Paula Wilson

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Sent: Wednesday, August 31, 2011 12:59 PM
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Cc: Hugh O'Riordan; Michael Brush
Subject: REM Guidance
Attachments: Petroleum REM body_public comment draft 8-31-11 ots.pdf

Paula,

Attached is our review/comments for the Idaho Risk Evaluation Manual for Petroleum Releases Draft. Document format is Adobe Acrobat X (Portable Document Format – unsecured). We can discuss the changes, as appropriate, at our Tuesday-scheduled meeting.

We are still reviewing the appendices and the software. We will forward the reviewed appendices in a separate submittal. Since we just received the software yesterday, we will need more time to review past today's requested comment date.

The end is near.

Thanks again,

Mike Backe

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Idaho
Risk Evaluation Manual for Petroleum Releases

Draft

Idaho Department of Environmental Quality
1410 North Hilton
Boise, Idaho 83706

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Acronyms and Abbreviations

µg	Microgram
AST	Above ~~ground~~ Ground Storage Tank
ASTM	American Society for Testing and Materials
AUL	Activity and Use Limitation
BTEX	Benzene, Toluene, Ethyl Benzene, and Xylenes
CAL-EPA	California Environmental Protection Agency
CAP	Corrective Action Plan
CAS	Chemical Abstract Service
~~Cc~~cm^3	Cubic Centimeter
CLP	Contract Laboratory Program
COI	Chemical(s) of Interest
C_{cw}	Concentration in Groundwater (Between Source and Surface Water) at Alternate Point of Compliance
cm^2	Square Centimeter
CSF	Cancer Slope Factor
C_{soil}	Source Area Concentration in Soil
C_{swpoe}	Point of Exposure Concentration in Surface Water
DAF	Dilution Attenuation Factor
DEQ	State of Idaho, Department of Environmental Quality
DOE	U.S. Department of Energy
DQO	Data Quality Objective
Eh	Redox Potential
EPA	U.S. Environmental Protection Agency
EU	Exposure Unit
ft	Foot
gm	Gram
GW	Groundwater
GWP	Groundwater Protection
HI	Hazard Index
HQ	Hazard Quotient
IDAPA	Idaho Administrative Procedures Act
IDWR	Idaho Department of Water Resources
IELCR	Individual Excess Lifetime Cancer Risk
IRIS	Integrated Risk Information System
ISCE	Initial Site Characterization and Evaluation
IUPAC	International Union of Pure and Applied Chemists
IUR	Inhalation Unit Risk
kg	Kilogram

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L	Liter
LNAPL	Light Non-Aqueous Phase Liquid
m	Meter
MCL	Maximum Contaminant Level
mg	Milligram
MTBE	Methyl Tertiary Butyl Ether
NA	Natural Attenuation
NAPL	Non-Aqueous Phase Liquid
NCEA	National Center for Environmental Assessment
NFA	No Further Action
NPDES	National Pollutant Discharge Elimination System
PAH	Polycyclic Aromatic Hydrocarbons
POC	Point of Compliance
POE	Point of Exposure
PSC	Petition for Site Closure
PST	Petroleum Storage Tank
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RA	Relative Absorption
RATL	Remedial Action Target Level
RBCA	Risk-Based Corrective Action
RCRA	Resource Conservation and Recovery Act
REDOX	Reduction-~~o~~Oxidization
REM	Risk Evaluation Manual
RE	Risk Evaluation
RF	Reduction Factor
RfD	Reference Dose
RfC	Reference Concentration
RMP	Risk Management Plan
RNA	Remediation by Natural Attenuation
ROE	Route(s) of Exposure
RSL	EPA Regional Screening Level
RUSL	Residential Use Screening Level
SAB	EPA's Science Advisory Board
SCM	Site Conceptual Model
SF	Slope Factor
SVOC	Semi-Volatile Organic Chemical
STATECOMM	State Communications Center
SW	Surface Water
TEQ	Total Toxic Equivalency

TEF	Toxic Equivalency Factors
UCL	Upper Confidence Limit
UECA	Uniform Environmental Covenants Act
USACE	United States Army Corps of Engineers
VOC	Volatile Organic Compound

Introduction

In April 2009, the Idaho Legislature approved the Department of Environmental Quality (DEQ) Rules IDAPA 58.01.24, Standards and Procedures for Application of Risk Based Corrective Action at Petroleum Release Sites (the Rule). This rule required that DEQ prepare a risk evaluation manual for petroleum releases which would be used as guidance for implementation of the Rule. This document represents that implementation guidance. The Rule may be obtained at: *http://adm.idaho.gov/adminrules/rules/idapa58/0124.pdf*.

Organization of This Document

The document begins with a general description of the steps in the risk evaluation (RE) process, which is then followed by detailed implementation information for each step. DEQ has developed software that complements the process described and is provided at no charge. Contact DEQ regarding its availability.

Information in the body of this manual is supported by 12 appendices. Appendices A–D address default exposure factors, fate and transport parameter values, physical and chemical properties, and toxicity values. Appendix E presents models and equations. Appendix F provides the methodology and calculations for remedial action target levels (RATLs). Appendix G discusses the vapor intrusion pathway, and Appendix H addresses the application of natural attenuation. Appendix I includes an estimation of exposure point concentrations. A sample table of contents from a risk evaluation report is provided in Appendix J. Appendix K addresses practical quantitation limits, and Appendix L contains a quality assurance project plan (QAPP) template.

Section 1. Overview of the Risk Evaluation Process

1.1 Steps in the Risk Evaluation Process

The overall evaluation process for a site where a petroleum release is discovered and reported to DEQ is illustrated in Figure 1. The process consists of multiple steps, each of which is briefly described in the pages following Figure 1. In some cases, when adequate data are available concerning a release, the owner or operator (as defined IDAPA 58.01.24.010) of the release site may skip the screening level evaluation and proceed directly to the site-specific RE, a more detailed level of evaluation, without formally completing the intermediate steps. DEQ should be notified in these instances. A comparison of the two RE options, with the types of values, models, and other factors used in each option, is presented in Table 1.

1.1.1 Site Discovery

The risk-based site management process begins with the discovery of a petroleