entity responsible for implementing investigation/remedial action/corrective action/etc. in programs other than the Petroleum Tank Cleanup Section.

Risk-based corrective action (RBCA) - A decision-making process based on the protection of public health, safety, and welfare, and the environment, which results in the consistent assessment, remediation and/or resolving (closure) of petroleum releases.

Risk-based screening level (RBSL) - A chemical concentration considered acceptable for a given exposure scenario based on estimated risk to potential receptors.

Risk Assessment - an analysis of the potential for adverse health effects caused by a chemical(s) of concern from a site to determine the need for remedial action or the development of cleanup levels where remedial action is required.

RSL – See regional screening levels.

Soil Screening Levels (SSLs) – A risk-based concentration used for initial comparison of site soil data to identify contaminants of concern for leaching to groundwater.

SPLP – See Synthetic Precipitation Leaching Procedure.

SSL – See soil screening level.

Synthetic Precipitation Leaching Procedure (SPLP) – A sample preparation method developed to model an acid rain leaching environment. It is used for quantifying contaminant partitioning and mobility in site soils.

TEH – Total extractable hydrocarbons. The total amount of hydrocarbon compounds calculated in a petroleum mixture or product using the EPH Method (Montana Method) falls within the molecular carbon molecule range of C-9 and C-36.

TPH – Total petroleum hydrocarbons. TPH may also refer to total purgeable hydrocarbons.

Total Petroleum Hydrocarbons (TPH) - This term is generally applied to analytical methods that report one concentration for the petroleum hydrocarbons present and that are no longer approved by DEQ to assess risks posed by petroleum contamination.

Total Purgeable Hydrocarbons (TPH) – the sum of the volatile hydrocarbon compounds with carbon numbers up to C10 in a substance and includes volatile aromatics.

Tier 1 – The simplest level of RBCA for petroleum releases in Montana. In Tier 1 RBCA, petroleum contaminant levels are compared to pre-determined RBSLs generating a list of COPCs used to determine whether additional evaluations and/or cleanup may be necessary. The Tier 1 process may not be applicable to sites where site-specific cleanup levels have already been chosen or will be identified through an appropriate authority.

Tier 2 – Follows the Tier 1 analysis in the RBCA process. The site-specific CSM consulted and direct exposure COPCs and leaching to groundwater COPCs are separated and adjusted to develop site-specific COCs.

TSP – Trisodium phosphate.

Vadose zone – The part of the soil column extending down from the ground surface to the depth where the subsurface materials are saturated with groundwater. It is also known as the unsaturated zone.

Vapor Intrusion (VI) - Vapor intrusion is the migration of volatile chemicals from the subsurface into overlying or subterranean structures. Volatile chemicals in contaminated soil or groundwater can emit vapors that may migrate through subsurface soils and into air spaces of adjacent or overlying structures. Depending upon the chemicals, some vapors inhaled by occupants can cause adverse health effects, including an increased lifetime cancer risk. In some cases, the vapors may accumulate in buildings to levels that may pose near-term safety hazards, acute health effects or aesthetic problems.

VI – See vapor intrusion.

VOC – See volatile organic compounds.

Volatile organic compounds (VOCs) - Organic chemicals that have a high vapor pressure at ordinary room temperature (60º Fahrenheit), some of which may have short- and long-term adverse health effects.

Volatile petroleum hydrocarbons (VPH) - A group of petroleum hydrocarbons that includes the petroleum fractions typically found in gasoline and other lighter petroleum products that are not analyzed and reported as specific compounds, like benzene. VPH is also the analytical method developed by the Massachusetts Department of Environmental Protection to determine the fractional composition of these compounds.

VPH - See volatile petroleum hydrocarbons.

Executive Summary of 2023 Changes

The Montana Department of Environmental Quality (DEQ) conducts periodic reviews of its Montana Risk-Based Corrective Action (RBCA) Guidance for Petroleum Releases to determine if changes to methods and toxicity information warrant updating the guidance. Following is a bulleted list of substantive changes made to the May 2018 version of the RBCA. The changes in RBSL calculation parameters are documented in the RBCA Appendices. Additional minor editorial changes and updates were also made.

- Construction worker Risk Based Screening Levels (RBSLs) re-calculated using subchronic toxicity values where available.
- Residential and Commercial worker RBSLs re-calculated to incorporate the Montana State Exposure Frequencies.
- All Direct Contact non-carcinogenic RBSLs were re-calculated to incorporate a Hazard Quotient 0.1 (instead of 0.125) to ensure protectiveness in the initial screening phase. This will allow up to 10 (instead of 8) non-carcinogenic compounds present in the initial screening.
- Comprehensive review completed of all equation inputs for both Direct Contact (soil) and water RBSLs; updates made, where needed, based on updates to chemical-specific toxicity values, or data reference updates. This and other equation changes mentioned above led to either an increase or a decrease in the final RBSL, depending on the chemical and receptor.
- Clarification added for evaluating construction worker exposure using soil sample data collected throughout the entire 0 – 10 ft interval.
- New Table 4 series (4a, 4b, & 4c) added. These are Tier 2 RBSL tables walking the user through the Tier 2 RBSL adjustment along with instructions for use to determine the appropriate Tier 2 RBSL for each release.
- Appendix D provides an expanded discussion on the derivation of groundwater RBSLs and a discussion on actions needed based on exceedances of water quality standards or screening levels.
- Order of compounds in screening Tables rearranged to be consistent with most common laboratory reports.
- Table 4, Conceptual Site Model (CSM) table, removed from guidance. RBCA now refers readers to the Release Closure Plan to access the CSM and instructions on filling it out.
- Tables 1 (Surface Soil RBSLs) & 2 (Subsurface Soil RBSLs) removed and replaced with one table (new Table 1) which provides the RBSLs used for release confirmation only and a new Table 2 that contains all Teir 1 RBSLs.
- Table F deleted and recommendation to work with your program on metals screening levels added.
- Section 4, Vapor Intrusion, has been deleted. RBCA now refers readers to DEQ Vapor Intrusion Guidance.
- Section 6, Tier 3 RBCA Evaluation, has been deleted. The changes in this guidance have incorporated adjustments previously occurring at the Tier 3 stage. The Tier 3 RBCA

evaluation now refers to statistical and contaminant fate and transport analyses, using site-specific input parameters for varying exposure scenarios, see Section 1.2.

- Massachusetts Method references for EPH and VPH updated to newest versions. In field methanol preservation option added for VPH. Airtight collection of VPH soils option retained but must be preserved in methanol by the lab within 48 hours.
- Methanol field preservation option added for VOC/oxygenates and 1,2-Dichloroethane (1,2-DCA) in addition to field collection without methanol (with minimal headspace/airtight) and appropriate lab preservation (methanol or other as allowed in SW-846 5035A) within 48 hours of field collection.
- 2018 RBCA Section 3.4.3 updated: Discussion regarding the incorporation of old Total Petroleum Hydrocarbon data (DRO/GRO) has been expanded adding additional information on the adjustments.
- Text was added throughout the document to expand on the RBCA process in general and help walk users through the process.
- 2018 Master Table – Direct Contact Commercial Worker RBSL column provided the Construction Worker RBSL for C19 – C36, C11-C22, Acenaphthylene, and Anthracene since the Construction Worker RBSL was more conservative than the calculated Commercial RBSL. The 2023 Master Table (Table 2) provides the calculated Commercial worker RBSL for these compounds with clarification that Construction worker RBSLs should be screened across the entire soil column (surface and subsurface soil).

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RISK-BASED CORRECTIVE ACTION EVALUATION PROCESS

1.0 INTRODUCTION

1.1 Overview of Risk-Based Corrective Action

This guidance describes the risk-based corrective action (RBCA) process for petroleum releases in the State of Montana. The RBCA process is a decision-making process for the assessment of and response to petroleum releases, based on the protection of human health and the environment. The decision processes combine risk and exposure assessment practices in a tiered approach where corrective actions are tailored to site-specific conditions and risks. This ensures chosen cleanup activities are protective of human health and the environment (ASTM, 2015).

The Department of Environmental Quality (DEQ) developed this document to describe the RBCA evaluation process. This document also provides a description of the concepts and terms used in RBCA for petroleum releases in Montana and is not intended to address other chemical (non-petroleum) releases. This document is applicable to suspect petroleum releases, and petroleum storage tank system (PST) permits regulated by DEQ's Waste Management and Remediation Division and Enforcement Program. In addition, this guidance may be used as a screening tool using the Tier 1 Risk Based Screening Levels (RBSLs) for new releases at hazardous waste sites that are covered by Resource Conservation and Recovery Act (RCRA) permits or orders or at State Superfund or Groundwater Remediation Program sites. For hydrocarbon compounds not specifically addressed in this document, a site-specific approach may be developed in consultation with DEQ. The appropriate regulating agency or bureau should be contacted to determine whether the RBCA evaluation process is appropriate.

The following is a general sequence of events outlined in the RBCA process (ASTM, 2015):

1. Comparing data to appropriate Tier 1 RBSLs and identifying contaminants of potential concern (COPCs).
2. Confirming a release has occurred.
3. Prioritizing the release based on risks (throughout the RBCA process).
4. Deciding whether further evaluation is warranted (based on Tier 1 RBSL exceedances) and if remedial action is needed.
5. Performing a remedial investigation (RI), including the development of a conceptual site model (CSM).
6. Collecting additional site-specific information and/or data, if needed.
7. Developing Tier 2 site-specific RBSLs.
8. Comparing concentrations of COPCs to Tier 2 RBSLs to develop a list of contaminants of concern (COC) at the site.
9. Deciding whether further evaluation is warranted or if additional remedial action is warranted.
10. Resolving the petroleum release when COC analytical results are less than Tier 1 or Tier 2 RBSLs.

1.2 RBCA Risk Evaluation Process

The goal of RBCA is to identify and reduce risks to public health, safety, welfare, and the environment. RBCA uses environmental risk analysis, which incorporates elements of toxicology, hydrogeology, chemistry, geology, and engineering to assess the existing and potential risks from a petroleum release. This information is used to develop contaminant concentration levels determined to be acceptable in the State of Montana.

DEQ's RBCA process is implemented in a tiered approach, involving increasing levels of data collection and analysis. The assumptions of earlier Tiers are replaced with more area-specific and site-specific data and information. With the evaluation of each tier, results are reviewed, and recommendations and decisions are made regarding whether additional site-specific information or remedial action is needed.

Release Confirmation – A petroleum release from a PST system is confirmed when any soil analytical data exceeds the first and only numeric column of the Tier 1 Surface Soil RBSL Table (Table 1) (as required by Administrative Rules of Montana (ARM) 17.56.506) or when groundwater exceeds background. The ARM also requires any person conducting subsurface investigations, to report a suspected petroleum release to DEQ. Failure to report a suspected or confirmed release may result in enforcement actions. See Section 2.0 for more details on confirming a release.

Remedial Investigation (RI) –The user is asked to identify the sources of contamination, determine the extent and magnitude of the release, and identify obvious environmental impacts (if any). Environmental impacts would include any potentially impacted humans and environmental receptors (for example, workers, residents, water bodies, and so forth), and potentially significant transport pathways (for example, soil leaching, groundwater flow, vapor intrusion, utility corridors, and so forth). The RI will also include information collected from historical records and a visual inspection of the site. Please refer to the Petroleum Tank Cleanup (PTC) Section's Remedial Investigation Guidance for sites regulated by PTC to view detailed information on this step and see Section 3.0 for evaluating data collected during the RI process.

Development of a Conceptual Site Model – This step occurs within the RI phase. The goal of a CSM is to provide a description of relevant site features including surface and subsurface conditions to help understand the extent and magnitude of identified contamination and the risk it may pose to receptors (NJDEP, 2019). The CSM is an iterative tool that should be used throughout the RBCA process and refined as additional site information and data is gathered. The CSM lists sources of contamination, potential exposure pathways, receptors that may be exposed, and identifies complete and incomplete pathways. See Section 2.2 for more details on developing a CSM.

Screening Analytical Data: Tier 1 – This is the lowest level of complexity in the RBCA evaluation process and uses Montana's non-site-specific screening values for exposure pathways utilizing conservative site and exposure assumptions. The site evaluation process consists of assessing site conditions, sample collection, and determining maximum (worst case) contaminant concentrations. Data is compared to Tier 1 RBSLs to determine whether a suspected release is confirmed, to determine if there is a need for additional evaluation, or if the release can be resolved.

Sites with potential impacts to soil and groundwater from petroleum releases are initially evaluated through the RBCA Tier 1 evaluation process. Tier 1 is an initial step in evaluating the data collected at each site. Data are compared to the generic risk-based screening levels for petroleum-related compounds found in Tables 2, and 3. When petroleum contamination is demonstrated to be less than Tier 1 RBSLs, the release or suspected release may be resolved without the need for site-specific risk analysis or additional remediation. When petroleum contamination exceeds Tier 1 RBSLs, the site could proceed to a Tier 2 evaluation where contaminant concentrations are compared to the appropriate Tier 2 RBSLs to facilitate remedial action decisions at the site.

A petroleum release from a PST is confirmed when any soil analytical data exceed the first numeric column of the Tier 1 Surface Soil RBSL Table (Table 1) (as required by ARM 17.56.506), EPA RSLs where RBSLs are not available, or when any groundwater data exceed background, or in the absence of background data, the risk-based values presented in Table 3 (See Section 2 for more information). The administrative rule also requires any person conducting subsurface investigations, as well as any other parties, to report a suspected petroleum release to DEQ. Failure to report a suspected or confirmed release may result in enforcement actions.

Screening Soil Analytica Data: Tier 2 – For sites where chemicals exceed Tier 1 RBSLs, remedial action may or may not be immediately warranted. A Tier 2 evaluation allows Tier 1 screening levels to be adjusted based upon site-specific information for direct contact and leaching to groundwater exposure scenarios. Tier 2 involves looking at the CSM and determining which exposure pathways may be complete based on exceedances of Tier 1 RBSLs and require additional evaluation. This guidance focuses only on the direct contact and leaching to groundwater exposure pathways. If a site has exceedances of the direct contact Tier 1 RBSLs, soil RBSLs may be adjusted at this step based upon site-specific information such as the number of COCs representing carcinogenic or non-carcinogenic health effects. If a site has exceedances of the Tier 1 leaching to groundwater RBSLs, additional site-specific data or information may be necessary for a Tier 2 evaluation.

Adjustments cannot be made to groundwater RBSLs. These RBSLs are based on either Circular DEQ-7 Montana Numeric Water Quality Standards (DEQ, 2019; or most recent version) or risk-based calculations. If a site has exceedances of the RBCA Groundwater RBSLs, please contact the appropriate DEQ project officer to discuss next steps to address this exposure pathway. See Section 4 for more details on the Tier 2 process for the direct contact and leaching to groundwater exposure pathways.

Screening Soil Analytical Data: Tier 3 – A Tier 3 evaluation includes more sophisticated statistical and contaminant fate and transport analyses, using site-specific input parameters for varying exposure scenarios. Therefore, the development of Tier 3 RBSLs involves the collection of significant additional site information and completion of more extensive modeling efforts than is required for either a Tier 1 or Tier 2 evaluation (ASTM, 2015).

A Tier 3 evaluation looks different depending upon the exposure pathway impacted. For example, a site where the leaching to groundwater pathway cannot practically be dealt with under the Tier 1 or Tier 2 processes will need additional in-depth site-specific evaluation and/or fate and transport modeling, including area-specific or site-specific data. Similarly, a site with a direct contact exposure pathway that cannot be addressed under the Tier 1 or Tier 2 process may need additional data for statistical purposes and may need the help of a Risk Assessor to more closely evaluate the health effects caused by exposure to the contaminants at the site.

Corrective Actions – The final step in the RBCA process. If concentrations of COCs at a site are above Tier 1 or Tier 2 RBSLs and clean up levels have been selected (Tier 1 or Tier 2 RBSLs), then corrective action measures should be implemented to reduce the risk to human health and/or the environment.

Additional Evaluation not included in this guidance – The Vapor Intrusion (VI) exposure pathway is not included in this guidance, though it should be reflected in the CSM if potentially applicable for the site. DEQ developed a separate guidance to walk users through the steps needed to address concerns from vapors. Please refer to DEQ's Vapor Intrusion Guidance for information on evaluating vapor intrusion at petroleum releases. Also, depending upon the site, there could be other guidance and processes that need to be followed. Please consult with the appropriate DEQ project officer and reference DEQ's Petroleum Tank Cleanup Website and the Cleanup & Reclamation website for additional information for petroleum releases from PST systems or other program-specific websites for non-PST petroleum releases.

2.0 Overview of Petroleum Storage Tank Release Response

This RBCA Guidance uses the term PST system to include both underground storage tanks (UST) and above-ground (<30,000 gallon) storage tanks (AST) along with permanently installed piping, dispensers, loading rack, fill ports, etc. required to operate the systems used to store and dispense petroleum products. Definition details are available at ARM 17.56.101. For releases from PST systems, initial conditions and information related to the release are typically documented on DEQ's 24-Hour Release Report and the Petroleum Release Notification 30-Day Form. However, this guidance can be used for any release of petroleum, whether from a PST system or otherwise (e.g., tanker truck wrecks or other activities causing a release of petroleum products to the environment). Other programs within DEQ may have varying reporting processes from those outlined in this guidance. For example, DEQ's Enforcement Program uses a Complaint/Spill Report to document initial information about a release and other DEQ programs may have their own reporting requirements that are not covered in this guidance. If the petroleum release is not from a PST system, please coordinate directly with the DEQ program regulating the site for specific requirements on reporting.

DEQ confirms most releases from PST systems based on laboratory analyses of concentrations of petroleum compounds in soil and/or groundwater samples collected for a suspected release; additional data and conditions confirming releases are detailed in ARM 17.56.504. Petroleum releases may also occur in other forms and are not limited to those from an AST or UST. DEQ compares the laboratory concentrations of petroleum-related compounds in soil samples to the RBCA RBSLs specified in Table 1 for release confirmation ; to the Environmental Protection Agency's (EPA) Regional Screening Levels (RSLs) for contaminants in soil that are not listed in RBCA; and to background contaminant levels in water (ARM 17.56.506). Where background has not been established, contaminants in water are compared to Table 3 or DEQ-7 water quality standards for contaminants not listed in RBCA, and EPA tapwater RSLs for any compounds not found in the DEQ-7 water quality standards. The release is confirmed if any of the above are exceeded.

Table 1 is a compilation of the most conservative (most protective) soil RBSLs calculated for any of the Tier 1 exposure scenarios for the soil leaching to groundwater and the soil direct contact pathways. Table 3 is a compilation of groundwater RBSLs and standards that can be used to compare groundwater data for release confirmation purposes.

If soil or groundwater data exceed the RBSLs presented in Table 1 or Table 3 (or groundwater is above background), DEQ must be notified by calling the PTC Hotline to report a release (number can found on the PTC DEQ webpage). Also, any spills over 25 gallons, or any amount spilled that cannot be cleaned up within 24 hours or causes a sheen on surface water would be considered a "release" (ARM 17.56.505).

Typically, analytical data have been collected when a release to the environment is known or suspected. Once a release is confirmed, and the initial response and abatement is completed, a RI can begin, in coordination with DEQ, to collect additional data used in defining the extent of contamination. These data will also assist in developing the conceptual site model and identifying the contaminants of potential concern.

An RI must determine the source of petroleum contamination, and the extent and magnitude of the release. It should also identify and discuss any obvious environmental impacts, potentially impacted human or environmental receptors (workers, residents, wildlife, etc.) and identify any potential or significant transport pathways including, but not limited to, depth to groundwater, nearby utilities, surface water bodies, stormwater conduits, etc. The RI will also involve compiling information from historical records of the site and an overall visual inspection of the site. All this information is used to help prioritize the release and determine appropriate response actions (ASTM, 2015).

DEQ uses information and laboratory analytical data provided by the owner or operator or responsible party (at non-PTC sites) to determine whether a release can be resolved using Tier 1, or if further evaluation is needed under Tier 2. Some site conditions, such as surface water or sediment contamination, or vapor intrusion prevent resolving a release under Tier 1. In such cases, DEQ may require additional investigation to gather more information and develop release cleanup and management strategies, and site-specific screening or cleanup levels.

2.1 Remedial Investigation/Site Assessment

For guidance on how to conduct a remedial investigation at a petroleum release site regulated by PTC, please see the Remedial Investigation Guidance document found on the Petroleum Tank Cleanup website under “guidance.” Part of the RI process for petroleum release sites regulated by PTC includes filling out the Release Closure Plan and the CSM as information becomes available and continuing refinement of these tools as the release moves toward resolution (more on the CSM in section 2.2). Other programs may have other applicable guidance; consult your DEQ contact with questions. The CSM will illustrate which RBSLs are appropriate depending on receptors and pathways and will help identify data gaps to address before a release can be resolved.

2.2 Conceptual Site Model

A CSM should be developed during the remedial investigation after a petroleum release has been confirmed. Discussions on the CSM and templates can be found in the Remedial Investigation Guidance (DEQ, 2017), Remedial Alternative Analysis of Petroleum Releases (DEQ, 2018a), and the Release Closure Plan (DEQ, 2018b). The guidances and more can be found on the PTC website under “guidance”.

The CSM visually maps out and documents potentially impacted human and/or environmental receptors that may be exposed to materials from a confirmed release. It also identifies potential exposure pathways, points of exposure, and exposure routes; and ensures adequate data are collected for interpreting whether these exposure pathways are complete.

The CSM begins with the petroleum source. Sources of petroleum contamination include storage tanks, piping and dispensers, and surface spills or overfills, such as from a refueling truck or other activities. A leak or release from any source can potentially contaminate the surrounding media and create an exposure pathway to a receptor. For example, petroleum leaking beneath a dispenser can enter and contaminate the soil. The petroleum can then leach through the soil to the groundwater where a nearby domestic well may pump the contaminated groundwater into a house creating a potential pathway between the petroleum contamination released from the dispenser and a resident user of the well. COPCs from a leak or release can spread through various environmental media such as soil, groundwater, surface water, and air. COPCs are transported by many processes, including gravity, advection, dispersion, diffusion, and volatilization.

Figure 1 is an example of common exposure pathways for gasoline leaking from an underground storage tank system. Vapors can migrate through the soil vertically or laterally to contribute to VI, which can cause human health impacts. Soluble fractions of gasoline can dissolve into and move through groundwater and impact wells. Vapors can penetrate concrete subfloors in basements creating an explosive hazard in nearby houses or other enclosed structures.

The Release Closure Plan (located on DEQ’s Petroleum Tank Cleanup webpage) provides a template for a tabular version of a typical petroleum tank release CSM. Additional information regarding the components of a CSM is provided below. The initial CSM is developed based upon the information available for the site at the time a release is confirmed. As the site is characterized and risks are evaluated through Tier 1 screening, the CSM is adjusted and refined based upon new information. For example, if the groundwater is not known to be contaminated but petroleum compounds are later found in groundwater, additional exposure pathways and receptors may be added. The CSM provides the basis for determining what data and analyses are necessary to assess risks and determine remediation requirements. The PTC CSM should be included in all RI Reports for sites regulated by PTC. When an exposure pathway is determined to be incomplete, this decision and an explanation as to why the pathway is currently and likely to remain incomplete must be included in the CSM.

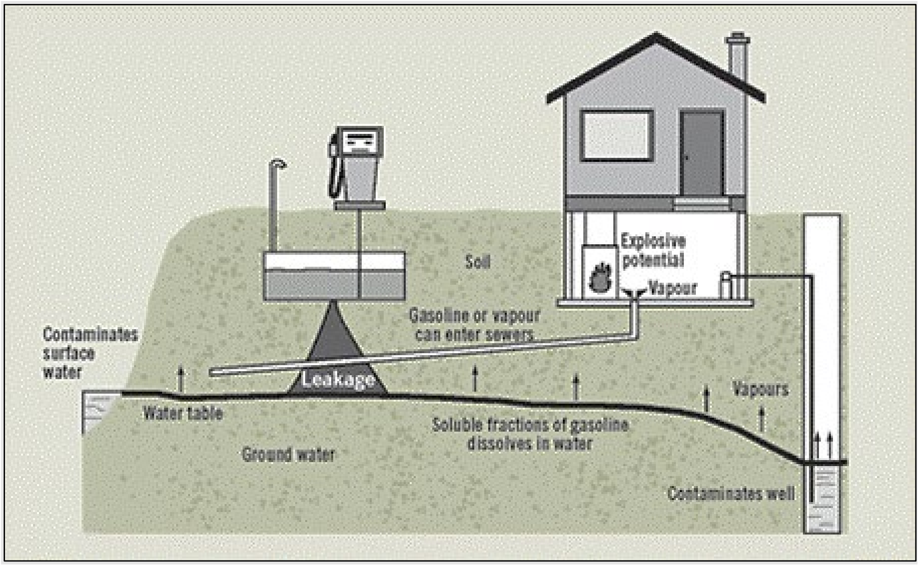


Figure 1 - Graphical depiction of conceptual site model

2.2.1 Receptors

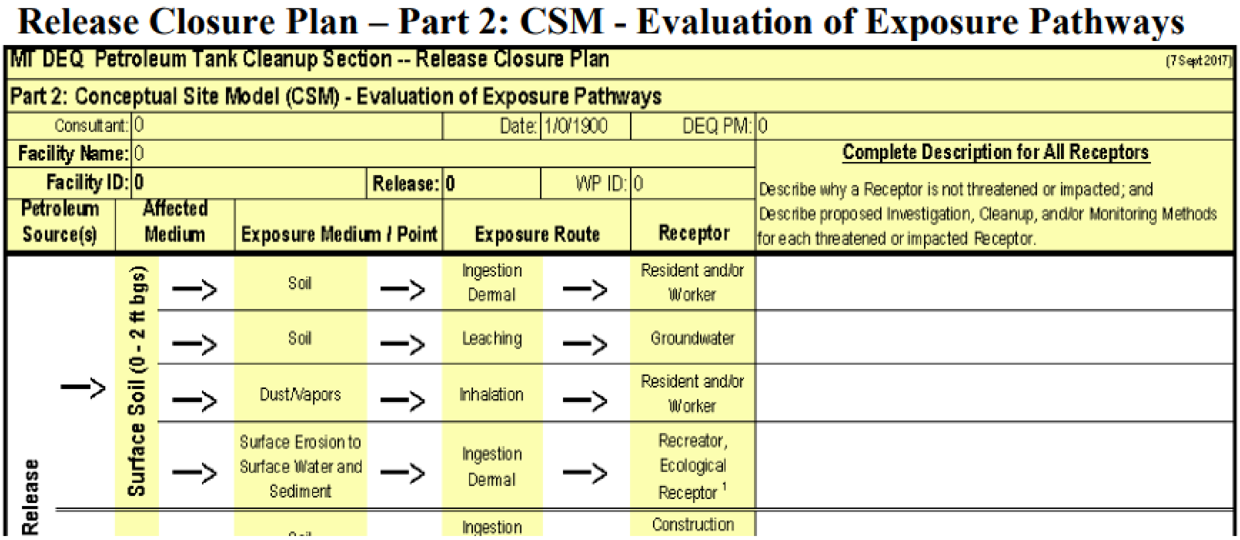
Receptors are entities that are or may be exposed to contaminants in environmental media (surface soil, groundwater, outdoor air, etc.). Typical receptors include:

- Adults and children in a residential scenario;
- Adult workers in a commercial scenario; and
- Adults in a construction scenario (which includes residential excavations).

These are the receptors considered in this guidance; however, some sites may have additional receptors such as recreational receptors (park visitors, campers, etc.) that can also be evaluated. Both current and potential future receptors and both on-site and off-site receptors should be evaluated. Therefore, current and reasonably anticipated future land uses for a site and surrounding properties will need to be determined.

2.2.2 Exposure Pathways

Exposure pathways describe how a Contaminant of Potential Concern (COPC) may come into contact with a receptor. A complete exposure pathway is the path a contaminant takes from the source, through an environmental media, to a receptor that can be affected by the contaminant. There are five elements of a pathway: source, affected medium, exposure medium/point, exposure route and receptor. Determining if a pathway is complete (all five elements are in place) is the basis for building a conceptual site model. If all five elements are not present, the pathway is incomplete and there is no exposure. The five elements are represented in the PTC CSM (Figure 2).



Release Closure Plan – Part 2: CSM - Evaluation of Exposure Pathways

MT DEQ Petroleum Tank Cleanup Section -- Release Closure Plan (7 Sept 2017)

Part 2: Conceptual Site Model (CSM) - Evaluation of Exposure Pathways

Consultant: 0 | Date: 1/0/1900 | DEQ PM: 0

Facility Name: 0

Facility ID: 0 | Release: 0 | WP ID: 0

Petroleum Source(s)		Affected Medium		Exposure Medium / Point		Exposure Route		Receptor	Complete Description for All Receptors Describe why a Receptor is not threatened or impacted; and Describe proposed Investigation, Cleanup, and/or Monitoring Methods for each threatened or impacted Receptor.
Release	-->	Surface Soil (0 - 2 ft bgs)	-->	Soil	-->	Ingestion Dermal	-->	Resident and/or Worker	
			-->	Soil	-->	Leaching	-->	Groundwater	
			-->	Dust/Vapors	-->	Inhalation	-->	Resident and/or Worker	
			-->	Surface Erosion to Surface Water and Sediment	-->	Ingestion Dermal	-->	Recreator, Ecological Receptor [1]	
						Ingestion		Construction	

Figure 2 - Example of the CSM template used in the Petroleum Tank Cleanup Section (DEQ, 2018b)

The CSM is broken up between the different media a receptor could encounter. Each receptor is evaluated based on its exposure to both soil and groundwater. Indoor air (vapor intrusion) is also an important exposure pathway to consider and include in the CSM if appropriate; however, indoor air (vapor intrusion) is not addressed in this RBCA guidance. Please see DEQ's 2021 Vapor Intrusion Guidance for more information on evaluating exposure to petroleum vapors through indoor air.

Exposure to soil is evaluated by splitting the soil column into two sections: surface soil and subsurface soil. Surface soil is defined as the top 0-2 ft. of soil. Most activities, walking, running, planting plants or other landscaping activities occur within this soil depth therefore, the residential receptor and the commercial work receptor were developed to represent exposure to soils in the top two feet. of the soil column. This means, to evaluate risk of exposure to contaminants to these receptors, data collected from within the 0-2 ft. below ground surface (bgs) range is compared to the Residential or Commercial RBSLs.

Subsurface soil is any soil located deeper than two feet below the ground surface. Exposure to this deeper soil is primarily through deeper construction activities, therefore, the construction receptor was developed to represent any activities that may expose someone to contamination deeper than two feet and extending to 10 feet bgs. To get to these subsurface soils, a construction worker would also come in contact with surface soils. Therefore, when screening data collected at a site to evaluate risk of exposure to a construction worker, analytical results from sample intervals within the 0-10 ft. bgs soil interval should be compared to or "screened" using the construction worker RBSLs. Some sites may not require surface soil collection, only subsurface soil samples, in this case, the subsurface soil samples should be compared to the construction worker RBSLs. Please note, samples for comparison to construction worker screening levels should not be composited across the entire 0-10 feet bgs interval.

2.2.3 Exposure Medium/Points and Exposure Routes

The exposure medium/point is where a receptor comes in contact with the contamination. This could be exposure at the source by workers but can also be exposure in areas further away from the source where the contaminant has been transported, thereby creating a link between the source/release and surrounding receptors. For example, source contamination may travel through the soil and into the groundwater. Contamination, now in the groundwater, can travel to a receptor's drinking water well. Drinking water has now become an exposure medium/point.

Exposure routes are the physical ways in which COCs in contaminated media may come into contact with potential receptors and include:

- Ingestion;
- Dermal Contact; and
- Inhalation of soil dust or water particles.

This exposure is termed "Direct Contact" exposure.

2.3 Exposure Pathway - Vapor Intrusion

Vapor intrusion (VI) is the migration of volatile and semi-volatile chemical contaminants from subsurface media into structures or buildings. Vapor Intrusion evaluations are conducted separately from the RBCA soil and groundwater evaluations; however, it is part of the overall site investigation and should be documented in the CSM. DEQ's Montana Vapor Intrusion Guide was developed to guide users through how to evaluate risks posed by actual and potential VI at contaminated sites as this exposure route is not addressed in the RBCA Guidance.

DEQ's VI Guide details site assessment and sampling for petroleum-vapor intrusion (PVI) at petroleum releases, and a 3-step screening process to evaluate PVI pathway(s). The PVI screening process requires site-specific information and multiple sets of soil and groundwater samples to determine whether a PVI exposure pathway is complete. When the PVI pathway is incomplete the PVI potential is eliminated, and the petroleum release screens out. If the PVI pathway is complete, additional investigation and PVI sampling within/beneath buildings and structures may be required. Refer to DEQ's VI guide and apply those detailed PVI methods and analysis to a petroleum release's cumulative soil and groundwater analytical data.

2.4 Sampling Protocols

Petroleum products include specific compounds such as methyl tertiary-butyl ether (MTBE), benzene, toluene, ethylbenzene, xylenes, naphthalene, lead scavengers (1,2-DCA and ethylene dibromide (EDB), and Polycyclic Aromatic Hydrocarbons (PAHs). Groupings of compounds contained in the Volatile Petroleum Hydrocarbon (VPH) and Extractable Petroleum Hydrocarbons (EPH) laboratory analyses are critical to evaluating risks posed by many chemicals present in typical petroleum products under the RBCA process. These analyses report groupings of chemicals, or "fractions" of the total sum of petroleum chemicals present in a sample. The toxicity and behavior of a surrogate chemical have been assigned to represent each fraction in risk and fate and transport analyses.

Table A provides useful information that should be reviewed and addressed when collecting soil samples for analysis, including holding time, preservation method, and type and number of sample containers that should be used. Sampling for volatile organic compounds (VOCs), PAHs, RCRA metals, oxygenates, and lead scavengers also have specific sampling requirements as outlined below.

Parameter	Analytical Method	Sample Container/ Preservation	Holding Time
Soil Samples			
VPH	Montana Method VPH	60 mL or 40 mL VOA vials or 4 oz wide mouth jar. Collect at least 10 g of soil, cool to 4 ±2° C. Must be preserved at the lab in methanol within 48 hours of collection. or Methanol preservation in the field.1 mL methanol for every g soil, +/- 25%; lab can provide appropriate vials with methanol for easy collection; cool to 4 ±2° C. If preserving with methanol in the field, a sample containing no methanol must also be submitted for determining moisture percentage.	28 Days to analysis from collection. If collecting in the field without methanol, lab preservation in methanol w/in 48 hours and 28 days to analysis from collection.
EPH Screen	Montana Method EPH	4-oz wide-mouth amber glass jar, cool to 4±2° C	Extracted within 14 days of collection. Analyzed within 40 days of extraction.
EPH Fractionation with or without PAH's	Montana Method EPH (PAHs: 8270))	One 4-oz glass jar, cool to (4 ± 2) ºC	Following EPH Screen 14-day to extraction, 40 days to analysis.
VOCs/Oxygenates/ 1,2 DCA/lead scavengers EDB	EPA Method 8260 /SW-846-5035A	One 4-oz. glass jar, cool to (4 ± 2) ºC Preserve in methanol in field or at lab within 48 hours of collection.	48 hours to lab extraction. 14-day hold time from collection MeOH preservation: 14 days to extraction and analysis from collection.
RCRA Metals plus zinc (Except Hg)	EPA Method 6010 or 6020	One 4-oz. plastic or glass jar, no preservation	6 months
Mercury (Hg)	EPA Method 7471 B	One 4-oz. plastic or glass jar, no preservation	28 days
% Moisture-required for all soil samples	USDA Handbook 60 method 26 (or equivalent)		

Table A - Soil Sampling and Preservation Protocol
Alternate approved versions of the methods are allowed.

2.4.1 Soil Sampling and Reporting Procedures

The number of soil samples collected and analyzed should delineate the extent and magnitude of the area of confirmed or suspected contamination. For compliance with the RBCA approach, soil samples should be collected from worst-case areas associated with surface spills or other likely sources of petroleum contamination. Samples associated with petroleum release sites should be submitted to a laboratory capable of implementing DEQ's analytical protocol. The laboratory reporting limit should be less than DEQ's screening criteria and in line with the requirements provided in Montana's DEQ-7 water quality standards. Table B shows analyses based on product type and testing procedure. The Montana EPH and VPH analytical methods, developed by the Massachusetts Department of Environmental Protection and modified by DEQ, should be used for all RBCA evaluations in Montana (see Appendix C for more details).

When sample results are reported to DEQ as part of a standard reporting process for any phase of remediation – initial site assessment, remedial investigation, cleanup, or compliance monitoring, the report should include all associated laboratory documentation including chromatograms, quality control/quality assurance data and chain of custody forms, as well as soil sample locations, sample depths, and other pertinent site history data. Use DEQ's Data Validation Summary Form (DVSF) to summarize your analysis of the validity and usability of the data for each appended laboratory analytical report. DVSF considerations include the following: deviations from the planned sampling, sample preservation, shipping, etc. results of the sample blanks collected (e.g., trip, field, equipment); calculated relative percent difference between duplicate samples and parent samples; laboratory reporting limits that exceeded DEQ's screening limits; and differences in the planned vs. actual sampling. Quality assurance/quality control requirements for petroleum releases regulated by PTC are further described in the MT Quality Assurance Plan (QAP) for Investigation of Underground Storage Tank Releases found on the DEQ PTC website under guidance documents.

Table B outlines the analytical methods necessary to apply RBCA analysis for various petroleum products in soil and water. VPH analysis is necessary for petroleum products that typically contain light range hydrocarbons to determine the concentrations of MTBE, benzene, toluene, ethylbenzene, xylenes, naphthalene (collectively referred to as MBTEXN) and light end aliphatic and aromatic hydrocarbon fractions. EPH analysis is necessary in conjunction with VPH for most of the petroleum product types excluding gasoline, aviation gas, and mineral/dielectric oils. DEQ uses a two-step screening technique to evaluate soils at sites where the EPH analysis is necessary to reduce the analytical costs for the EPH analysis. The first step in the screening technique generates a total extractable hydrocarbon (TEH) concentration. If the initial screening result is 200 mg/kg or less, no additional EPH analysis is necessary. However, if the TEH concentration is greater than 200 mg/kg, then the EPH fractionation step is necessary.

PAH analysis is needed on a site-specific basis if heavy hydrocarbons, diesel, refinery wastes, or unknown oils/sources are present. A release of waste oil, heavy-end hydrocarbons such as Bunker C, and/or unknown wastes should be analyzed for PAHs. The requisite sampling parameters will be supplied to the lab by the case manager prior to submitting the samples to the lab.

At sites that have used or currently use aviation fuel and those that may have had releases of leaded gasoline, analyses for the lead scavengers 1,2-DCA and EDB (also known as 1,2-dibromoethane) should be performed. Lead scavengers were added to leaded gasoline from the 1920's through the 1980's to reduce engine fouling caused by the tetra ethyl lead that was added to gasoline as an anti-knocking compound. Lead scavengers may still be present in off-road fuels such as racing gasoline and leaded aviation gasoline.

For samples analyzed by both the VPH and EPH procedure, there are two methodological issues that warrant discussion and clarification (MADEP, 2022):

- When a sample is analyzed by both the VPH and EPH methods, it is not necessary to quantitate or address a (VPH) value for C9-C12 Aliphatic Hydrocarbons, as these hydrocarbons are included within the C9-C18 Aliphatic Hydrocarbon range detected by the EPH test method. Note that there may be cases where the C9-C12 Aliphatic concentration via the VPH test method exceeds the C9-C18 Aliphatic concentration quantitated by the EPH method – this dichotomy occurs because the VPH method tends to over-quantitate aliphatics in this range (because the Flame Ionization Detection (FID) method is also quantitating aromatic compounds). In general, the EPH method should provide more accurate data for this range.

- In cases where Target Analytes are quantitated by both the VPH and EPH methods, naphthalene will be reported by both procedures. Because it is within the dividing region between purgeable and extractable organics, naphthalene is a problem analyte in both methods: it's the heaviest VPH compound, and difficult to purge, while at the same time being the lightest EPH compound, and therefore subject to volatilization losses during the EPH extraction process. *Accordingly, in such cases, the highest reported concentration should be used.*

Petroleum Product	**VPH**	**EPH Screen**	**EPH Fractionation**	**EPH for PAHs**	**RCRA Metals + Zinc**	**EPA Method 8260B – Oxygenates /VOCs**	**Lead Scavengers**
Gasoline/Aviation Gasoline	R						SS
Diesel (#1 & #2)	R	R	X	SS			
#1 - #2 Heating Oils	R	R	X	SS			
#3 - #6 Fuel Oils		R	X	X			
Used/Waste Oil	R	R	X	X	SS	R	SS
Kerosene, Jet Fuel (Jet-A, JP-4, JP-5, JP-8, etc.)	R	R	X	SS			
Mineral/Dielectric Oils		R	X				
Heavier Wastes		R	X	X			
Crude Oil	R	R	X	X			
Unknown Oils/Sources	R	R	X	X	SS	R	SS

Table B - Testing Procedures for Soils and Water

R - required analysis

X - analysis to be run if the EPH screen concentration in is >200 mg/kg TEH or >1,000 µg/L TEH in soil and water, respectively.

SS - Site-specific determination.

2.4.1.1 Dry-Weight Reporting for Soil and Sediment Samples

Soil and sediment sample values are reported on a dry-weight basis. The initial contaminant concentration measured by a laboratory is the "as-is" or "wet weight" result. Calculations are made to wet weight contaminant concentrations to account for the moisture content of the soil (as determined by the lab) and the corrected concentrations are reported as dry weight. This eliminates the variability of contaminant concentrations as a function of moisture content.

2.4.1.2 Moisture Data Reporting for Soil and Sediment Samples

Since all soil and sediment data are reported on a dry-weight basis, moisture percentage is also determined so an adjustment can be made to the "as-is" or wet weight result. The moisture percentage should be included on the laboratory data reports so that fate and transport of contaminants may be evaluated.

2.4.2 Groundwater Sampling Protocols

At some sites, it may be necessary to investigate groundwater quality to verify that contaminant concentrations are below RBSLs and DEQ-7 water quality standards. Please see Table B to determine what compounds to test for in groundwater at a potential/verified release site. Please note the methodological issues identified under soils also apply to groundwater analysis using the Montana VPH and EPH procedures.

Table C provides useful information that should be reviewed and addressed when collecting aqueous samples for analysis including holding time, preservation method, and type and number of sample containers that should be used. Sampling for VOCs, PAHs, RCRA metals, oxygenates, and lead scavengers also have specific sampling requirements.

To reduce analytical costs, DEQ uses the EPH screening technique. The EPH screen approach is similar to that previously described for soils and generates a TEH concentration. If the initial screening result is 1,000 µg /L TEH or less, EPH fractionation is not necessary. If the TEH concentration exceeds 1,000 µg/L, fractionation is necessary to determine the fraction concentrations.

At least one high and one low seasonal groundwater sampling event may be needed to evaluate seasonal COC variability.

Parameter	Analytical Method	Sample Container/ Preservation	Holding Time
VPH	Montana Method VPH	Three 40-mL VOC vials with zero headspace, acidify with HCl to pH <2: cool to 4±2° C.	14 days to analysis
EPH Screen	Montana Method EPH	Two 1-L amber glass bottle, acidify with 1:1 HCl (or alternate acids, as allowed by method) to pH <2; cool to 4±2° C	14 days to extraction. 40 days to analysis following extraction.
EPH	Montana Method EPH	1-Liter amber glass bottle. Acidify with 1:1 HCl (or alternate acids, as allowed by method) to pH <2; cool to 4±2° C	14 days to EPH Screen extraction, 40 days to analysis following extraction.
VOCs (Drinking Water)	EPA Method 524.2	Three 40-ml vials with zero headspace, acidify with HCl to pH <2, cool to (4 ± 2) ºC. Remove chlorine with Ascorbic Acid.	14 days to analysis
VOCs	EPA Method 8260	Three 40-ml vials with zero headspace, acidify with HCl to pH <2, cool to (4 ± 2) ºC	14 days to analysis
PAHs (Semi-volatile Organics)	EPA Method 8270	Two 1-liter amber glass bottles **do not acidify**, cool to (4 ± 2) ºC. Remove chlorine with ~4 drops of 10% Sodium Thiosulfate ($Na_2S_2O_3$)	7 days to extraction, 40 days to analysis
Lead Scavengers EDB 1,2-DCA	 EPA Method 8011 EPA Method 8260[1]	Six 40-ml vials, acidify with HCl to pH <2, cool to (4 ± 2) ºC. Remove chlorine with ~4 drops of 10% Sodium Thiosulfate ($Na_2S_2O_3$)	14 days to analysis
RCRA Metals plus zinc (except Hg)	EPA Method 6010/200.7 or 6020/200.8	One 250-ml HDPE bottle, acidify with nitric acid (HNO_3) to pH <2, cool to (4 ± 2) ºC; field filtered 0.45 µm for dissolved metals (can also be filtered at lab with advanced arrangements)	6 months

Mercury (Hg)	EPA Method 245.1 or 7470	One 250-ml HDPE bottle, acidify with HNO_3 to pH <2	28 days

Table C - Aqueous Sampling and Preservation Protocol
Alternate approved versions of the methods are allowed

2.4.2.1 Aqueous Sample Preservation

The VPH method recommends the use of three 40 milliliter (ml) vials. The samples are to be preserved by adding hydrochloric acid (HCl) to reduce the pH to 2 or less. The vial should be checked to ensure no air bubbles are present in the vial before placing on ice. Please refer to Table C for additional sampling procedures.

Trisodium phosphate (TSP) is used as an alternative to acid preservation for fuel oxygenates. It prevents the biological degradation of the target analytes and does not cause hydrolysis of ethers to alcohols.

If carbonaceous materials are present, or MTBE or other oxygenate ethers are present and the sample is not acid preserved because the method uses a high-temperature sample preparative method, the holding time is 7 days instead of 14 shown in Table C, 8260 and SW 846, table 4-1.

At sites where drinking water supplies, either water supply lines or domestic or public water supply wells, are threatened by petroleum contamination, VOC analysis by EPA Method 524.2 of the water inside the well or pipelines may be necessary. HCl is used as a preservative. If the water system is chlorinated, ascorbic acid needs to be added to prevent the formation of chlorination by-products. If the supply is not chlorinated, then only HCl is used for preserving the sample. Please note that per Public Water and Sewage System Requirements in the Administrative Rules of Montana, modifications to public water systems (such as the addition of a filter) cannot be made without the approval of DEQ's Engineering Infrastructure and Subdivision approval. As a best practice, sampling of public water systems for petroleum contaminants should be communicated with DEQ's Public Water Supply Bureau.

3.0 TIER 1 RBCA EVALUATION PROCESS

The Tier 1 evaluation can be applied for initial evaluation of contaminated soil and groundwater and simple releases that can be resolved using routine methods with limited site characterization. A Tier 1 evaluation generally includes the following actions: conducting a remedial investigation to determine the magnitude and extent of petroleum contamination in soil and groundwater associated with the release, developing a CSM to identify potentially complete exposure pathways and receptors, and comparing contaminant concentrations to the Tier 1 RBSL Tables and which exposure pathways are considered complete. This allows owner, operators and responsible parties to decide whether a release will require additional evaluation or corrective actions.

For petroleum releases from a PST system, owners/operators and their environmental professionals follow guidelines to complete forms such as the Petroleum Release Notification

30-Day Form. This provides DEQ with the information necessary to determine what corrective action is necessary, and whether a release can be resolved without further action.

3.1 Evaluating Site Data & Contaminants of Potential Concern

Determining the extent of contamination can begin with comparing data to the Tier 1 RBSL look-up tables. These tables contain screening levels for all potential human site receptors exposed to soil and groundwater as well as leaching to groundwater RBSLs (see Tables 2, 3, and 4). They are arranged to correspond with the conceptual site model in categories that reflect different site conditions, such as current or future land use and varying depths to groundwater.

It is important to go back to the CSM and understand which exposure routes and receptors are being evaluated since the first step to evaluating site data is to group soil data by soil depth and receptors. Soil data is grouped based on the sample depth. DEQ considers "surface soil" as any soil located 0-2 feet ft. bgs. This depth is used to look at exposure to contaminants in soil by residents, commercial workers, and construction workers. All of these receptors could come in contact with soils between 0 and 2 ft. bgs. Subsurface soil is located at depths below 2 ft. bgs; however, soil data collected from 0 – 10ft. (surface and subsurface soil data) are used to evaluate construction worker exposure during excavations of future tank pulls or other activities occurring at these depths. Exposure to soil by receptors in both the surface and subsurface soil is referred to as "Direct Contact" exposure since the activities occurring are putting the receptor in direct contact with the soil.

Another important route of exposure to evaluate is leaching to groundwater, and soil data from the entire soil column are evaluated for leaching potential. Leaching occurs when the contaminant moves downward through the soil to the underlying groundwater. At this point, the contaminant could negatively impact the beneficial use of the groundwater and could travel to nearby drinking water wells. Contaminated groundwater can also pose a risk to indoor air via the vapor intrusion pathway.

All surface soil data should be compared, or screened, against the RBSLs for the residential, commercial worker and leaching to groundwater RBSLs, where applicable for each site. All surface soil and subsurface soil should be screened against construction worker and leaching to groundwater RBSLs. It is helpful to highlight any exceedances in your results tables.

The results of the Tier 1 screening process will clearly show the site's COPC for the residential receptor, the commercial worker, the construction worker, and protection of groundwater. The list of COPCs may differ for each receptor.

3.1.1 Direct Contact

As mentioned above, exposure to soil is evaluated by splitting the soil column into two sections: surface soil and subsurface soil. Surface soil is defined as the top 0-2 ft. of soil. Most activities, walking, running, gardening/landscaping or other landscaping activities occur within this soil depth. The data collected at this depth is compared to the residential RBSLs and to the commercial worker RBSLs. This leads to two different lists of COPCs. Any compounds that exceed the residential RBSLs are considered COPCs for the residential receptor and any compounds that exceed the commercial worker RBSLs are considered COPCs for the commercial worker receptor. The residential RBSLs are lower than (more conservative than) the commercial RBSLs, so if contamination at a site meets residential RBSLs then it will also be protective of commercial workers.

The same process is applied to the construction worker receptor; however, the construction worker comes in contact with both surface soil and subsurface soils. Therefore, data collected throughout the soil column is compared to the construction worker RBSLs to develop a list of COPCs for this receptor.

The future use of sites should also be considered. For example, a site may be currently used as commercial/industrial but have planned redevelopment and zoning determinations that could change in the future to allow residential use. Residential sites are those where someone resides or may reside in the future, potentially including farms and ranches and gas stations with associated residences. Commercial sites are those without residents, used only for commercial/industrial purposes. This determination is only relevant for sites with petroleum-contaminated surface soil, including contaminated surface soil at permitted land farm locations. When site conditions and uses are not well defined, DEQ uses the most conservative soil RBSLs to screen data and make cleanup decisions.

3.1.2 Leaching to Groundwater

The leaching to groundwater pathway is used to identify concentrations in soil that have the potential to contaminate groundwater above Montana DEQ-7 water quality standards or groundwater RBSLs. Migration of contaminants from soil to groundwater can be envisioned as a two-stage process (EPA, 2023; Figure 3):

1. Release of contaminants from soil, as free product or becoming soil leachate.
2. Transport of the contaminant through deeper soils to groundwater.

The leaching to groundwater scenario considers both of these fate and transport mechanisms when developing the leaching RBSLs (Table 2).

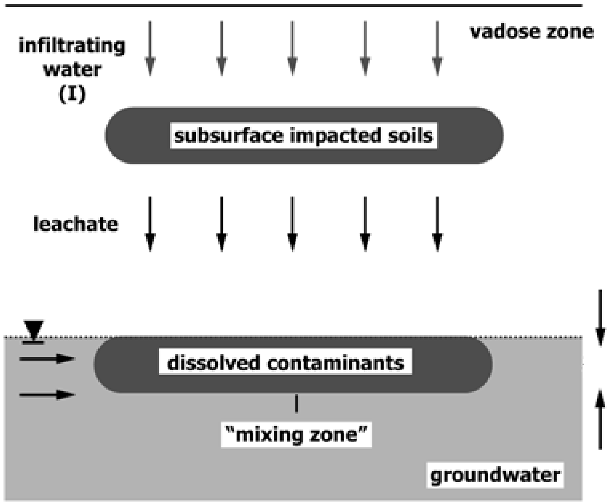


Figure 3 Leaching to Groundwater - Contaminant transport through soil (ASTM, 2015)

The Tier 1 leaching to groundwater RBSLs are divided into three categories depending on the (vertical) distance between the depth of high groundwater and the depth of contaminated soil (sample depth):

1) Groundwater less than 10 feet below contamination (or sample depth);
2) Groundwater between 10 and 20 feet below contamination; and
3) Groundwater greater than 20 feet below contamination.

The distance to groundwater is generally determined using the difference between the depth the soil sample was collected and the depth of the highest seasonal water level in a monitoring well screened in the uppermost zone of saturation within 500 feet of the release. Nearby water supply wells may not be appropriate in some cases to determine the depth to the uppermost saturated zone (first water) as they may be completed in a deeper zone. In determining which RBSL is appropriate, it is necessary to know three depths:

1) The depth the sample was taken below the ground surface;
2) The depth the high-water table is below the ground surface during high groundwater conditions; and
3) Known distance to groundwater below soil sample collection depth (calculated by subtracting 1 from 2).

Example: a soil sample is collected below an underground storage tank at a depth of 10 feet bgs., and the seasonal high-water table is 25 feet below the ground surface. Therefore, the depth from the soil sample to the groundwater is 15 feet and laboratory analytical data collected from this point should be compared to the RBSLs listed in the 10-20 feet to groundwater column.

3.1.3 Evaluating Groundwater Data

Groundwater can be a significant transport and exposure pathway for contaminants. Groundwater may be encountered during tank removals and visual inspection indicates groundwater could be impacted by a release. Other times, soil data exceeding the leaching to groundwater RBSLs may indicate that contaminants have moved through the soil column and entered the groundwater. Therefore, during the remedial investigation it is important to collect groundwater data, including groundwater flow direction, aquifer characteristics, nearby wells and their usage, and depth to high and low groundwater. For sites regulated by PTC, both the Montana Remedial Investigation Guidance for Petroleum Releases (DEQ, 2017 or most recent version) and the Montana Groundwater Monitoring Work Plan and Report Guidance for Petroleum Releases (DEQ, 2021a) should be consulted to ensure the appropriate information is being collected to evaluate the impacts to groundwater. If the leaching to groundwater RBSLs are exceeded, analytical data should also be collected to determine if contaminant concentrations exceed groundwater RBSLs (Table 3).

If concentrations exceed the groundwater RBSLs, additional sampling may be needed to determine the extent and magnitude of petroleum contamination in groundwater. Table 3 contains both DEQ-7 water quality standards (DEQ, 2019) and risk-based screening levels calculated for petroleum releases. For those petroleum compounds that do not have a DEQ-7 water quality standard, DEQ calculated groundwater RBSLs using the EPA RSL tapwater formulas, assumptions, and toxicity data outlined in Appendix D. **If there are visible signs of contamination (sheen/globules, etc.) or odor or taste concerns, the release cannot be resolved until they are mitigated, even if contaminant concentrations are below RBSLs.**

The RBSLs for the EPH and VPH fractions use a conservative toxicity value to calculate a screening level for a range of chemicals, ascribing the conservative toxicity value to all compounds detected in the ascribed range. Fractions are treated as a single entity or unique chemical in the screening process even though the fractions represent mixtures of hydrocarbon compounds.

3.2 Evaluating and Comparing Historical Total Petroleum Hydrocarbon Data with EPH and VPH Data

Total petroleum hydrocarbons (TPH) represent a broad family of compounds and is defined as the measurable amount (concentration) of petroleum-based hydrocarbons in an environmental media (ATSDR, 1999). The TPH value is a measurement representing a mixture of several hundred petroleum-based hydrocarbon compounds and does not provide information on the composition (individual constituents of a given hydrocarbon mixture). Thus, this TPH value itself is not a direct indicator of risk to humans or the environment (ASTDR, 1999). Total Petroleum Hydrocarbons (TPH), Diesel Range Organics (DRO), and Gasoline range organics (GRO) laboratory analyses were typical in Montana prior to 2000; consequently, in this Guidance they are now considered historical data.

Analytical methods commonly used for TPH include EPA Method 8015 Modified. This method reports the concentration of purgeable and extractable hydrocarbons, sometimes referred to as GRO and DRO. Lab reports typically include a value for “Total purgeable hydrocarbons” (GRO) and “Total extractable hydrocarbons” (DRO).

The Total purgeable hydrocarbons “TPH” acronym can be confused with total petroleum hydrocarbons also abbreviated as “TPH”, but it is important to understand these are not representing the same hydrocarbon mixtures; therefore, the adjustments discussed below cannot be applied to Total Purgeable Hydrocarbon values.

Figure 4 illustrates the relationship between TPH, GRO, DRO, EPH, and VPH.

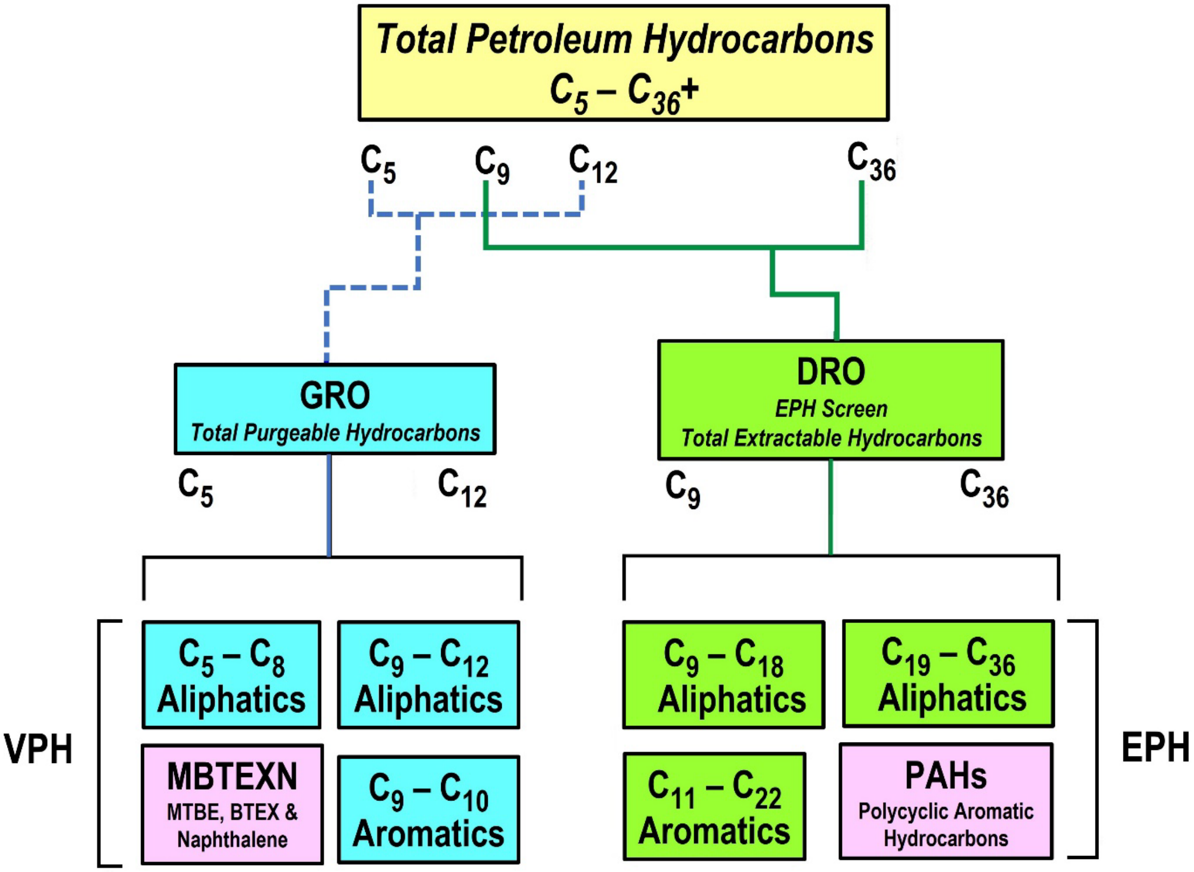


Figure 4 - Relationship of TPH, GRO, DRO, EPH & VPH
This image was edited to reflect the terminology used in this guidance. Original Source (MADEP, 2002)

Use of the Montana VPH/EPH approach is the preferred means to characterize risks from petroleum products released to the environment; however, there are historical total petroleum hydrocarbon (TPH) data that have been obtained in the past for contaminated sites. For a Tier 1 evaluation, DRO data may be converted to EPH fractional data using the guidelines discussed below. Historical data that exceeds current RBSLs indicates additional evaluation of a release may be necessary; then the Montana VPH/EPH approach should be used for future data collection.

Figure 4 above illustrates how TPH is the sum of volatile petroleum hydrocarbons (or GRO) and extractable petroleum hydrocarbons (or DRO); therefore, conservative assumptions can be made to “convert” historical TPH data into EPH/VPH fractional data. Since DRO is essentially a summation of the three EPH fractions (i.e., C9-C18 aliphatics, C19-C36 aliphatics, and C11-C22 aromatics), it is possible to “convert” DRO data into the EPH fractional ranges, by making informed and reasonably conservative judgements on the chemistry of the DRO data. Compositional assumptions for soil data that are protective at most sites are provided in Table D.

Petroleum Product	C11-C22 Aromatics	C9-C18 Aliphatics	C19-C36 Aliphatics
Diesel/#2/Crankcase Oil	60%	40%	0%
#3-#6 Fuel Oil /Bunker C	70%	30%	0%
Kerosene and Jet Fuel	30%	70%	0%
Mineral Oil Dielectric Oil	20%	40%	40%
Unknown Oil	100%	0%	0%

Table D - Recommended DRO Compositional Assumptions in Soil
Source: Massachusetts Department of Environmental Protection, *Implementation of the MADEP VPH/EPH Approach*, October 2002

A similar approach can be taken for GRO soil data. Since the GRO data is essentially the sum of the three VPH fractions (C5-C8 aliphatics, C9-C10 aromatics, and C9-C12 Aliphatics) and benzene, toluene, ethylbenzene, and xylenes (BTEX)/MtBE/Naphthalene, it is possible to "convert" GRO soil data to VPH fractional ranges. For this conversion, consider all the non-BTEX/MTBE hydrocarbons having higher molecular weights than C8 to be C9-C10 Aromatics. This can be done by subtracting the BTEX/MtBE/Naphthalene concentrations from the GRO total concentration and comparing the difference to the C9-C10 Aromatics RBSL (MADEP, 2002). This can also be done by consulting with your lab if the analytical reports are available. For water data, these conservative assumptions can be made (MADEP, 2002):

- For DRO water data, the DRO concentration should be assumed to be the most conservative EPH fraction (based on lowest RBSL) for groundwater, although it is permissible to remove the concentrations of target PAH analytes (e.g., naphthalene), if known; and
- For GRO water data, the entire GRO concentration should be assumed to be the most conservative VPH fraction (based on lowest RBSL) for groundwater, although it is permissible to remove the concentration of target BTEX/MTBE, if known.

3.3 Evaluating Inorganics in Soil and Groundwater Data

Some petroleum releases may have analytical data for metals. Please reach out to the regulating program for the appropriate screening process.

Sites with petroleum and metal COPCs cannot follow the steps described in Section 4, using the Tier 2 tables. Since metals also have carcinogenic and non-carcinogenic effects, the Tier 1 screening levels will need to be adjusted in a way that considers both the petroleum and metal effects. Please contact DEQ or involve a risk assessor to make the appropriate adjustments.

All metals groundwater data should be screened using DEQ-7 water quality standards.

3.4 Using Tier 1 RBSL Tables

The end goal of the Tier 1 process is the development of a list of COPCs for the site to determine potential areas of exposure and the extent of contamination. It is important to reference the CSM to ensure data is collected at each potential exposure point so a determination can be made on whether a receptor may be at risk. Once sampling events are complete, data is compared to the Tier 1 RBSL tables to develop a list of site COPCs for the receptors identified in the CSM. This list should include any soil and groundwater samples with compound concentrations exceeding the Tier 1 RBSLs. Site concentrations are compared to the direct contact Tier 1 RBSLs, the leaching to groundwater RBSLs and groundwater RBSLs/standards. This screening process will result in a list of COPCs for each receptor (residential, commercial, & construction worker) as well as lists of COPCs for leaching to groundwater and groundwater. Any compounds with concentrations above Tier 1 RBSLs are considered COPCs for the site. The Tier 1 process consists of two different tables: Table 2 – Soil RBSLs (Petroleum) and Table 3 – Groundwater RBSLs. **Table 1 of this guidance is only used to confirm a release has occurred. It is not used to screen data collected to investigate/assess a confirmed release.** Once DEQ generates a 24-Hour Report and has confirmed a release, the Tier 1 RBSLs in Table 2 and 3 should be used for the remedial investigation and compliance monitoring.

Table 2 is a compilation of Tier 1 RBSLs for petroleum-contaminated soil at petroleum sites. Application of these RBSLs require site-specific information, including site use, depth of high groundwater, and depth (ft. bgs) for each soil sample collected. Table 2 RBSLs are organized into two (2) separate exposure routes - leaching and direct-contact scenarios. The Tier 1 RBSLs include three (3) depth-specific columns for petroleum compounds leaching from soil to groundwater; and three (3) receptor-specific columns of direct-contact risk for petroleum compounds in soil. The depth-specific leaching RBSLs (0 - 10 ft., >10 – 20 ft., and >20 ft.) are based on the vertical distance between an individual soil sample and shallowest groundwater. The receptor-specific direct contact RBSLs, surface soil residential (0 – 2 ft. bgs), surface soil commercial (0 – 2 ft. bgs), and subsurface soil construction (0 – 10 ft. bgs) are based on site use and depth of soil samples. All personnel, workers, residents, and visitors at a petroleum-release site are exposed to the surface soil. Construction workers are exposed to both surface and subsurface soil. The Tier 1 evaluation of a suite of soil samples typically requires data comparison to RBSLs to multiple columns in Table 2, including direct contact for surface and subsurface soils and leaching to groundwater for soils throughout the soil column.

Table 3 is used to evaluate groundwater data and provides the DEQ-7 water quality standards DEQ 2019; or most recent version), where available, and DEQ RBSLs for compounds without DEQ-7 water quality standards.

3.4.1 Presentation of Data

Presentation of the data collected for the Tier 1 screening process should show how decisions on next steps were made. A cumulative table of soil data collected during the Tier 1 evaluation of the release should include the laboratory analytical data; sample ID; sample depths (ft. bgs); direct contact receptors and/or potential future use (residential, commercial, construction); and the site-appropriate leaching to groundwater Tier 1 soil RBSLs listed in Table 2, for releases managed in the Petroleum Tank Section. An example of a cumulative table of soil data (including a blank table for use) is available under the Guidance dropdown at the Petroleum Tank Cleanup Section (PTCS) webpage. Other programs, outside of PTCS, may request data presented differently, please communicate with the program regulating the release for specific reporting requirements.

For direct contact, review the sample depths in the cumulative soil data table; if there are sample depths 0 – 2 ft. bgs, then insert a row of Tier 1 RBSLs in the cumulative table for direct-contact surface soil (commercial, residential or both depending on the site); and, if there are sample depths 0 – 10 ft. bgs, then insert a row of Tier 1 RBSLs for direct-contact subsurface soil construction. Direct contact RBSLs do not apply to soil samples >10 ft. bgs. Insert a row for leaching to groundwater based RBSLs for comparison to soil samples from anywhere in the soil column (surface to water table).

Review the cumulative soil data table and determine which analytes exceed either the surface or subsurface direct contact RBSLs. Any concentrations that exceed an applicable RBSL should be highlighted, bolded, etc.

A cumulative table of groundwater data collected during the Tier 1 evaluation should include well number, sample ID collection date, and any concentrations that exceed an applicable RBSL or standard (Table 3) should be highlighted, bolded, etc. An example of a cumulative table of groundwater data (including a blank table for your use) is available under the Guidance dropdown at the PTCS webpage.

The text of the document should clearly list the COPCs for each direct contact receptor that was screened and list the COPCs for leaching to groundwater and for groundwater. These lists will be important in evaluating and adjusting RBSLs should the site proceed to the Tier 2 process.

3.5 Summary of Tier 1 Evaluation Procedures

Procedures for evaluating a **confirmed** release using RBCA Tier 1 are summarized as follows:

- Document site conditions by contacting DEQ and, for underground storage tank releases, filling out the proper forms such as the 30-Day Release Form.
- Remedial Investigation: Refer to the PTC Remedial Investigation Guidance for Petroleum Releases (for PTC-regulated releases) or contact your DEQ project officer (for releases regulated by other programs). Develop a conceptual site model to characterize the site's exposure setting identifying the different exposure pathways, points of exposure, exposure routes, and receptors to ensure adequate data are collected for all impacted media.
- Screening Data: Compare data to the Tier 1 RBSLs in Table 2 and Table 3, using the following procedures:
  a) Generate a list of contaminants of concern (compounds exceeding their Tier 1 RBSLs) for the following exposure pathways/receptors:
    - Direct Contact, Residential Receptor: Surface soil (located at a depth of 0-2 ft.) data is compared to Residential RBSLs apply if anyone lives at the site or may live at the site in the future (e.g., farms and ranches).
    - Direct Contact, Commercial Worker Receptor: Surface soil (located at a depth of 0-2 ft.) is compared to Commercial RBSLs if the site is used as a place of business with regular employee presence, no one lives at the site, and an analysis of the reasonably anticipated future uses of the site indicates it is unlikely that people may live at the site in the future.
    - Direct Contact, Construction Worker Receptor: Surface and Subsurface Soil data (collected 0-10 ft.) are compared to construction worker RBSLs when contamination exists in the surface and subsurface soil and to ensure protection of construction workers for any future construction/development/landscaping.
    - Leaching to Groundwater: All soil data (regardless of depth) is compared to leaching to groundwater RBSLs. Determine depth to high groundwater and determine depth at

which soil sample was collected. Calculate the distance from the soil sample to groundwater; compare data to corresponding leaching RBSLs from Table 2.

- For example, RBSLs for Leaching with 0 – 10 ft. to groundwater, apply if the depth to high groundwater is less than ten feet below the soil sample location.
- RBSLs for Leaching >10-20 feet to groundwater apply if groundwater is between ten and twenty feet below the soil sample location.
- RBSLs for Leaching >20 feet to groundwater apply if groundwater is greater than twenty feet below the soil sample location.

b) Groundwater Data: Compare groundwater data to Tier 1 groundwater RBSLs (Table 3) to evaluate potential groundwater impacts whenever groundwater sampling results or site conditions indicate that groundwater may be contaminated. Groundwater sampling results that represent a range of hydrological scenarios (e.g., seasonal high and low) may be necessary for a complete evaluation. ARM 17.56.605(6) states two years of monitoring or another reasonable time period approved by DEQ may be required.

- Corrective action may not be necessary if soil and groundwater data are less than the corresponding RBSL values. Owners and Operators or responsible parties (including their contractors) should evaluate those results in conjunction with available site information; and then determine the next steps toward resolving the release.
- If soil data exceed Tier 1 RBSLs, corrective action or a Tier 2 evaluation should be completed.
- If Corrective action to meet Tier 1 RBSLs is the chosen next step, refer to the appropriate guidance and complete the required corrective actions.

3.6 Corrective Actions or Proceed to Tier 2

Cleanup to Tier 1 RBSLs can be achieved by removing contaminated material from the release area until remaining contaminant concentrations are below Tier 1 RBSLs. However, RBCA screening levels may also be reached by using combinations of other methods that reduce the potential for exposure. Acceptable methods might include excavation, in situ treatment technologies, source control or treatment, engineered controls that reduce or restrict migration, or enhancement technologies that promote biodegradation.

The Tier 2 process is only used to address contaminated soil, through both the direct contact and leaching to groundwater pathways. A Tier 2 evaluation is not completed for contaminants in groundwater exceeding the groundwater RBSLs because most of the RBSLs are based on DEQ-7 Water Quality Standards that are not to be exceeded. If groundwater exceeds the RBSLs presented in Table 3, please reach out to your DEQ project officer. If soil analytical data exceed the Tier 1 RBSLs, the site can proceed through the Tier 2 process to address the soil contamination.

The Tier 2 process described in Section 4 is also not appropriate if a site has both petroleum and metal COPCs. The Tier 2 process only provides direction on RBSL adjustments for sites with petroleum COPCs provided in this guidance. The Tier 2 process calculates more site-specific RBLS based on the site-specific compounds present at the site, often increasing the final cleanup levels that need to be met.

Some petroleum spills can be mitigated easily and remediated to meet Tier 1 RBSLs but for sites with more complex issues, a Tier 2 evaluation may be warranted. The Tier 2 evaluation allows Tier 1 RBSLs to be adjusted to site-specific screening levels for direct contact exceedances and leaching to groundwater. If the Vapor Intrusion pathway is suspected to be an issue at a site, a separate evaluation will be done following DEQs Vapor Intrusion Guidance (2021b). Section 4 describes how to conduct a Tier 2 evaluation and calculate site-specific RBSLs.

4.0 TIER 2 RBCA EVALUATION PROCESS

Completion of a Tier 1 evaluation is required prior to implementing the Tier 2 process. If a site has not undergone a Tier 1 evaluation, please refer to Section 3.0 and complete the Tier 1 steps before moving forward with a Tier 2 evaluation.

The Tier 2 process is only for petroleum exceedances in soil, both direct contact and leaching to groundwater. A Tier 2 evaluation is not completed for contaminants in groundwater exceeding the groundwater RBSLs. These RBSLs are based on either Circular DEQ-7 Montana Numeric Water Quality Standards (DEQ, 2019; or most recent version) or risk-based calculations. Investigation of site conditions and analysis of data collected during the Tier 1 evaluation process are used to determine the Tier 1 COPCs and the nature and extent of contamination at the site. Soil and groundwater data are compared to the Tier 1 RBSLs in Tables 2 and 3 to determine whether a site can be resolved (closed) or whether additional investigation, cleanup, or monitoring is required.

The Tier 1 process concludes with screening contaminant concentrations to the Tier 1 direct contact RBSLs, the Tier 1 leaching to groundwater RBSLs, and the groundwater standards and RBSLs. This will create a few different lists of COPCs: one representing the direct contact exposure pathway for each site receptor, one representing the leaching to groundwater pathway, and one representing the groundwater pathway.

Contaminant concentrations below Tier 1 RBSLs for a particular pathway demonstrate that pathway is incomplete (i.e., this pathway does not pose a potential risk to site receptors). Document these conclusions on the site CSM and no further action is needed for evaluating that exposure pathway or that particular contaminant. However, if concentrations exceed Tier 1 RBSLs, additional evaluation will be needed (see Section 3.5). There are site-specific conditions where cleanup may be appropriate using the Tier 1 RBSLs as cleanup levels, and confirmation sampling can confirm that contamination has been removed.

It is important to note the Tier 2 process is different depending upon the exposure pathways being evaluated. The following sections lay out the Tier 2 process for the direct contact (Section 4.2) and leaching to groundwater pathways separately (Section 4.3). If one pathway is determined incomplete based on the Tier 1 evaluation, this should be documented in the CSM, and the Tier 2 evaluation can be completed for the remaining pathway.

If a site has completed a Tier 1 investigation and COPCs include metals or petroleum compounds not included in this guidance, the RBCA Tier 2 process outlined in this section should not be followed. Please work with a risk assessor and contact the DEQ Project Officer to discuss next steps.

4.1 Tier 2 Exposure Pathways

The exposure pathways focused on in the Tier 2 process are based on the outcome of the Tier 1 evaluation. If there were no exceedances of Direct Contact Tier 1 RBSLs for the resident, commercial industrial worker, or construction worker, then the pathway is determined incomplete, recorded as incomplete in the CSM, and a Tier 2 evaluation for direct contact for that receptor(s) is not needed (since no COPCs came out of the Tier 1 evaluation). The same is true for leaching to groundwater. If there were no exceedances of leaching to Groundwater Tier 1 RBSLs for the appropriate depth to groundwater, the pathway is determined incomplete, recorded as incomplete in the CSM, and a Tier 2 evaluation for the leaching pathway is not needed. This Tier 2 process will be site specific depending on the site CSM and COPCs from the Tier 1 evaluation.

If there were exceedances of Direct Contact Tier 1 RBSLs for the resident, commercial worker, or construction worker, refer to Section 4.2 to work through adjusting the RBSLs specific to the site's list of COPCs.

If there were exceedances of Leaching to Groundwater Tier 1 RBSLs, see Section 4.3 for options on how to evaluate this pathway based on the site-specific soil characteristics and hydrology. When evaluating leaching to groundwater, the primary goal is to show at what soil concentration a given compound will not be expected to impact the groundwater above RBSLs. This can be done in a few different ways. Owners/operators or responsible parties and their contractors are encouraged to choose the option that best suits the needs of the site.

4.2 Direct Contact Pathway - Tier 2 Process

Calculation of Tier 2 Soil RBSLs for the direct contact pathway requires a cumulative table of soil data collected during the Tier 1 evaluation of the release, including the laboratory analytical data; sample ID, sample depth (ft. bgs); current site use or potential future use (residential, commercial, construction); and the site-appropriate direct contact Tier-1 soil RBSLs listed in Table 2. Note that other programs may require a different presentation of data. If sufficient soil data was not collected during the Tier 1 evaluation of the release to determine if direct contact pathways for the three receptors are complete, please refer to Section 3.0 and complete the Tier 1 steps before moving forward with a Tier 2 evaluation.

The Tier 1 process should conclude with a review of the cumulative soil data table and should determine which analytes exceed either the surface or subsurface direct contact RBSLs. A list of COPCs for each receptor – residential, commercial, and construction worker – should have been created, where applicable. The Tier 2 process focuses only on the compounds listed as COPCs. Any compounds not listed as a COPC (concentrations did not exceed the Tier 1 RBSL) are no longer a concern for the site.

One of the first steps in the Tier 2 process for direct contact is determining which effect, carcinogenic or non-carcinogenic, is represented by each compound in the list of COPCs created from the Tier 1 process. This information can be found in Table 2. The carcinogenic (c) and non-carcinogenic (n) effects are labeled 'c' or 'n' in the middle column of Table 2. Note that direct-contact RBSLs for benzene, naphthalene, and benzo(a)pyrene represent carcinogenic effects for the residential and commercial receptor (0-2 ft. bgs) and non-carcinogenic effects for the construction scenario (0-10 ft. bgs).

4.2.1 Derivation of Direct Contact – Tier 2 RBSLs

Non-carcinogenic Analytes

The Tier 1 RBSLs listed in Table 2 were developed on a conservative basis detailed in Appendix B. The Tier 1 RBSLs are derived in a way that would allow exposure to ten (10) compounds representing non-carcinogenic effects, with concentrations as high as their respective Tier I RBSLs, without the likelihood of adverse effects. Therefore, it is possible to calculate risk-based Tier 2 RBSLs for non-carcinogenic (n) analytes by multiplying the analyte's Tier 1 RBSL by 10 and dividing by the number of non-carcinogenic analytes that exceed their respective Tier 1 RBSLs. Here is that algebraic formula:

$$\text{Tier 2 RBSL}_{\text{n}} = \text{Tier 1 RBSL}_{\text{n}} \text{ x } \left(\frac{10}{\text{\# of non} - \text{Carcinogenic Exceedances}} \right)$$

Carcinogenic Analytes

The Tier 1 RBSLs listed in Table 2 were developed on a conservative basis detailed in Appendix B. The Tier 1 RBSLs are derived in a way that would allow exposure to ten (10) compounds with carcinogenic effects, at concentrations as high as their respective Tier I RBSLs, without any adverse effects. Therefore, DEQ determined it possible to calculate risk-based Tier 2 RBSLs for a carcinogenic (c) analyte by multiplying the analyte's Tier 1 RBSL by 10 and dividing by the number of carcinogenic analytes that exceed their respective Tier 1 RBSLs. Here is that algebraic formula:

$$\text{Tier 2 RBSL}_{\text{c}} = \text{Tier 1 RBSL}_{\text{c}} \text{ x } \left(\frac{10}{\text{\# of Carcinogenic Exceedances}} \right)$$

This Tier 2 adjustment process is only appropriate for direct contact exposure pathways and direct contact RBSLs and is NOT appropriate for leaching to groundwater or groundwater. Section 4.3 below describes the methods that can be taken for site-specific leaching to groundwater evaluations.

4.2.2 Using Look-up Tables for Direct Contact – Tier 2 Soil RBSLs

DEQ developed look-up tables that list some possible direct contact Tier 2 soil RBSLs for non-carcinogenic and carcinogenic petroleum analytes. Table 4a (Direct Contact Residential), Table 4b (Direct Contact Commercial), and Table 4c (Direct Contact Construction). These tables are used to adjust the Tier 1 RBSLs for the COPCs generated from the Tier 1 evaluation. These tables only apply to sites with COPCs listed in these tables. If a site has any COPCs **not included** in these tables, these tables cannot be used to adjust any compounds at the site. Please contact your DEQ project officer to discuss the appropriate next steps.

Please follow the steps below for the Tier 2 Look-up tables:

1. Review the list of COPCs for each receptor (residential COPCs, commercial worker COPCs, construction worker COPCs) developed during the Tier 1 process.

2. Determine, for each compound, what is driving the risk – carcinogenic effects or non-carcinogenic effects. This can be found in the center column of Table 2 where each compound is marked with a "c" or an "n".

3. Add up the number of compounds with carcinogenic effects and the number of non-carcinogenic effects. This will be done separately for each receptor.

4. Moving to Tables 4a, 4b, & 4c, choose the look-up table(s) associated with the corresponding receptor (residential, commercial, construction worker) then find the column with the corresponding number of non-carcinogenic RBSLs. Look down the column for the RBSL listed for each non-carcinogenic compound of interest.

5. For carcinogenic compounds, select the column with the corresponding number of carcinogenic compounds and look down the column for the RBSL listed for the compound of interest.

6. These RBSLs are the Tier 2 adjusted RBSLs.

7. Complete a second round of screening by entering the Tier 2 RBSLs into the site-specific cumulative soil data table and determine which compounds have concentrations exceeding the Tier 2 RBSLs. Highlight or bold the exceedances.

8. For each receptor, report the list of compounds that exceed the Tier 2 RBSLs. This list of compounds is the list of COCs for the site. These compounds should be addressed through corrective action.

4.3 Leaching to groundwater

When the Tier 1 evaluation concludes with a list of COPCs that exceed the RBSLs for the leaching to groundwater pathway, additional steps can be taken to evaluate whether remedial action (cleanup) is needed. This evaluation is focused on ensuring that soil contamination does not leach to the groundwater, causing exceedances of the groundwater RBSLs in Table 3. To do this, it is important to look at this pathway holistically to answer the following questions:

- How quickly will the contaminants in soil leach to the groundwater?
- Have the compounds already leached to groundwater? If so, to what extent?

The information provided in the rest of this section will help provide answers to these questions and help demonstrate whether leaching is expected to occur or has already occurred. One of the options below or, a combination of more than one may be used to evaluate site-specific leaching to groundwater scenarios. These calculations vary from simple to complex and generally site-specific soil and hydrological data are necessary to estimate contaminant travel time through the vadose zone, calculate a site-specific dilution attenuation factor (DAF) and/or conduct further fate and transport modeling. Groundwater data is also very beneficial to determining the impact leaching has had or is having on the groundwater and any wells in the surrounding area.

4.3.1 Collection of Site-Specific Data

In order to develop site-specific screening levels for leaching to groundwater, it may be necessary to collect additional data to characterize chemical partitioning behavior and the site-specific DAF. Collecting this data during the initial site characterization phase in Tier 1 is recommended to save time and money; however, this data can also be collected later in the process. Site-specific data needed may include the following, depending on the complexity of the evaluation (i.e., site-specific DAF versus fate and transport modeling):

- **Soil characteristics:** from the major soil types present in surface and subsurface soils, and aquifer sediments below the water table: fraction of organic carbon (foc) from uncontaminated areas of the site; dry bulk density; soil moisture; soil pH; and soil texture.
- **Hydrologic characteristics**: hydraulic conductivity; hydraulic gradient; and aquifer thickness.
- **Source characteristics**: COC source dimensions and concentrations; COC leaching characteristics; and non-aqueous phase liquids composition.
- **Chemical biodegradation**: groundwater COC concentrations and geochemical data.

DEQ's Technical Guidance "General Field Data Needs for Fate and Transport Modeling" (DEQ, 2008) identifies the information needed and describes how the data are used for fate and transport modeling.

4.3.2 Calculating Site-Specific Dilution Attenuation Factor

Calculating a site-specific DAF is one of the simpler processes for generating a site-specific leaching to groundwater RBSL. As precipitation moves through contaminated soil, contamination is dissolved in the water. During this movement through the soil column, contaminants dissolved in this liquid, or soil leachate, may be reduced (or attenuated) by adsorption and degradation, and once the soil leachate reaches the groundwater, it may be diluted by the clean groundwater flowing through the aquifer. The reduction in concentration is represented by the DAF, defined as the ratio of the contaminant concentration in soil leachate to the concentration in groundwater at the receptor point (EPA, 1996).

The DAF is used to assess whether soil concentrations are likely to cause groundwater contamination above DEQ-7 water quality standards or RBSLs for groundwater. A low DAF value indicates little to no dilution or attenuation of contaminants (soil leachate and receptor well concentrations are equal), and high DAF values correspond to a large reduction in contaminant concentration from the soil to the receptor well. The variables in the DAF calculation represent conditions and physical processes occurring at the site; therefore, the following site information is needed for a site-specific DAF assessment:

- Aquifer parameters including hydraulic conductivity, hydraulic gradient, and aquifer thickness.
    - Hydraulic conductivity as determined through site-specific aquifer tests (pump or slug tests) or estimated through knowledge of local hydrogeologic conditions (EPA, 1996);

  - Hydraulic gradient as measured on a map of the site's water table, or based on estimates from knowledge of local hydrogeologic conditions (EPA, 1996);
  - Aquifer thickness as determined from soil boring or well logs or based on estimates from knowledge of local hydrogeologic conditions. This information will be used to calculate the mixing zone depth (see equation below). Mixing zone depth should not exceed the aquifer thickness, so if the calculation results in a number larger than the aquifer thickness, use the aquifer thickness in place of the mixing zone depth (EPA, 1996).
- Source length parallel to groundwater flow as determined through site-specific sampling data.
- Infiltration or recharge rate as determined through use of the Hydrologic Evaluation of Landfill Performance (HELP) model (Schroeder et al., 1984) or based on estimates of local/regional precipitation to estimate the fraction of the annual precipitation which percolates vertically through the soil column and into the aquifer.

Example Calculation of a site-specific mixing zone depth using the following equation (EPA, 1996):

$$\mathrm{D} = [0.0112 \text{ x } \mathrm{L}^2]^{0.5} + \mathrm{d_a}\{1 - \mathrm{EXP}\left[\frac{(-\mathrm{LI})}{(\mathrm{Kid}_a)}\right]\}$$

Where:

D = Mixing zone depth (ft)
L = Length of source parallel to groundwater flow (ft)
d_a = Aquifer Thickness (ft)
I = Infiltration rate (ft/day)
K = Aquifer hydraulic conductivity (ft/day)
i = Hydraulic gradient (ft/ft)

As identified above, if $\mathrm{D} > \mathrm{d_a}$, replace value for D with $\mathrm{d_a}$ in DAF equation below.

Example Calculation of a site-specific DAF using the following equation (EPA, 1996):

$$\mathrm{DAF} = 1 + \frac{\mathrm{KiD}}{\mathrm{IL}}$$

Where:

DAF = Dilution attenuation factor (unitless)
K = Aquifer hydraulic conductivity (ft/day)
i = Hydraulic gradient (ft/ft)
D = Mixing zone depth (ft)
I = Infiltration rate (ft/day)
L = Length of source parallel to flow (ft)

Once a site-specific DAF is determined, it can be used in place of the default DAF of 10 built into the leaching-based RBSLs to provide a site-specific evaluation of leaching (e.g., divide the leaching-based RBSL by 10 to remove the default DAF and then multiply the number by the site-specific DAF to get the adjusted, or site-specific, leaching-based screening level). If the contaminant concentrations are less than this site-specific screening level, the leaching to groundwater pathway can be eliminated from concern.

EXAMPLE:

Parameter	Tier 2 Site-Specific Values	Units
Aquifer hydraulic conductivity	165	ft/day
Hydraulic gradient	0.0057	ft/ft
Mixing zone depth	10	ft
Infiltration rate	0.00081	ft/day
Length of source parallel to flow	400	ft
Site -Specific DAF	**30**	**--**

For example, assume that a site has benzene in subsurface soil at a concentration of 0.15 mg/kg. The leaching based RBSL, from Table 2, for benzene is 0.07 mg/kg, so if the RBSL is divided by 10 to remove the generic DAF, and then multiplied by the site-specific DAF of 30 (the DAF calculated in the example above), the resulting site-specific screening level is 0.21 mg/kg. The site concentration of benzene is 0.15 mg/kg, which is less than the site-specific screening level of 0.21 mg/kg, so the benzene concentration is not a concern for the leaching to groundwater pathway.

4.3.3 Vadose Zone Travel Time

The vadose zone travel time of a contaminant is an estimate of how long it will take a COC in the vadose zone to reach groundwater. This information can be used to determine the amount of time it took or the time it will take for a compound to leach to groundwater. It is particularly useful when the date of a release is known and can be used to illustrate that contaminants have already leached and have diluted, attenuated, or degraded, when they will likely reach groundwater, or when their contaminant-specific characteristics are such that they are not likely to reach groundwater. The following steps are included in calculating a COC's travel time:

Step 1 - Calculate vertical pore water velocity though the vadose zone

(a) Estimate infiltration rate based on precipitation and any water application at the site;
(b) Estimate representative water filled porosity of vadose zone soils based on measured soil moisture content;
(c) Divide infiltration rate by water filled porosity = vertical pore water velocity.

Step 2 - Calculate chemical partitioning coefficient K_d – Two Options

- Option 1 - Calculate using EPA equations in the Soil Screening Guidance Document: Technical Background Document - Part 2: Development Of Pathway-Specific Soil Screening Levels (EPA, 1996; available at https://www.epa.gov/superfund/superfund-soil-screening-guidance) and site-measured fraction organic carbon (foc):

(a) **If dealing with pentachlorophenol or other ionizing organic chemicals not addressed under RBCA** use Equation 27 on Page 39 to calculate K_{oc} values as a function of pH. Otherwise, use the EPA-tabulated value for K_{oc}.
(b) For organics use Equation 23 on Page 37 to calculate $K_d = K_{oc} f_{oc}$; for inorganics use the EPA-tabulated value for K_d.

- Option 2 - **If Synthetic Precipitation Leaching Procedure (SPLP) analysis has been conducted**: calculate site-specific K_d using Equation 22 on Page 36 of the Soil Screening Guidance – Part 2 (see Option 1 above for link). Use the measured SPLP water concentration for C_w, and the measured chemical concentration in the soil concentration for C_t.

Step 3 Calculate chemical retardation coefficient in vadose zone soils

Use Equation (3) in the Simple Derivation of the Retardation Equation and Application to Preferential Flow and Macrodispersion (Bouwer, 1991; available at http://info.ngwa.org/gwol/pdf/910655328.PDF) to calculate the chemical retardation coefficient.

Step 4 Calculate chemical velocity in vadose zone soils

Chemical velocity in vadose zone = (vertical pore water velocity) / (retardation coefficient)

Step 5 Solve for chemical travel time to water table

Chemical travel time to water table = (distance between contamination and groundwater) / (chemical velocity in vadose zone)

EXAMPLE:

Site information:

- The following compounds are present in the silty clay soil at a site at concentrations above the leaching-based Tier 1 RBSLs: benzene, naphthalene, benzo(a)anthracene, and benzo(a)pyrene.
- The vadose zone travel time calculations show that benzene would have leached in approximately two years, naphthalene in 24 years, benzo(a)anthracene in 7,100 years, and benzo(a)pyrene in 19,000 years.
- The release was documented to have occurred 22 years previously and groundwater has been sampled periodically since the release.
- Evaluation of the groundwater data shows that benzene has routinely been detected at concentrations above the DEQ-7 water quality standard/RBSL, naphthalene was detected in samples historically, but is no longer seen at concentrations above the DEQ-7 water quality standard/RBSL, and benzo(a)anthracene and benzo(a)pyrene have never been detected in groundwater at the site.

As a result of this exercise, benzene remains the only compound of concern. Naphthalene, while a problem historically, has leached and concentrations are now reduced below the DEQ-7 water quality standard/RBSL and the PAH compounds are unlikely to ever reach groundwater given their relative immobility in this site-specific setting, as determined through the calculations.

4.3.4 Synthetic Precipitation Leaching Procedure

SPLP is a sample preparation method developed by the EPA to model an acid rain leaching environment. It is designed to predict the mobility of organic and inorganic compounds and determine the potential for leaching to ground and surface waters. SPLP data can be used to quantify contaminant partitioning in soils but should not be used by directly comparing to DEQ-7 water quality standards. Soil samples need to be collected from the same interval and analyzed for the COC using the normal soil analytical methods and SPLP (which will result in a leachate (liquid - µg/L) concentration). Once collected, the data can be used to develop a site-specific leaching to groundwater screening level. This can be done in the following ways:

- To define site-specific partitioning behavior (i.e., calculate the soil water partitioning coefficient or K_d). The ratio between the total soil concentration and the reported COC SPLP concentration can be used to define the partitioning behavior. This can be used in fate and transport modeling in place of literature values and is discussed in DEQ's Technical Guidance "General Field Data Needs for Fate and Transport Modeling" (DEQ, 2008).
- To develop a site-specific leaching to groundwater screening level. There are several ways to do this, as described in New Jersey Department of Environmental Protection's "Development of Site-Specific Impact to Ground Water Soil Remediation Standards Using the Synthetic Precipitation Leaching Procedure" (NJDEP, 2021).

4.4 Tier 2 Chemicals of Concern & Corrective Action

Tier 1 RBSLs are conservative by design and when additional, site-specific information about the COPCs is available, the RBSLs may be adjusted during the Tier 2 evaluation to better represent the site-specific information available.

Chemicals of Concern are any compounds that exceed the Tier 2 RBSLs for either direct contact or leaching to groundwater. These chemicals should be addressed through corrective action. There may be limited situations where additional steps can be taken from a risk assessment perspective for the direct contact pathway; however, this requires owners/operators or responsibly parties and their consultants to work closely with a toxicologist/environmental risk assessor.

4.5 Summary of Tier 2 Evaluation Process

Procedures for evaluating a release using the RBCA Tier 2 process are summarized as follows:

1) *Direct Contact Evaluation – Tier 2 RBSL Adjustments:*
    a) Determine the site-specific Tier 2 adjusted RBSLs following the steps in Section 4.2.1 for soil samples that exceed direct contact Tier 1 RBSLs for each receptor.

    DEQ developed look-up tables for all potential Tier 2 RBSLs representing direct contact exposure for the residential (Table 4a), commercial (Table 4b), and construction worker receptors (Table 4c). These three tables are located in the Tables section and on DEQ's Petroleum Tank Cleanup website.

  b) If site concentrations are below the site-specific Tier 2 RBSLs, the site may be evaluated for closure.
  c) If site concentrations are above site-specific Tier 2 RBSLs, the compound(s) is a COC for the site and additional remediation, or evaluation , may need to be implemented. Next steps should be discussed with the appropriate regulating program.

2) Leaching to Groundwater Evaluation:
  a) If site soil concentrations exceed Tier 1leaching to groundwater RBSLs (Table 2), a site-specific, Tier 2, leaching to groundwater analysis may be appropriate. Section 4.3 outlines some of the different options for this analysis.
  b) If soil sampling results, following the Tier 2 evaluation, exceed Tier 2 leaching to groundwater RBSLs, remedial action may be necessary.

5.0 REFERENCES

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Tables

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Table 1

Petroleum-Release Confirmation Risked-Based Screening Levels (RBSLs) for Soil

Laboratory analytical results that exceed the Table 1 Release Confirmation Soil RBSLs listed below confirm that a release has occurred per ARM 17.56.506. These represent the most conservative Tier 1 RBSLs (compiled in Table 2) for Leaching to groundwater and Residential Direct Contact including ingestion, inhalation, and dermal routes of exposure.

Chemical / Analyte / Compound	Effects - carcinogenicity	RBSL, mg/kg	Basis
For Gasoline & Light Hydrocarbons measured using the Montana Method for Volatile Petroleum Hydrocarbons (VPH)			
MTBE	c	0.078 *	l
Benzene	c	0.07	l
Toluene	n	21	l
Ethylbenzene	c	8.4	dc
Xylenes	n	75	dc
Naphthalene	c	2.9	dc
C9-C10 Aromatics	n	60	dc
C5-C8 Aliphatics	n	90	dc
C9-C12 Aliphatics	n	160	dc
Lead Scavengers			
1,2-Dichloroethane (DCA)	c	0.019	l
1,2-Dibromoethane (EDB)	c	0.000086 *	l
For Diesel & Heavy Hydrocarbons measured using Montana Method for Extractable Petroleum Hydrocarbons (EPH)			
**EPH Screen	n/a	200	n/a
C9-C18 Aliphatics	n	290	dc
C19-C36 Aliphatics	n	25,000	dc
C11-C22 Aromatics	n	370	l
Acenaphthene	n	27	l
Anthracene	n	2,300	dc
Benz(a)anthracene	c	1.6	dc
Benzo(a)pyrene	c	0.17	dc
Benzo(b)fluoranthene	c	1.7	dc
Benzo(k)fluoranthene	c	17	dc
Chrysene	c	170	dc
Dibenzo(a,h)anthracene	c	0.17	dc
Fluoranthene	n	85	l
Fluorene	n	35	l
Indeno(1,2,3-cd)pyrene	c	1.7	dc
Naphthalene	c	2.9	dc
Pyrene	n	83	l
1-Methylnaphthalene	c	2.1	l
2-Methylnaphthalene	n	6.9	l

Notes:

* = Best achievable practical quantitation limit exceeds RBSL; therefore, if compound detected, additional evaluation may be necessary.

** = the 200 ppm EPH screen concentration is used to determine that additional analysis -- fractionation -- is needed

n/a = Not applicable; EPH screen is an indicator concentration requiring fractionation and not a Risked-Based Screening Level

n = based on non-carcinogenic effects
l = leaching
c = based on carcinogenic effects
dc = direct contact
mg/kg = milligramsper kilogram

Soil RBSLs are not designed to be protective of a vapor intrusion (VI) pathway; refer to the most recent DEQ Vapor Intrusion Guidance.

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Table 2

All Potential Tier 1 Risked-Based Screening Levels* (RBSLs) for Soil, mg/kg

Leaching RBSLs: require vertical distance (feet) from base of petroleum-contaminated soil sample to groundwater.

Direct Contact RBSLs: require depth below ground surface (feet bgs) to petroleum-contaminated soil sample.

Chemical / Analyte / Compound	**Leaching RBSLs, mg/kg** Distance (feet) from Soil Sample to Groundwater			**Direct Contact RBSLs, mg/kg** Carcinogenic Effects, Receptors, and Depth Intervals			
	0-10 feet	**10-20 feet**	**>20 feet**	**c**arcinogenic **n**on-carcinogenic	**Residential 0 - 2 feet bgs**	**Commercial 0 - 2 feet bgs**	**Construction 0 - 10 feet bgs**
For Gasoline & Light Hydrocarbons measured using the Montana Method for Volatile Petroleum Hydrocarbons (VPH)							
MTBE	0.078	0.16	0.25	c	67	310	9,100
Benzene	0.07	0.21	0.33	c/n	1.7 ^{c}	7.6 ^{c}	190 ^{n}
Toluene	21	65	100	n	630	6,300	14,000
Ethylbenzene	26	84	130	c	8.4	38	1,200
Xylenes	320	1,000	1,600	n	75	330	1,900
Naphthalene	12	40	62	c/n	2.9 ^{c}	13 ^{c}	120 ^{n}
C9-C10 Aromatics	130	470	720	n	60	300	4,000
C5-C8 Aliphatics	220	770	1,200	n	90	450	2,000
C9-C12 Aliphatics	11,000	40,000	60,000	n	160	800	3,000
Lead Scavengers							
1,2-Dichloroethane (DCA)	0.019	0.052	0.079	c	0.67	3.0	100
1,2-Dibromoethane (EDB)	0.000086	0.00022	0.00033	c	0.05	0.24	7.3
For Diesel & Heavy Hydrocarbons measured using Montana Method for Extractable Petroleum Hydrocarbons (EPH)							
C9-C18 Aliphatics	53,000	170,000	270,000	n	290	1,600	6,000
C19-C36 Aliphatics	Considered Immobile			n	25,000	330,000	1,600,000
C11-C22 Aromatics	370	1,300	2,000	n	540	6,200	33,000
Acenaphthene	27	91	140	n	470	6,000	10,000
Anthracene	2,600	8,800	14,000	n	2,300	30,000	50,000
Benz(a)anthracene	6.8	23	35	c	1.6	31	390
Benzo(a)pyrene	2.3	7.5	12	c/n	0.17 ^{c}	3.1 ^{c}	15 ^{n}
Benzo(b)fluoranthene	23	76	120	c	1.7	31	390
Benzo(k)fluoranthene	230	750	1,200	c	17	310	3,900
Chrysene	690	2,300	3,500	c	170	3,100	39,000
Dibenzo(a,h)anthracene	7.5	24	38	c	0.17	3.1	39
Fluoranthene	85	280	440	n	310	4,000	5,000
Fluorene	35	120	180	n	310	4,000	40
Indeno(1,2,3-cd)pyrene	77	250	380	c	1.7	31	390
Naphthalene	12	40	62	c/n	2.9 ^{c}	13 ^{c}	120 ^{n}
Pyrene	83	280	430	n	230	3,000	15,000
1-Methylnaphthalene	2.1	7.1	11	c	25	110	1,400
2-Methylnaphthalene	6.9	23	35	n	31	400	200

*Refer to RBCA Guidance Appendix B for derivation of Risk-Based Screening Levels (RBSLs)

mg/kg = milligrams per kilogram

bgs = below ground surface

c = RBSL based upon carcinogenicity

n = RBSL based upon non-carcinogenicity

c/n = RBSL basis varies by receptor

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Table 3

Groundwater Standards and Risked-Based Screening Levels (RBSLs)

Table applies to groundwater and consists of current DEQ-7 Human Health Standards, where available. For compounds without DEQ-7 standards, the risk-based screening levels (RBSLs) have been developed using EPA's RSL equations and information found in Appendix D. For EPH compounds, a total extractable hydrocarbon (TEH) concentration of 1,000 µg/L is used to determine if fractionation is needed. For surface water, see Appendix D.

Chemical / Analyte / Compound	Effects - carcinogenicity	Basis	Groundwater Standard or RBSL, µg/L
For Gasoline and Light Hydrocarbons measured using the Massachusetts Method for Volatile Petroleum Hydrocarbons (VPH)			
MTBE	n	DEQ-7	30
Benzene	c	DEQ-7	5
Toluene	n	DEQ-7	1,000
Ethylbenzene	n	DEQ-7	700
Xylenes	n	DEQ-7	10,000
Naphthalene	c	DEQ-7	100
C9-C10 Aromatics	n	rbsl	980
C5-C8 Aliphatics	n	rbsl	700
C9-C12 Aliphatics	n	rbsl	3,000
Lead Scavengers			
1,2-Dichloroethane (DCA)	c	DEQ-7	4
Ethylene dibromide (EDB)	c	DEQ-7	0.017
For Diesel and Heavy Hydrocarbons measured using the Massachusetts Method for Extractable Petroleum Hydrocarbons (EPH)			
EPH / TEH Screen fractionation required(a)			1,000
C9-C18 Aliphatics	n	rbsl	3,000
C19-C36 Aliphatics	n	rbsl/bu	100,000/bu
C11-C22 Aromatics	n	rbsl	1,100
Acenaphthene	n	DEQ-7	70
Anthracene	n	DEQ-7	2,100
Benz(a)anthracene	c	DEQ-7	0.5
Benzo(a)pyrene	c	DEQ-7	0.05*
Benzo(b)fluoranthene	c	DEQ-7	0.5
Benzo(k)fluoranthene	c	DEQ-7	5
Chrysene	c	DEQ-7	50
Dibenzo(a,h)anthracene	c	DEQ-7	0.05*
Fluoranthene	n	DEQ-7	20
Fluorene	n	DEQ-7	50
Indeno(1,2,3-cd)pyrene	c	DEQ-7	0.5
Naphthalene	c	DEQ-7	100
Pyrene	n	DEQ-7	20
1-Methylnaphthalene	c	rsl	11
2-Methylnaphthalene	n	rsl	36

Notes: (a) = An exceedance of the 1,000 µg/l EPH/TEH screen value indicates only that fractionation is required. If none of the fractions exceed, EPH/TEH does not need to be identified as a Contaminant of Potential Concern exceeding RBSLs.

µg/L = micrograms per liter

Effect: n = non-carcinogenic RBSLs and DEQ-7 standards are based on a hazard quotient of 1.

c = carcinogenic DEQ-7 standards are based on a cancer risk 1X10^{-5}.

bu = beneficial use ceiling - if taste/odor or any other parameters that render a water harmful, detrimental or injurious to the beneficial uses for that water are violated, the site cannot be closed

Basis: rbsl = MT DEQ Petroleum Tank Cleanup program groundwater risk-based screening level;

rsl = Regional Screening Level from US EPA, May 2023

DEQ-7 = Human Health Groundwater Standard (refer to DEQ's most recent Circular DEQ-7 Montana Numeric Water Quality Standards);

* = The best achievable practical quantitation limit (0.1 µg/L) may be greater than the DEQ-7 human health standard; therefore, if the compound is detected, additional evaluation may be necessary.

Table 4a

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Calculated Tier 2** Soil RBSLs* for Direct Contact Residential Receptor 0 - 2 feet bgs

Effects c: carcinogenic n: non-carcinogenic	Tier 1 Soil RBSLs, mg/kg Direct Contact Residential Receptor		Calculated Tier 2 RBSLs for Surface Soil Exceedances of Tier 1 RBSLs, mg/kg											
			Tier 2 RBSL = Tier 1 RBSL X 10 / (number of Non-Carcinogenic Analytes >Tier 1 RBSLs)						*Tier 2 RBSL = Tier 1 RBSL X 10 / (number of Carcinogenic Analytes >Tier 1 RBSLs)*					
	Chemical / Analyte / Compound	**0 - 2 feet bgs**	**Number of Non-Carcinogenic Analytes >Tier 1 RBSLs**						**Number of Carcinogenic Analytes >Tier 1 RBSLs**					
			1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
	For Gasoline & Light Hydrocarbons measured using the Montana Method for Volatile Petroleum Hydrocarbons (VPH)													
c	MTBE	**67**	---	---	---	---	---	---	670	335	223	168	134	112
c	Benzene	**1.7**	---	---	---	---	---	---	17	8.5	5.7	4.3	3.4	2.8
n	Toluene	**630**	6,300	3,150	2,100	1,575	1,260	1,050	---	---	---	---	---	---
c	Ethylbenzene	**8.4**	---	---	---	---	---	---	84	42	28	21	16.8	14
n	Xylenes	**75**	750	375	250	188	150	125	---	---	---	---	---	---
c	Naphthalene	**2.9**	---	---	---	---	---	---	29	15	9.7	7.3	5.8	4.8
n	C9-C10 Aromatics	**60**	600	300	200	150	120	100	---	---	---	---	---	---
n	C5-C8 Aliphatics	**90**	900	450	300	225	180	150	---	---	---	---	---	---
n	C9-C12 Aliphatics	**160**	1,600	800	533	400	320	267	---	---	---	---	---	---
	Lead Scavengers													
c	1,2-Dichloroethane (DCA)	**0.67**	---	---	---	---	---	---	6.7	3.4	2.23	1.68	1.34	1.12
c	1,2-Dibromoethane (EDB)	**0.05**	---	---	---	---	---	---	0.5	0.3	0.17	0.13	0.10	0.08
	For Diesel & Heavy Hydrocarbons measured using Montana Method for Extractable Petroleum Hydrocarbons (EPH)													
n	C9-C18 Aliphatics	**290**	2,900	1,450	967	725	580	483	---	---	---	---	---	---
n	C19-C36 Aliphatics	**25,000**	250,000	125,000	83,333	62,500	50,000	41,667	---	---	---	---	---	---
n	C11-C22 Aromatics	**540**	5,400	2,700	1,800	1,350	1,080	900	---	---	---	---	---	---
n	Acenaphthene	**470**	4,700	2,350	1,567	1,175	940	783	---	---	---	---	---	---
n	Anthracene	**2,300**	23,000	11,500	7,667	5,750	4,600	3,833	---	---	---	---	---	---
c	Benz(a)anthracene	**1.6**	---	---	---	---	---	---	16	8.0	5.3	4.0	3.2	2.7
c	Benzo(a)pyrene	**0.17**	---	---	---	---	---	---	1.7	0.85	0.57	0.43	0.34	0.28
c	Benzo(b)fluoranthene	**1.7**	---	---	---	---	---	---	17	8.5	5.7	4.3	3.4	2.8
c	Benzo(k)fluoranthene	**17**	---	---	---	---	---	---	170	85	57	43	34	28
c	Chrysene	**170**	---	---	---	---	---	---	1,700	850	567	425	340	283
c	Dibenzo(a,h)anthracene	**0.17**	---	---	---	---	---	---	1.7	0.85	0.57	0.43	0.34	0.28
n	Fluoranthene	**310**	3,100	1,550	1,033	775	620	517	---	---	---	---	---	---
n	Fluorene	**310**	3,100	1,550	1,033	775	620	517	---	---	---	---	---	---
c	Indeno(1,2,3-cd)pyrene	**1.7**	---	---	---	---	---	---	17	8.5	5.7	4.3	3.4	2.8
c	Naphthalene	**2.9**	---	---	---	---	---	---	29	15	9.7	7.3	5.8	4.8
n	Pyrene	**230**	2,300	1,150	767	575	460	383	---	---	---	---	---	---
c	1-Methylnaphthalene	**25**	---	---	---	---	---	---	250	125	83.3	62.5	50	41.7
n	2-Methylnaphthalene	**31**	310	155	103	78	62	52	---	---	---	---	---	---

*Refer to RBCA Guidance Appendix B for derivation of Risk-Based Screening Levels (RBSLs)

**Refer to RBCA Guidance Section 4.0 for details of Tier 2 Evaluation Process and calculation of Tier 2 RBSLs

mg/kg = milligrams per kilogram

bgs = below ground surface

20-Feb-2024

Table 4b

Calculated Tier 2** Soil RBSLs* for Direct Contact Commercial Receptor 0 - 2 feet bgs

Effects c: carcinogenic n: non-carcinogenic	**Tier 1 Soil RBSLs, mg/kg** Direct Contact Commercial Receptor		**Calculated Tier 2 RBSLs for Surface Soil Exceedances of Tier 1 RBSLs, mg/kg**											
			Tier 2 RBSL = Tier 1 RBSL X 10 / (number of Non-Carcinogenic Analytes >Tier 1 RBSLs)						*Tier 2 RBSL = Tier 1 RBSL X 10 / (number of Carcinogenic Analytes >Tier 1 RBSLs)*					
	Chemical / Analyte / Compound	**0 - 2 feet bgs**	**Number of Non-Carcinogenic Analytes >Tier 1 RBSLs**						**Number of Carcinogenic Analytes >Tier 1 RBSLs**					
			1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
	For Gasoline & Light Hydrocarbons measured using the Montana Method for Volatile Petroleum Hydrocarbons (VPH)													
c	MTBE	**310**	---	---	---	---	---	---	3,100	1,550	1,033	775	620	517
c	Benzene	**7.6**	---	---	---	---	---	---	76	38	25	19	15.2	12.7
n	Toluene	**6,300**	63,000	31,500	21,000	15,750	12,600	10,500	---	---	---	---	---	---
c	Ethylbenzene	**38**	---	---	---	---	---	---	380	190	127	95	76	63
n	Xylenes	**330**	3,300	1,650	1,100	825	660	550	---	---	---	---	---	---
c	Naphthalene	**13**	---	---	---	---	---	---	130	65	43	33	26	22
n	C9-C10 Aromatics	**300**	3,000	1,500	1,000	750	600	500	---	---	---	---	---	---
n	C5-C8 Aliphatics	**450**	4,500	2,250	1,500	1,125	900	750	---	---	---	---	---	---
n	C9-C12 Aliphatics	**800**	8,000	4,000	2,667	2,000	1,600	1,333	---	---	---	---	---	---
	Lead Scavengers													
c	1,2-Dichloroethane (DCA)	**3**	---	---	---	---	---	---	30	15	10	7.5	6	5
c	1,2-Dibromoethane (EDB)	**0.24**	---	---	---	---	---	---	2.4	1.2	0.80	0.60	0.48	0.40
	For Diesel & Heavy Hydrocarbons measured using Montana Method for Extractable Petroleum Hydrocarbons (EPH)													
n	C9-C18 Aliphatics	**1,600**	16,000	8,000	5,333	4,000	3,200	2,667	---	---	---	---	---	---
n	C19-C36 Aliphatics	**330,000**	3,300,000	1,650,000	1,100,000	825,000	660,000	550,000	---	---	---	---	---	---
n	C11-C22 Aromatics	**6,200**	62,000	31,000	20,667	15,500	12,400	10,333	---	---	---	---	---	---
n	Acenaphthene	**6,000**	60,000	30,000	20,000	15,000	12,000	10,000	---	---	---	---	---	---
n	Anthracene	**30,000**	300,000	150,000	100,000	75,000	60,000	50,000	---	---	---	---	---	---
c	Benz(a)anthracene	**31**	---	---	---	---	---	---	310	155	103	78	62	52
c	Benzo(a)pyrene	**3.1**	---	---	---	---	---	---	31	15.5	10.3	7.8	6.2	5.2
c	Benzo(b)fluoranthene	**31**	---	---	---	---	---	---	310	155	103	78	62	52
c	Benzo(k)fluoranthene	**310**	---	---	---	---	---	---	3,100	1,550	1,033	775	620	517
c	Chrysene	**3,100**	---	---	---	---	---	---	31,000	15,500	10,333	7,750	6,200	5,167
c	Dibenzo(a,h)anthracene	**3.1**	---	---	---	---	---	---	31	15.5	10.3	7.8	6.2	5.2
n	Fluoranthene	**4,000**	40,000	20,000	13,333	10,000	8,000	6,667	---	---	---	---	---	---
n	Fluorene	**4,000**	40,000	20,000	13,333	10,000	8,000	6,667	---	---	---	---	---	---
c	Indeno(1,2,3-cd)pyrene	**31**	---	---	---	---	---	---	310	155	103	78	62	52
c	Naphthalene	**13**	---	---	---	---	---	---	130	65.0	43	33	26	22
n	Pyrene	**3,000**	30,000	15,000	10,000	7,500	6,000	5,000	---	---	---	---	---	---
c	1-Methylnaphthalene	**110**	---	---	---	---	---	---	1,100	550.0	367	275	220	183
n	2-Methylnaphthalene	**400**	4,000	2,000	1,333	1,000	800	667	---	---	---	---	---	---

*Refer to RBCA Guidance Appendix B for derivation of Risk-Based Screening Levels (RBSLs)

**Refer to RBCA Guidance Section 4.0 for details of Tier 2 Evaluation Process and calculation of Tier 2 RBSLs

mg/kg = milligrams per kilogram

bgs = below ground surface

20-Feb-2024

Table 4c

Calculated Tier 2** Soil RBSLs* for Direct Contact Construction Receptor 0 - 10 feet bgs

Effects c: carcinogenic n: non-carcinogenic	Tier 1 Soil RBSLs, mg/kg Direct Contact Construction Receptor		Calculated Tier 2 RBSLs for Subsurface Soil Exceedances of Tier 1 RBSLs, mg/kg											
			Tier 2 RBSL = Tier 1 RBSL X 10 / (number of Non-Carcinogenic Analytes >Tier 1 RBSLs)						*Tier 2 RBSL = Tier 1 RBSL X 10 / (number of Carcinogenic Analytes >Tier 1 RBSLs)*					
	Chemical / Analyte / Compound	**0 - 10 feet bgs**	**Number of Non-Carcinogenic Analytes >Tier 1 RBSLs**						**Number of Carcinogenic Analytes >Tier 1 RBSLs**					
			1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
	For Gasoline & Light Hydrocarbons measured using the Montana Method for Volatile Petroleum Hydrocarbons (VPH)													
c	MTBE	**9,100**	---	---	---	---	---	---	91,000	45,500	30,333	22,750	18,200	15,167
n	Benzene	**190**	1,900	950	633	475	380	317	---	---	---	---	---	---
n	Toluene	**14,000**	140,000	70,000	46,667	35,000	28,000	23,333	---	---	---	---	---	---
c	Ethylbenzene	**1,200**	---	---	---	---	---	---	12,000	6,000	4,000	3,000	2,400	2,000
n	Xylenes	**1,900**	19,000	9,500	6,333	4,750	3,800	3,167	---	---	---	---	---	---
n	Naphthalene	**120**	1,200	600	400	300	240	200	---	---	---	---	---	---
n	C9-C10 Aromatics	**4,000**	40,000	20,000	13,333	10,000	8,000	6,667	---	---	---	---	---	---
n	C5-C8 Aliphatics	**2,000**	20,000	10,000	6,667	5,000	4,000	3,333	---	---	---	---	---	---
n	C9-C12 Aliphatics	**3,000**	30,000	15,000	10,000	7,500	6,000	5,000	---	---	---	---	---	---
	Lead Scavengers													
c	1,2-Dichloroethane (DCA)	**100**	---	---	---	---	---	---	1,000	500	333	250	200	167
c	1,2-Dibromoethane (EDB)	**7.3**	---	---	---	---	---	---	73	37	24	18.3	14.6	12.2
	For Diesel & Heavy Hydrocarbons measured using Montana Method for Extractable Petroleum Hydrocarbons (EPH)													
n	C9-C18 Aliphatics	**6,000**	60,000	30,000	20,000	15,000	12,000	10,000	---	---	---	---	---	---
n	C19-C36 Aliphatics	**1,600,000**	16,000,000	8,000,000	5,333,333	4,000,000	3,200,000	2,666,667	---	---	---	---	---	---
n	C11-C22 Aromatics	**33,000**	330,000	165,000	110,000	82,500	66,000	55,000	---	---	---	---	---	---
n	Acenaphthene	**10,000**	100,000	50,000	33,333	25,000	20,000	16,667	---	---	---	---	---	---
n	Anthracene	**50,000**	500,000	250,000	166,667	125,000	100,000	83,333	---	---	---	---	---	---
c	Benz(a)anthracene	**390**	---	---	---	---	---	---	3,900	1,950	1,300	975	780	650
n	Benzo(a)pyrene	**15**	150	75	50	38	30	25	---	---	---	---	---	---
c	Benzo(b)fluoranthene	**390**	---	---	---	---	---	---	3,900	1,950	1,300	975	780	650
c	Benzo(k)fluoranthene	**3,900**	---	---	---	---	---	---	39,000	19,500	13,000	9,750	7,800	6,500
c	Chrysene	**39,000**	---	---	---	---	---	---	390,000	195,000	130,000	97,500	78,000	65,000
c	Dibenzo(a,h)anthracene	**39**	---	---	---	---	---	---	390	195	130	98	78	65
n	Fluoranthene	**5,000**	50,000	25,000	16,667	12,500	10,000	8,333	---	---	---	---	---	---
n	Fluorene	**40**	400	200	133	100	80	67	---	---	---	---	---	---
c	Indeno(1,2,3-cd)pyrene	**390**	---	---	---	---	---	---	3,900	1,950	1,300	975	780	650
n	Naphthalene	**120**	1,200	600	400	300	240	200	---	---	---	---	---	---
n	Pyrene	**15,000**	150,000	75,000	50,000	37,500	30,000	25,000	---	---	---	---	---	---
c	1-Methylnaphthalene	**1,400**	---	---	---	---	---	---	14,000	7,000	4,667	3,500	2,800	2,333
n	2-Methylnaphthalene	**200**	2,000	1,000	667	500	400	333	---	---	---	---	---	---

*Refer to RBCA Guidance Appendix B for derivation of Risk-Based Screening Levels (RBSLs)

**Refer to RBCA Guidance Section 4.0 for details of Tier 2 Evaluation Process and calculation of Tier 2 RBSLs

mg/kg = milligrams per kilogram

bgs = below ground surface

APPENDIX A

Vadose Zone Modeling Technical Support Document

SOIL LEACHING TO GROUNDWATER MODELING

This appendix describes the methods the Montana Department of Environmental Quality (DEQ) used to develop Tier 1 soil leaching to groundwater risk-based screening levels (RBSLs). The soil leaching to groundwater RBSLs were calculated using two computer codes and the EPA soil-water partition equation for organic contaminants (*Soil Screening Guidance Technical Support Document*, EPA, 1996). The EPA partitioning equation was used to relate chemical of concern (COC) concentrations in soil moisture to the total concentration detected in a soil sample, assuming linear partitioning and equilibrium conditions. Dilution/Attenuation Factors (DAFs), representing the ratio of COC concentration in soil leachate at the source area to the COC concentration at the down gradient edge (DGE) were calculated using the VS2DT Solute Transport in Variably Saturated Porous Media code developed by the USGS. The DGE was established as a monitoring well constructed at the DGE of the contaminated source zone, with a well screen extending 1 meter into the water table. The Hydrologic Evaluation of Landfill Performance (HELP) code (U.S. Army Engineer Waterways Experiment Station) was used to generate a generic water budget, including estimates of water infiltration, runoff, evapotranspiration, and soil moisture percolation rates into the contaminated source area. The percolation rates generated by the HELP code were incorporated into the VS2DT modeling.

Physical processes simulated by the DEQ Tier 1 soil leaching to groundwater model include COC adsorption and desorption onto vadose zone soils and the aquifer matrix, advection and hydrodynamic dispersion of COCs in the vadose and saturated zones, and dilution due to mixing of soil leachate and groundwater. The model setup includes a finite contaminant source zone. Biological degradation of the COCs is not considered in the model.

Three scenarios were simulated. In the most conservative scenario, the contaminated source was assumed to be located 0.1 meter above the water table. In the second scenario, the distance between the source and the water table was 3.1 meters. The final scenario incorporated a 6.1-meter layer of unimpacted soil between the source and the water table. DEQ-7 human health standards were used as the groundwater target for individual COCs. Groundwater targets for petroleum fractions were developed based on the toxicity and aesthetics of surrogate chemicals representative of each fraction. In all cases, the soil RBSL represents a COC concentration that, based on the results of the modeling effort, would produce a maximum groundwater concentration equal to the groundwater target at the DGE.

Generic application of the RBSLs to petroleum release sites throughout Montana dictated the use of several conservative assumptions in the soil leaching to groundwater model. Conservative elements included the use of sandy soil as the default soil type, incorporation of an upper end estimate of the water percolation rate, and the assumption that no biodegradation of COCs in the vadose or saturated zones occurs. A description the VS2DT and HELP codes, model input parameters, and results of the modeling efforts are presented below.

Model Description: VS2DT

VS2DT simulates the movement of water in variably saturated porous media under isothermal and isohaline conditions. The governing equation describing the movement and occurrence of water combines the principle of conservation of mass with equations for fluid flux and storage. A thorough discussion of the derivation of VS2D, the USGS code prior to the addition of a solute transport module, is presented in *Documentation of Computer Program VS2D to Solve the Equations of Fluid Flow in Variably Saturated Porous Media*, USGS, 1987. The code uses finite differences to discretize spatial and temporal domains. Non-linear conductance and storage terms and unsaturated hydraulic conductivities are calculated using equations developed by Brooks and Corey, van Genuchten, or Haverkamp.

The code was modified in 1990 to simulate solute transport, using a governing equation accounting for advective transport, hydrodynamic dispersion, and solute sources and sinks. The hydrodynamic dispersion term includes mechanical dispersion and molecular diffusion in water. The code does not simulate volatilization or COC movement in soil vapor. A discussion regarding the addition of the solute transport module is presented in *Simulation of Solute Transport in Variably Saturated Porous Media with Supplemental Information on Modifications to the U.S. Geological Survey's Computer Program VS2D*, USGS, 1990.

Model Description: HELP

The HELP code was written to simulate water movement through landfills. The model accepts weather, soil, and design data and accounts for surface water and snow storage, snowmelt, runoff, infiltration, evapotranspiration, vegetative growth, soil moisture storage, and unsaturated vertical drainage. The HELP code uses many routines previously developed and used in other hydrologic models, including the WGEN synthetic weather generator (U.S. Department of Agriculture) and Soil Conservation Service (SCS) runoff curves. Snowmelt modeling is based on the National Weather Service River Forecast System Snow Accumulation and Ablation Model, and frozen soils are simulated using a subroutine from the Chemicals, Runoff, and Erosion from Agricultural Management System (CREAMS) code. Vertical drainage is simulated using Darcy's law using unsaturated hydraulic conductivity based on the Brooks and Corey relationship. Results are expressed as daily, monthly, and annual water budgets. Documentations of the HELP Model include the *HELP Model User's Guide for Version 3*, EPA, 1994 and the *HELP Model Engineering Documentation for Version 3*, EPA, 1994.

DEQ Soil Leaching Model Setup

The conceptual model for the soil leaching to groundwater pathway was developed as a two-dimensional cross-section consisting of a vadose zone of varying thickness overlying a water table aquifer two meters in thickness. Soil properties were homogeneous and isotropic throughout the model domain. The vertical profile consisted of 1.4 meters of unimpacted soil, overlying 1.5 meters of contaminated soils, overlying a 2-meter saturated zone located 0.1 meter, 3.1 meters, and 6.1 meters below the bottom of the contaminated soils.

The HELP modeling was performed to simulate water movement through the top 1.5-meter layer of soil and generate a soil moisture flux rate for the top boundary of the VS2DT model domain. The HELP code was selected based on its widespread use, flexibility, and thorough documentation. Necessary soil data included porosity, field capacity, wilting point, saturated hydraulic conductivity, initial moisture storage, and SCS runoff curve number. Design specifications included vegetative cover, soil layer thickness and areal dimensions, surface slope and slope length, and evaporative zone depth. Daily precipitation for six Montana cities (Billings, Great Falls, Havre, Helena, Kalispell, and Miles City) was simulated by the HELP code for a 30-year period based on statistical qualities of 5 years of daily field data recorded in these cities. In the same manner, 30 years of synthetic daily temperature and solar radiation data were generated by the code.

The top of the soil column was modeled as bare ground with a surface slope of 1 percent, with 95 percent of the surface area available for runoff. Default soil properties for a well-graded sand (soil texture #3) were used in the HELP model. This soil series was selected primarily due to its saturated hydraulic conductivity value, which was approximately one-half the value used in the VS2DT simulation. This reduction in conductivity was included to reflect a moderate degree of compaction expected in surface soils and/or the presence of a semi-permeable cover at many sites. HELP model results indicated that percolation through the bottom of the 1.5-meter layer ranged from 8.3 cm/yr. (Kalispell) to 3.8 cm/yr. (Helena).

VS2DT Boundary Conditions

The VS2DT model domain was 13 meters in the horizontal direction and 5, 8, and 11 meters in the vertical direction, depending on the depth to groundwater. The top horizontal boundary of the VS2DT model domain was set as a constant flux boundary, and a percolation rate of 2.5×10^{-4} meters per day, corresponding to the Kalispell percolation rate, was used. A water saturated zone was established using constant head boundaries extending 2 meters up from the bottom of the model domain, and were set with a total head difference of 0.06 meters from the left side to the right side of the model domain, resulting in a groundwater gradient of 0.005 m/m. The bottom of the model domain was set 2 meters below and parallel to the water table, and the bottom boundary of the domain and side boundaries of the vadose zone were set as no flow boundaries. The source zone dimensions were set to 9 meters wide (parallel to the groundwater flow direction) and 1.5 meters in thickness. The contaminated source was bordered by two meters of unimpacted soils on each side.

VS2DT Initial Conditions

The VS2DT code requires that initial values of total head, moisture content, or pressure heads be specified everywhere in the model domain. For each distance to groundwater scenario, a preliminary model run was performed to compute an equilibrium pressure head profile for all nodes in the domain based on the boundary conditions and soil textural parameters. The equilibrium pressure head matrices generated by the preliminary runs were subsequently used in the VS2DT simulations for each distance to groundwater scenario. Figure 1 presents the steady-state moisture content profile for the 0.1-meter (most conservative) distance to groundwater scenario.

Unfortunately, the VS2DT code will not accept total COC concentrations in soils as an initial condition. Instead, COC concentrations in soil moisture were set to a constant value (typically 10 g/m^3). An average soil moisture content was calculated for the source zone using the soil moisture profile generated by VS2DT. The total soil concentration in equilibrium with the target soil moisture concentration (back calculated for each COC using the groundwater target multiplied by the DAF) was estimated using the EPA soil-water partitioning equation.

VS2DT Finite Difference Parameters

Rapid changes in pressure heads and moisture content near the capillary fringe dictated relatively fine vertical discretization. Maximum grid spacing in the vertical direction was 0.1 meters in the vadose zone and 0.25 meters in the saturated zone. The minimum grid spacing was 0.01 meters in the vicinity of the water table. Maximum changes in grid spacing ranged from a factor of 1.5 to 2.0. Grid spacing in the horizontal direction was 0.5 meters and was reduced to 0.25 meters in the vicinity of the compliance monitoring well. Time discretization was set using a maximum time step of 1 day. At the beginning of the simulation, the time step was set to 0.01 day and was subsequently increased by a factor of 1.5 until the 1-day time step was achieved.

Closure criteria for total heads was set to $1.0\text{x}10^{-4}$ meters, and closure criteria for the solute transport equation was set to $1.0\text{x}10^{-5}$ g/m^3 (g/m^3 units convert to mg/L). The strongly implicit procedure (SIP) was used in calculating total head values, and central differencing in space and time was used for the solute transport equation. The arithmetic mean of adjacent cells was used to calculate intercell conductivities.

Physical and Chemical Parameters

Physical parameters for vadose and saturated zone soils, including hydraulic conductivity, specific storage, porosity, residual moisture content, and van Genuchten non-linear parameters were estimated using the *Subtitle D Landfill Application Manual for the Multimedia Exposure Assessment Model Final Report,* US EPA, 1995. The values selected for these parameters were consistent with a well-sorted sand. Chemical-specific parameters, including the molecular diffusion coefficient in water and the organic carbon-water partitioning coefficient were estimated using the EPA Soil Screening Guidance Technical Support Document. Organic carbon content of vadose and saturated zone soils was estimated as 0.006 g/g and 0.001 g/g, respectively. Longitudinal dispersivity for COCs in the vadose zone was estimated using the equation $D_l = 0.02 + 0.022*L$ where D_l is the longitudinal dispersivity, and L is the vertical distance between the center of the contaminated source area and the top of the water table. For the saturated zone dispersivities, the longitudinal dispersivity was estimated as one tenth the horizontal distance between the center of the contaminated source and the DGE monitoring well, and the transverse dispersivity (in the vertical direction) was estimated as one tenth of the value of the longitudinal dispersivity. For the vadose zone, the transverse dispersivity was set equal to the longitudinal dispersivity as the flow of soil moisture perpendicular to bedding planes is expected to result in greater transverse spreading of COCs compared to saturated zone flow parallel to bedding planes. Physical and chemical input parameters incorporated in the leaching to groundwater model are presented in Tables 1 and 2.

Down Gradient Edge

Conceptually, the DGE was set as a monitoring well constructed with a screened interval extending one meter from the top of the water table. As implemented in the VS2DT code, COC concentrations at five adjacent cell nodes in a vertical line, corresponding to the DGE location, were reported for each time step. The uppermost cell was located 10 centimeters below the top of the water table, under the DGE of the vadose zone source. The vertical dimensions of the cells were 0.1, 0.15, 0.25, and 0.25 meters, respectively. In order to generate an average DGE well concentration accounting for the differences in cell dimensions, the concentration in each cell was multiplied the cell vertical dimension, the values for all five cells were totaled, and divided by the total vertical length of the five cells (1 meter). This calculation was performed on the output from each time step, and the highest average of the five nodes was recorded.

RBSL Calculation

Back-calculation of RBSLs incorporated the COC-specific DAF generated by the VS2DT modeling and the EPA soil-water partitioning equation. Table 3 presents the EPA partitioning equation and the parameters required for the calculation of the Tier 1 soil targets. DAFs for the most conservative scenario, with the contaminated source located immediately above the water table (0.1-meter scenario), ranged from 20.4 (MTBE) to 12.6 (Acenaphthalene and Anthracene). The majority of the PAHs have very high soil-water partitioning coefficients and correspondingly high retardation factors, resulting in exceedingly long travel times between the source and the DGE well. As a result, the DAFs for some PAH COCs were estimated using for DAFs computed for Dibenzo(a, h)Anthracene (Table 3).

Mass Balance Results

Use of fine spatial and temporal discretization combined with the steady-state flow of soil moisture and groundwater incorporated in the simulations resulted in low water and COC mass balance errors. Percent mass balance for water was calculated as the ratio between the reported fluid volume balance and the total fluid flux. Similarly, the percent mass balance error for the COCs was the ratio between the reported solute mass balance and the initial starting mass. All simulations assumed linear COC partitioning between soil and water. The VS2DT code calculates an initial mass of COC sorbed to soil as the initial water concentration multiplied by the partitioning coefficient, soil bulk density, and dimensions of the source area.

Sensitivity Analysis Results

Analysis of sensitivity of model output to selected input parameters was performed for the VS2DT and HELP codes. Sensitivity of VS2DT was measured using the benzene/0.1-meter scenario. Sensitivity analysis model runs were performed using expected minimum and maximum values of selected input parameters. Parameter sensitivity was reported as the ratio of predicted DGE concentrations for the minimum and maximum case for each input parameter. Sensitivity results for VS2DT indicated that the benzene/0.1-meter distance to groundwater scenario was most sensitive to the saturated hydraulic conductivity, source width, groundwater gradient, and soil moisture percolation rate. With the exception of the source width, these parameters affect the water balance between percolating soil moisture and the underlying saturated zone. Increasing the saturated zone hydraulic conductivity from 1 meter per day to 15 meters per day resulted in a reduction in the maximum DGE concentration by a factor of 5.3. Sensitivity results for the HELP code indicated that simulation was most sensitive to the soil type, site location, and maximum depth of evapotranspiration.

APPENDIX B

Risk Based Screening Levels – Direct Contact

1.0 DIRECT CONTACT

Appendix B explains the methods Montana Department of Environmental Quality (DEQ) used to develop direct contact risk-based screening levels (RBSLs) for Tier 1 of the risk-based corrective action (RBCA) process. The appendix is made up of tables and spreadsheets used to develop the RBSLs. The following is a brief explanation of these tables and spreadsheets. Data sources are provided in the spreadsheets and a reference list is provided at the end of this appendix. DEQ chose conservative parameters to develop RBSLs applicable to a wide variety of petroleum release sites.

Risk assessment is an estimate of the likelihood of adverse effects that may result from exposure to certain health hazards, including pollutants in the environment. A risk is the chance that an adverse event will happen, multiplied by the degree or magnitude of an effect that might lead to impacts on human health. Risk assessment in humans can be based on if a chemical has carcinogenic or non-carcinogenic health risks. Potential human carcinogenic risk associated with chemical exposure is expressed in terms of an increased probability of developing cancer during a person's lifetime. For example, a 10^{-6} increased cancer risk over a lifetime means that there is one additional case of cancer during a lifetime in a population of a million people. Cancer risk or Target Risk (TR) is calculated for carcinogens with available cancer risk values (Cancer Slope Factors [SF], Inhalation Unit Risks [IUR]).

For non-carcinogens, the hazard quotient *(*HQ) is calculated to evaluate the potential for non-cancer health hazards to occur from exposure to a contaminant with available non-cancer health guidelines (Oral Reference Doses [RfDo], Inhalation Reference Concentrations [RfC]).

The Waste Management & Remediation Division calculated RBSLs representing both the carcinogenic risk and the non-carcinogenic hazards from exposure to each compound. The more conservative (most protective) concentration was chosen as the RBSL for each compound and is displayed on the tables within the RBCA guidance.

Table B1 provides a compilation of the chemical specific information used to calculate each RBSL, both carcinogenic and non-carcinogenic. Due to size, this table is available upon request.

DEQ chose toxicity values based upon the December 5, 2003, EPA OSWER Directive 9285.7-53, which provides a hierarchy of human health values recommended for risk assessments (EPA, 2003). DEQ's petroleum fraction screening procedure is based on the use of the Massachusetts method for volatile petroleum hydrocarbons and extractable petroleum hydrocarbons to help characterize risks posed by petroleum releases. Therefore, for the fraction toxicity data, RfDo, RfC and RAFw, DEQ used the Massachusetts toxicity values (MADEP, 2002), except for one fraction range, aliphatic C19-C36, for which PPRTV 2022 was used instead (please note the value for this fraction range did not change from 2009 with the 2022 PPRTV update).

For the C5-C8 aliphatics, MADEP 2003 used the previous IRIS RfC value for n-hexane (EPA, 1993) in its C5-C8 aliphatic calculation. The IRIS values for n-hexane has since been updated; therefore, the updated IRIS (EPA, 2005) RfC was used instead of the previous IRIS RfC.

Subchronic s-RfCs and subchronic s-RfDs were calculated where available or where they could be calculated using available toxicity studies.

The fraction subchronic toxicity values were calculated by removing the uncertainty factor of the subchronic toxicity studies to convert them to chronic RfDs and RfCs. Please note these may be more conservative subchronic toxicity numbers as some of the studies were more representative of semi-subchronic numbers (referred to as less-than lifetime studies, i.e., C9-C18 aliphatics).

C5-C8 aliphatics, C9-C12 and C9-C18 aliphatics (C9-C18 in MADEP, 2003), and C9-C10 and C11-C22 aromatics (C9-C32 in MADEP, 2003): removed the uncertainty factors of 10 for subchronic to chronic toxicity for reduced body weight, neurotoxicity and changes in serum chemistry and liver weight, and kidney effects, respectively .

C9-C12 and C9-C18 aliphatics (C9-C18 in MADEP, 2003) removed the uncertainty factor of 3 for subchronic to chronic neurotoxicity found in MADEP, 2003.

C9-C10 aromatics and C11-C22 aromatics (C9-C32 in MADEP, 2003) removed the uncertainty factor of 10 for subchronic to chronic.

The Volatilization Factors spreadsheet was used to calculate volatilization factors for the petroleum fractions using the method provided in the EPA RSL User's Guide (EPA, May 2023a). Volatile chemicals are defined as those chemicals having a Henry's Law constant greater than 10^{-5} (atm-m^3/mol) and a molecular weight less than 200 g/mole (EPA, 2023). DEQ used the EPA RSL Calculator (EPA, 2023) as the source of the volatilization factors for the target analytes, like benzene.

2.0 Direct Contact Exposure Assumptions

The following exposure assumptions were developed specific to sites located in Montana. These assumptions cannot be changed or altered in the Tier 1 evaluation. Site specific information may be substituted for several exposure assumptions. For DEQ to consider modifications to the default exposure assumptions, Owners/Operators or responsible parties and consultants would have to show the data behind the proposed exposure inputs and get the approval of the DEQ project team. Due to future use considerations, assumptions on worker exposures generally are not modified.

In 2005, DEQ conducted an analysis of Montana climate data from the Western Regional Climate Center going back to the late 1800s. DEQ determined that there was no location in Montana for which climate data were available that did not have a minimum of three months of an average snow depth of at least 2 inches or an average temperature at or below freezing or both. Therefore, DEQ determined that surface soil and dust exposure (ingestion, dermal, and inhalation) would only be likely to occur during the nine months of the year that did not meet those conditions and that Montana default exposure frequencies would be based upon this information.

For residential surface soil exposure, DEQ calculated that during 75% of the 365 days per year, the soil might be available for exposure. The rounded result was 270 days per year. This is the Montana default residential exposure frequency. The typical residential exposure scenarios include a two-week vacation and DEQ's assumption is that those vacation days would occur throughout the year and not all in any one season.

For commercial/industrial exposure, DEQ calculated that during 75% of the 250 working days per year, the soil might be available for exposure. (The 250 working days is based on 52 weeks of work, five days per week, and assumes a 10-day vacation.) This results in a Montana default commercial/industrial exposure frequency of 187 days per year.

For construction worker exposure, DEQ assumes that a building excavation might be open for exposure for as long as 4 months and that most land uses include some possibility of this type of construction. Therefore, the Montana default construction worker exposure frequency is 124 days per year. If the reasonably anticipated future use of a property (e.g., an active railroad grade) does not include building construction, an alternate utility worker exposure frequency may be appropriate.

Recreational and trespasser exposure frequencies should be site-specific based upon factors such as type of recreation anticipated, site features (e.g., playground equipment or potentially attractive features like ponds or sloughs) security measures in place, and proximity to residential or educational properties. Other exposure parameters (e.g., body weight, skin surface area) are set appropriately based upon the type of receptor and use.

3.0 Direct Contact Receptors – Carcinogenic and Non-carcinogenic Effects

Residential Receptor:
RBSLs for residential exposure to carcinogens are based on a target risk of $1X10^{-6}$, providing some assurance that overall site risks will not exceed $1X10^{-5}$, and are applied to the top 2 feet of soil at sites where the current and reasonably expected future usage is residential.

RBSLs for residential exposure to non-carcinogens are based on a target HQ of 0.1 which provides some assurance that the overall hazard index for a site will not exceed 1. These RBSLs are applied to the top two feet of soil at sites where the current and reasonably expected future usage is residential.

The Commercial Scenario
RBSLs for a commercial worker's exposure to carcinogens are based on a target risk of $1X10^{-6}$, providing some assurance that overall site risks will not exceed $1X10^{-5}$, and are applied to the top two feet of soil at sites where the current and reasonably expected future usage is commercial or industrial.

RBSLs for a commercial worker's exposure to non-carcinogens are based on a target HQ of 0.1 which provides some assurance that the overall hazard index for a site will not exceed 1. The RBSLs are applied to the top two feet of soil at sites where the current and reasonably expected future usage is commercial or industrial.

The Construction Worker
RBSLs for a construction worker's exposure to carcinogens are based on a target risk of $1X10^{-6}$, providing some assurance that overall site risks will not exceed $1X10^{-5}$ and are applied to soil from the ground surface to 10 feet of depth at all sites where there is a potential for residential redevelopment or landscaping, utility installation, pipe repair, or other future excavation.

RBSLs for a construction worker's exposure to non-carcinogens are based on a target HQ of 0.1 for each compound which provides some assurance that the overall hazard index for a site will not exceed 1. The RBSLs may be applied to the 0-10 ft. soil column at all sites where there is a potential for residential redevelopment or landscaping, utility installation, pipe repair, or other excavation in the future. This receptor is assumed an exposure duration of 1 year and is thus, subchronic. For this reason, the construction worker RBSLs were calculated using subchronic toxicity values. These values can be found in Table B1 (available upon request) along with references for each value.

4.0 Risk-Based Screening Level Equation Inputs

Table B1 provides the chemical specific input values and references for each compound included in the RBCA Guidance and is available upon request. All other variables are provided below for each receptor.

4.1 Residential Receptor

RBSLs for the residential receptor were calculated using EPA's RSL calculator (EPA, 2023). Montana-specific values are highlighted in orange and all other values are EPA default variables. The table below is compilation of all parameters used in both the carcinogenic and non-carcinogenic RBSL calculations from the EPA RSL calculator output.

Variable	State-Specific Value
A (PEF Dispersion Constant)	16.2302
A (VF Dispersion Constant)	11.911
A (VF Dispersion Constant - mass limit)	11.911
B (PEF Dispersion Constant)	18.7762
B (VF Dispersion Constant)	18.4385
B (VF Dispersion Constant - mass limit)	18.4385
C (PEF Dispersion Constant)	216.108
C (VF Dispersion Constant)	209.7845
C (VF Dispersion Constant - mass limit)	209.7845
foc (fraction organic carbon in soil) g/g	0.006
F(x) (function dependent on U_m/U_t) unitless	0.194
n (total soil porosity) L_{pore}/L_{soil}	0.43396
p_b (dry soil bulk density) g/cm^3	1.5
p_b (dry soil bulk density - mass limit) g/cm^3	1.5
PEF (particulate emission factor) m^3/kg	1359344438
p_s (soil particle density) g/cm^3	2.65
Q/C_{wind} (g/m^2-s per kg/m^3)	93.77
Q/C_{vol} (g/m^2-s per kg/m^3)	68.18
Q/C_{vol} (g/m^2-s per kg/m^3 - mass limit)	68.18
A_s (PEF acres)	0.5

A_s (VF acres)	0.5
A_s (VF mass-limit acres)	0.5
AF_{0-2} (mutagenic skin adherence factor) mg/cm^2	0.2
AF_{2-6} (mutagenic skin adherence factor) mg/cm^2	0.2
AF_{6-16} (mutagenic skin adherence factor) mg/cm^2	0.07
AF_{16-26} (mutagenic skin adherence factor) mg/cm^2	0.07
AF_{res-a} (skin adherence factor - adult) mg/cm^2	0.07
AF_{res-c} (skin adherence factor - child) mg/cm^2	0.2
AT_{res} (averaging time - resident carcinogenic)	365
BW_{0-2} (mutagenic body weight) kg	15
BW_{2-6} (mutagenic body weight) kg	15
BW_{6-16} (mutagenic body weight) kg	80
BW_{16-26} (mutagenic body weight) kg	80
BW_{res-a} (body weight - adult) kg	80
BW_{res-c} (body weight - child) kg	15
$DFS_{res-adj}$ (age-adjusted soil dermal factor) mg/kg	79758
$DFSM_{res-adj}$ (mutagenic age-adjusted soil dermal factor) mg/kg	330372
ED_{res} (exposure duration) years	26
ED_{0-2} (mutagenic exposure duration) years	2
ED_{2-6} (mutagenic exposure duration) years	4
ED_{6-16} (mutagenic exposure duration) years	10
ED_{16-26} (mutagenic exposure duration) years	10
ED_{res-a} (exposure duration - adult) years	20
ED_{res-c} (exposure duration - child) years	6
EF_{res} (exposure frequency) days/year	270
EF_{0-2} (mutagenic exposure frequency) days/year	270
EF_{2-6} (mutagenic exposure frequency) days/year	270
EF_{6-16} (mutagenic exposure frequency) days/year	270
EF_{16-26} (mutagenic exposure frequency) days/year	270
EF_{res-a} (exposure frequency - adult) days/year	270
EF_{res-c} (exposure frequency - child) days/year	270
ET_{res} (exposure time) hours/day	24
ET_{0-2} (mutagenic exposure time) hours/day	24
ET_{2-6} (mutagenic exposure time) hours/day	24
ET_{6-16} (mutagenic exposure time) hours/day	24
ET_{16-26} (mutagenic exposure time) hours/day	24
ET_{res-a} (adult exposure time) hours/day	24
ET_{res-c} (child exposure time) hours/day	24
THQ (target hazard quotient) unitless	0.1
$IFS_{res-adj}$ (age-adjusted soil ingestion factor) mg/kg	28350
$IFSM_{res-adj}$ (mutagenic age-adjusted soil ingestion factor) mg/kg	128700
IRS_{0-2} (mutagenic soil intake rate) mg/day	200
IRS_{2-6} (mutagenic soil intake rate) mg/day	200

IRS$_{6-16}$ (mutagenic soil intake rate) mg/day	100
IRS$_{16-26}$ (mutagenic soil intake rate) mg/day	100
IRS$_{res-a}$ (soil intake rate - adult) mg/day	100
IRS$_{res-c}$ (soil intake rate - child) mg/day	200
LT (lifetime) years	78
SA$_{0-2}$ (mutagenic skin surface area) cm^2/day	2373
SA$_{2-6}$ (mutagenic skin surface area) cm^2/day	2373
SA$_{6-16}$ (mutagenic skin surface area) cm^2/day	6032
SA$_{16-26}$ (mutagenic skin surface area) cm^2/day	6032
SA$_{res-a}$ (skin surface area - adult) cm^2/day	6032
SA$_{res-c}$ (skin surface area - child) cm^2/day	2373
TR (target risk) unitless	0.000001
T$_w$ (groundwater temperature) Celsius	25
Theta$_a$ (air-filled soil porosity) L$_{air}$/L$_{soil}$	0.28396
Theta$_w$ (water-filled soil porosity) L$_{water}$/L$_{soil}$	0.15
T (exposure interval) s	819936000
T (exposure interval) yr	26
U$_m$ (mean annual wind speed) m/s	4.69
U$_t$ (equivalent threshold value)	11.32
V (fraction of vegetative cover) unitless	0.5

4.2 Commercial Worker Receptor

RBSLs for the commercial worker receptor were calculated using EPA's RSL calculator (EPA, 2023) using EPA's "Composite Worker". Montana-specific values are highlighted in orange and all other values are EPA default variables. The table below is compilation of all parameters used in both the carcinogenic RBSL calculation or the non-carcinogenic RBSL calculation.

Variable	State-Specific Value
A (PEF Dispersion Constant)	16.2302
A (VF Dispersion Constant)	11.911
A (VF Dispersion Constant - mass limit)	11.911
B (PEF Dispersion Constant)	18.7762
B (VF Dispersion Constant)	18.4385
B (VF Dispersion Constant - mass limit)	18.4385
City (PEF Climate Zone) Selection	Default
City (VF Climate Zone) Selection	Default
C (PEF Dispersion Constant)	216.108
C (VF Dispersion Constant)	209.7845
C (VF Dispersion Constant - mass limit)	209.7845
foc (fraction organic carbon in soil) g/g	0.006
F(x) (function dependent on U$_m$/U$_t$) unitless	0.194
n (total soil porosity) L$_{pore}$/L$_{soil}$	0.43396

p_b (dry soil bulk density) g/cm^3	1.5
p_b (dry soil bulk density - mass limit) g/cm^3	1.5
PEF (particulate emission factor) m^3/kg	1359344438
p_s (soil particle density) g/cm^3	2.65
Q/C_{wind} (g/m^2-s per kg/m^3)	93.77
Q/C_{vol} (g/m^2-s per kg/m^3)	68.18
Q/C_{vol} (g/m^2-s per kg/m^3 - mass limit)	68.18
A_s (PEF acres)	0.5
A_s (VF acres)	0.5
A_s (VF mass-limit acres)	0.5
AF_{com} (skin adherence factor - composite worker) mg/cm^2	0.12
AT_{com} (averaging time - composite worker)	365
BW_{com} (body weight - composite worker)	80
ED_{com} (exposure duration - composite worker) yr	25
EF_{com} (exposure frequency - composite worker) day/yr	187
ET_{com} (exposure time - composite worker) hr	8
THQ (target hazard quotient) unitless	0.1
IRS_{com} (soil ingestion rate - composite worker) mg/day	100
LT (lifetime) yr	78
SA_{com} (surface area - composite worker) cm^2/day	3527
TR (target risk) unitless	0.000001
T_w (groundwater temperature) Celsius	25
$Theta_a$ (air-filled soil porosity) L_{air}/L_{soil}	0.28396
$Theta_w$ (water-filled soil porosity) L_{water}/L_{soil}	0.15
T (exposure interval) s	819936000
T (exposure interval) yr	26
U_m (mean annual wind speed) m/s	4.69
U_t (equivalent threshold value)	11.32
V (fraction of vegetative cover) unitless	0.5

4.3 Construction Worker

RBSLs for the construction worker receptor were calculated using EPA's RSL calculator (EPA, 2023) using EPA's "Composite Worker". Montana-specific values are highlighted in orange and all other values are EPA default variables. The table below is compilation of all parameters used in both the carcinogenic RBSL calculation or the non-carcinogenic RBSL calculation.

Variable	State-Specific Value
A (PEF Dispersion Constant)	16.2302
A (VF Dispersion Constant)	11.911
A (VF Dispersion Constant - mass limit)	11.911

B (PEF Dispersion Constant)	18.7762
B (VF Dispersion Constant)	18.4385
B (VF Dispersion Constant - mass limit)	18.4385
City (PEF Climate Zone) Selection	Default
City (VF Climate Zone) Selection	Default
C (PEF Dispersion Constant)	216.108
C (VF Dispersion Constant)	209.7845
C (VF Dispersion Constant - mass limit)	209.7845
foc (fraction organic carbon in soil) g/g	0.006
F(x) (function dependent on U_m/U_t) unitless	0.194
n (total soil porosity) L_{pore}/L_{soil}	0.43396
p_b (dry soil bulk density) g/cm^3	1.5
p_b (dry soil bulk density - mass limit) g/cm^3	1.5
PEF (particulate emission factor) m^3/kg	1359344438
p_s (soil particle density) g/cm^3	2.65
Q/C_{wind} (g/m^2-s per kg/m^3)	93.77
Q/C_{vol} (g/m^2-s per kg/m^3)	68.18
Q/C_{vol} (g/m^2-s per kg/m^3 - mass limit)	68.18
A_s (PEF acres)	0.5
A_s (VF acres)	0.5
A_s (VF mass-limit acres)	0.5
AF_{com} (skin adherence factor - composite worker) mg/cm^2	0.3
AT_{com} (averaging time - composite worker)	365
BW_{com} (body weight - composite worker)	80
ED_{com} (exposure duration - composite worker) yr	1
EF_{com} (exposure frequency - composite worker) day/yr	124
ET_{com} (exposure time - composite worker) hr	8
THQ (target hazard quotient) unitless	0.1
IRS_{com} (soil ingestion rate - composite worker) mg/day	330
LT (lifetime) yr	78
SA_{com} (surface area - composite worker) cm^2/day	3527
TR (target risk) unitless	0.000001
T_w (groundwater temperature) Celsius	25
$Theta_a$ (air-filled soil porosity) L_{air}/L_{soil}	0.28396
$Theta_w$ (water-filled soil porosity) L_{water}/L_{soil}	0.15
T (exposure interval) s	819936000
T (exposure interval) yr	26
U_m (mean annual wind speed) m/s	4.69
U_t (equivalent threshold value)	11.32
V (fraction of vegetative cover) unitless	0.5

4.3 Calculating Petroleum Fractions

Equation Parameters	**Values**
THQ (Target hazard quotient)	0.1

BWc (Child body weight - kg; EPA, November 2022)	15
AT (Averaging time - day; EPA, November 2022)	2190
ED (Exposure duration - yr; EPA, November 2022)	6
EF (Exposure frequency - day/yr; DEQ Generic Residential, DEQ 2023)	270
GIABS (Chemical specific oral relative absorption factor - unitless; MADEP, October 2003)	1
RfDo (Chemical specific oral reference dose - mg/kg-day; MADEP, November 2003	CS
IRSc (Child soil ingestion rate - mg soil/day; EPA, November 2022)	200
RfC (Chemical specific inhalation reference concentration - mg/m^3; PPRTV 2009)	CS
ETres (Residential exposure time - 24 hr/day*1 day/24 hr; EPA, November 2022)	1
VF (Chemical Specific, Volatilization factor - m^3/kg; EPA, November 2022)	CS
PEF (Particulate emission factor - m^3/kg; EPA, November 2022)	1.36E+09
ABSd (Chemical specific dermal relative absorption factor - unitless; EPA; November 2022)	CS
SAc (Child surface area - cm^2/day; EPA, November 2022)	2373
AFc (Child adherence factor - mg/cm^2; EPA, November 2022)	0.2
CS = Chemical Specific Parameter (See Table B1)	

- The Residential equation used for fraction calculation with values from Table B1 (available upon request) and DEQ-specific factors is below:

Cs = [(THQ*AT)/(ED*EF*(((1/RfDo*GIABS*CF*IRSc)/BWc)+(1/RfC*ETres*(1/PEF+1/VF))))]

- The Commercial Worker equation used for fraction calculation with values from Table B1 and DEQ-specific factors is below:

Cs = [(THQ*AT)/(ED*EF*(((1/RfDo*GIABS*CF*IRSa)/BWa)+(1/RfC*ETcom*(1/PEF+1/VF))))]

- The Construction Worker equation used for fraction calculation with values from Table B1 and DEQ-specific factors is below:

Cs = [(THQ*AT)/(ED*EF*(((1/RfDo*GIABS*CF*IRSa)/BWa)+(1/RfC*ETcom*(1/PEF+1/VF))))]

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APPENDIX C

Montana Method – Analytical Analyses

Montana Method for Volatile Petroleum Hydrocarbons (VPH) and Extractable Petroleum Hydrocarbons (EPH)

The Montana Method is based on the Massachusetts Department of Environmental Protection (MADEP) Method for the Determination of Volatile Petroleum Hydrocarbons (MADEP February 2018 Revision 2.1 (PID/FID); and the GS/MS option MADEP January 2017 Revision 0) and The Method for the Determination of Extractable Petroleum Hydrocarbons Extractable Petroleum Hydrocarbons (MADEP December 2019 Revision 2.1.

1.0 Montana Volatile Petroleum Hydrocarbons Method

The Montana Volatile Petroleum Hydrocarbons (VPH) Method adopts the Massachusetts VPH Method but with the following modifications and/or clarifications:

2.0 Sample Preservation and Holding Times

2.1 Soil/Sediment Samples

Soil/sediment samples may be collected in 4 oz. (120mL) wide mouth glass jars or 60 mL/40 mL VOA vials with Teflon-lined screw caps. Soil/sediment samples must be preserved in methanol as described in the Massachusetts VPH Method. Samples can be collected in the field with pre-preserved jars or sent to the laboratory to preserve within 48 hours of sample collection.

Pre-preserved collection method: The pre-preserved jars will be pre-weighed with the measured volume of methanol clearly marked. Most labs will provide a load sampling device with a handle portion and a syringe to collect the sample. Measurements will be clearly marked on the handle in grams. The desired ratio is 1g:1mL methanol or for 25 mL methanol add soil until the meniscus of the methanol is approximately at the 40 mL line; for 15 mL of methanol, add to approximately the 25 mL line. In all cases, the level of soil in the container may not rise above the level of methanol. If any methanol is lost during sampling from a spill, splash, etc. it must be discarded and redone.

Airtight field collection, methanol added in lab method: When collecting a sample without methanol, samplers/containers must allow for the collection and airtight storage of at least 5-25 grams of soil (airtight collection samplers that many labs will provide, or a 30 ml plastic syringe with the end sliced off is recommended). Documentation must be provided to ensure an airtight seal of the sampler/container (record sampling technique and containers used). All soil/sediment samples must be immediately cooled and maintained at a temperature of 4°C $^{+}$2°C. Samples must be extruded and immersed in methanol at the laboratory within 48 hours of sampling. Soil/sediment samples must be analyzed within 28 days of sample extraction.

Moisture Analysis: For both methods of soil sampling described above, a sample containing no methanol must also be submitted for determining moisture percentage. This sample does not need to be collected in a sealed sampler/container.

2.2 Aqueous Samples

Aqueous samples should be collected in 40-ml glass volatile organic analyte (VOC) vials with Teflon lined septa screw caps. Samples must have zero headspace remaining when filled and must be acidified to pH of 2.0 or less at the time of collection. The pH can be adjusted to the appropriate level by adding 3 or 4 (up to 10 drops HCl may be added) drops of 1:1 HCl to each 40-ml sample vial prior to collection. All aqueous samples must be immediately cooled and maintained at a temperature of 4°C ±2°C immediately after collection. Aqueous samples must be analyzed within 14 days of sample collection.

If the sample can be analyzed within 4 hours, HCl preservation is not necessary. If the sample effervesces, analysis of an un-preserved sample is recommended if the lab can accommodate the 4-hour timeframe.

Acid preservation is useful for the analysis of most VOCs and petroleum hydrocarbons, but significant losses can occur for ethers, such as MTBE. The combination of low pH and high temperatures dramatically increases the likelihood of hydrolysis. Therefore, with acid preservation, a heated purge method is not allowed for this method. If a heated purge is necessary to achieve proper analyte purge/partitioning, the sample could be preserved to a pH of greater than 11.0 using trisodium phosphate dodecahydrate and a heated purge. This is described in the method and is considered a significant modification of the method. A significant modification means there is no assured certainty of results obtained under these conditions.

3.0 Reporting

Moisture content of soil/sediment samples must be reported, and analytical results are to be reported on a dry-weight basis.

For comparison to Risk Based Screening Levels (RBSL), the concentrations of VPH fractions in soil/sediment and aqueous samples are adjusted to remove target compound concentrations that are specifically reported (e.g., benzene, toluene, etc.). VPH fractions include: C5-C8 aliphatics, C9-C12 aliphatics, and C9-C10 aromatics. C5-C8 aliphatics value is corrected for quantified analytes, such as MTBE, benzene and toluene, which have their own screening levels or standards. C9-C12 aliphatics value is corrected for target VPH analytes that are quantified and elute in this range, such as ethylbenzene, m, p, & o- xylenes and C9-C10 aromatics. No adjustments are made to the C9-C10 aromatics.

In addition to the target analytes and hydrocarbon fractions, laboratories must generate a Total Purgeable Hydrocarbons (TPH) result for soil/sediment and aqueous samples. The TPH value should include all Flame Ionization Detector (FID) hydrocarbon response, regardless of elution time. Quantify the response using the FID average response factor for all the VPH calibration mix constituents (do not include surrogates).

Analytical data packages should include a summary report that cross references the sample identification with the laboratory identification and identifies variations from standard operating procedures; laboratory analytical results; quality control data, which may include but is not limited to: surrogate recoveries, initial and continuing calibration blanks and spikes, method blanks, laboratory control blanks and spikes, and matrix spike and matrix spike duplicates; FID and photoionization (PID) chromatograms; chain of custody form(s); and a sample receipt checklist.

4.0 Montana Extractable Petroleum Hydrocarbons Method

The Montana EPH Method adopts the Massachusetts EPH Method with the following modifications and/or clarifications.

4.1 Sample Preservation and Holding Times

4.1.1 Soil/Sediment Samples

Soil/sediment samples are collected in 4 oz. (120 mL) wide-mouth amber glass jars with Teflon-lined screw caps. All soil/sediment samples must be immediately cooled and maintained at a temperature of 4°C ±2°C. Soil/sediment samples must be extracted by the laboratory within 14 days of sample collection and must be analyzed within 40 days of sample extraction.

4.1.2 Aqueous Samples

Aqueous samples should be collected in 1-liter amber glass bottles with Teflon lined screw caps. Samples must be preserved at the time of sampling by adding a suitable acid to reduce the pH to less than 2.0. The pH can be adjusted to the appropriate level by adding 5 ml of 1:1 HCl or other suitable acid to each bottle. All aqueous samples must be immediately cooled and maintained at a temperature of 4°C ±2°C immediately after collection. Aqueous samples must be extracted within 14 days of sample collection and analyzed within 40 days.

4.2 EPH Screen

The EPH method can be broken down into a two-step process. The first step, referred to as an EPH screen, is an extraction and analysis of hydrocarbons from the sample that generates a total extractable hydrocarbon (TEH) value. While the EPH screen provides little information on the chemical constituents, environmental fate of petroleum mixtures or toxicity it can be a cost-effective screening tool when relatively low concentrations of contamination are suspected. The laboratory determines the TEH number by determining the total area count for all peaks eluting in the C9-C36 aliphatic hydrocarbon range (this range includes the aromatic hydrocarbons as well). The lab will determine the peak area count for the surrogate compounds and subtract this area from the total area count. The TEH screen concentration is then quantified using the average response factor for all FID calibrated compounds (or MS). Further, fractionation and analysis is not required for samples that do not exceed the trigger value. The screening step may be omitted for samples that, based upon appearance and/or odor, or previous sample results, will exceed the trigger value.

To determine the fractions (C9-C18, C19-C36 aliphatics and C11-C22 aromatics), the sample is run through a silica gel column and analyzed as described in the method.
Some laboratories also report a post-silica gel TEH (or post-fractionated TEH). Running the sample that generates the TEH through a silica gel column (fractionation), results in the following two samples: aromatic and aliphatic hydrocarbons. The total area count for all peaks eluting in the C9-C36 aliphatic hydrocarbon range for the aliphatic fraction and the total area count for all peaks eluting in the C11 through C22 hydrocarbon range for the aromatic fraction (minus surrogate compounds) are added together to give the post-fractionated TEH. Though this number is not used for screening or regulatory purposes, it may be helpful to understand how much non-hydrocarbon mass has been removed. Non-hydrocarbon could include polar breakdown products of hydrocarbons, naturally occurring organic matter or other non-petroleum organics.

4.2.1 Soil/Sediment Samples

Soil/sediment sample with results that exceed trigger value of 200 mg/kg require the silica gel cleanup and EPH fractionation step to determine the aliphatic (C9-C18 aliphatics and C19-C36 aliphatics) and aromatic (C11-C22 aromatics) fractions.

4.2.2 Aqueous Samples

Groundwater samples reporting TEH concentrations at or above the trigger value of 1,000 µg/L require fractionation. If the sample is fractionated, labs are required to report the EPH screen concentration, the C9-C18 aliphatics, C19-C36 aliphatics, C11-C22 aromatic fraction concentrations, along with the post-fractionation TEH concentration.

4.2.3 Reporting

The C11-C22 aromatic fractions are adjusted for target compounds only when the combined target PAH concentration (total concentration of the 13 PAH target compounds) is three percent or greater of the C11-C22 aromatic concentration. The C11-C22 aromatic adjustment is accomplished by subtracting the combined target PAH concentrations from the C11-C22 aromatic fractions concentration.

Analytical data packages should include a summary report that cross references the sample identification with the laboratory identification and identifies variations from standard operating procedures; laboratory analytical results; quality control data, which may include but is not limited to: surrogate recoveries, initial and continuing calibration blanks and spikes, method blanks, laboratory control blanks and spikes, and matrix spike and matrix spike duplicates; FID chromatograms; chain of custody form(s); and a sample receipt checklist. [Note that other programs may have differing lists of what is required in an analytical data package, so check with the specific program regulating the release for more details.] Please see the Montana Quality Assurance Plan for Investigation of Underground Storage Tank Releases for more information on reporting requirements (DEQ, 2022; https://deq.mt.gov/files/Land/LUST/Documents/downloadables/QAPP-March2022_draft.pdf).

APPENDIX D

Risk Based Screening Levels and Standards

Groundwater and Surface Water Guidance

Screening Groundwater and Surface Water Data:

The Montana Risk-Based Corrective Action Guidance for Petroleum Releases Guidance uses several sources for comparing contaminate levels to either standards or screening levels, these are described in more detail below.

Contaminant concentrations in ground water are compared to Circular DEQ-7 Montana Numeric Water Quality Standards (DEQ-7 Standards) human health standards for groundwater, where available. For compounds that do not have a DEQ-7 Standard, a Risk-based screening level was calculated or an EPA-derived regional screening level for tap water was used (see Table 3).

Concentrations in surface water are compared to DEQ-7 surface water standards (depending on the water body classification, the more conservative of either the human health and aquatic life standards), where available, or other available screening levels (examples are Montana-derived Risk-Based Screening Levels, EPA derived Regional Screening Levels for tap water, and EPA "BTAG" freshwater screening levels for ecological receptors).

Groundwater Standards (DEQ-7):

Montana's water quality standards can be found in Montana Code Annotated (MCA) 75-5 part 3, Classification and Standards and in ARM, 17.30.620 through 17.30.670 (surface water), and ARM 17.30.1001 through 17.30.1045 (ground water) (2019 Circular DEQ-7, Montana Numeric Water Quality Standards).

As required by law, Montana's water quality standards must be met depending on the beneficial uses of the ground or surface water (ARM 17.30.1006 and ARM 17.30.6006-17.30.617 for GW and SW, respectively). ARM 17.30.1006 Classifications, Beneficial Uses, and Specific Standards for Groundwaters describes GW classifications and what uses need to be protected. Unless the natural specific conductance of the water is greater than 15,000 micro-Siemens/cm at 25°C (Class IV GW), all human health standards/risk-based screening levels must be met. Even if the natural specific conductance of the water is greater than 15,000 micro-Siemens/cm at 25°C (Class IV GW), the groundwater must meet DEQ-7 Standards for carcinogens (like benzene).

The DEQ-7 groundwater standards are based on EPA Drinking Water MCLs, Health Advisories, National Recommended Water Quality Criteria, or toxicology data from the integrated risk information system, several other toxicology sources are also used where information is not available from the above listed sources. DEQ-7 risk-based standards are developed with the assumption that an 80 kg person will consume 2.4 liters a day for 70 years. Note: DEQ-7 standards apply to groundwater based on the groundwater classification and are not tied to the use (or lack thereof) of groundwater as a drinking water source at a specific release or site.

DEQ-7, Narrative Standards, Risk-Based Screening Levels and EPA RSLs :

Montana's surface water and ground water rules contain narrative standards (ARM 17.30.620 through 17.30.670 and ARM 17.30.1001 through 17.30.1045). The narrative standards cover several parameters, such as alkalinity, chloride, hardness, sediment, sulfate, and total dissolved solids for which sufficient information does not yet exist to develop specific numeric standards. These narrative standards are directly translated to protect beneficial uses from adverse effects, supplementing the existing numeric standards (DEQ-7).

The petroleum fractions do not have DEQ-7 Standards. DEQ has calculated risk-based screening levels (RBSLs) for the petroleum fractions using toxicity values as outlined in Table B1 of Appendix B and Tables D1 and D2, below.

The EPA residential exposure scenarios were used for the averaging time (9490 days (365 days x 26 years); exposure duration (26 years based on the 2011 exposure factor's handbook); exposure frequency (350 days/year); water intake (IRw, 2.5 liters); volatilization factor (VF, 0.5); and residential exposure time (ETres of 1).

DEQ's petroleum fraction screening procedure is based on the use of the Massachusetts method for volatile petroleum hydrocarbons and extractable petroleum hydrocarbons to help characterize risks posed by petroleum releases. Therefore, for the fraction toxicity data, RfDo, RfC and RAFw, DEQ used the Massachusetts toxicity values (MADEP, 2002), with the exception of one fraction range, aliphatic C19-C36 for which PPRTV 2022 was used instead (please note the value for this fraction range did not change from 2009 with the 2022 PPRTV update). Because MADEP used the previous IRIS RfC value for n-hexane (EPA, 1993) in its C5-C8 aliphatic calculation and the IRIS values for n-hexane were updated, the updated IRIS (EPA, 2005) RfC was used instead of the previous IRIS RfC.

Regardless of if screening levels are exceeded or not, if there are visible signs of contamination (sheen/globules, etc., or odor or taste concerns), the site cannot be closed until these issues are resolved.

For the DEQ RBSL calculations, the EPA RSL equation for tap water screening levels was used as shown below:

RBSL (tap water µg/L) = (THQ*AT*CF*BW)/(ED*EF*((RAFw*IRw/RfDo) +(VF*ETres/RfC)))

Parameters	2023 updates
THQ (Target hazard quotient- unitless)	1
BWa (adult body weight - kg; EPA, May 2023)	80
AT (Averaging time - day; EPA, May 2023)	9490
CF (Conversion factor - µg/mg)	1000
ED (Exposure duration - yr; EPA, May 2023)	26
EF (Exposure frequency - day/yr; EPA, May 2023)	350
RAFw (Chemical specific water relative absorption factor – (MADEP, 2003)	
IRw (Ingestion rate - L/day; (EPA, May 2023)	2.5
RfDo (Chemical specific oral reference dose - mg/kg-day; MADEP, 2003 PPRTV, 2022))	
VF (Volatilization factor - L/m^3) (EPA, May 2023)	0.5
ETres (Residential exposure time - 24 hr./day*1 day/24 hr; EPA, May 2023)	1
RfC (Chemical specific inhalation reference concentration - mg/m^3 (MADEP, 2003 and PPRTV, 2022)	

Table D1 parameters and references for RBSL calculations. The green rows are chemical specific and can be found in Table D2.

Chemical	RFDo	RfC	RAFw

C5-C8 Aliphatics	0.04	0.7 (IRIS, 2005)	1
C9-C12 Aliphatics	0.1	0.2	1
C9-C10 Aromatics	0.03	0.05	0.91
C9-C18 Aliphatics	0.1	0.2	1
C19-C36 Aliphatics	3 (PPRTV, 2022)	X	1
C11-C22 Aromatics	0.03	.05	0.91

Table D2. Chemical specific values for fractions
X= value not included in the calculation

For Contaminants not included in Table 3:
There may be times when contaminants detected in water samples are not listed in Table 3. These contaminants may include metals, chlorinated compounds, pesticides, nitrate, and salts. If there are contaminants in the groundwater or surface water that are not listed in Table 3, these should be screened first using DEQ-7 Standards; and if there is no DEQ-7 Standard for a chemical, then it should be screened using the EPA RSLs for tap water. If you have questions, be sure to consult with your DEQ contact.

Surface Water:
Circular DEQ-7 contains surface water standards (based on protection of both human health and aquatic life) that are to be used when evaluating petroleum concentrations in surface water. DEQ-7 groundwater standards should not be compared to surface water results. DEQ-7 surface water standards can be found in the Montana Department of Environmental Quality's DEQ-7 Circular. Where DEQ-7 standards are not available, RBSLs or RSLs may be used for screening, with DEQ approval. For example, the ground water petroleum fraction RBSLs and tap water EPA RSLs may be used as screening levels in surface water for the protection of human health.

Sample methodology:
It is the responsibility of the owner/operator to ensure the appropriate methods and reporting limits are requested from the laboratory to meet analytical and reporting limit needs. If the data is not of sufficient quality, DEQ may reject the results and request the samples to be resubmitted.

References

Massachusetts Department of Environmental Protection (MADEP). 2002. Characterizing Risks Posed by Petroleum Contaminated Sites: Implementation of MADEP VPH/EPH Approach, Final Policy, October 2002. Bureau of Waste Site Cleanup, Boston, MA.

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United States Environmental Protection Agency. EPA. 2022. Provisional Peer-Reviewed Toxicity Values for Complex Mixtures of Aliphatic and Aromatic Hydrocarbons, September 2009. Superfund Health Risk Technical Support Center, National Center for Environmental Assessment. Office of Research and Development, U.S. Environmental Protection Agency.

EPA (United Stated Environmental Protection Agency), 1993. Integrated Risk Information System (IRIS) Chemical Assessment Summary for n-Hexane.

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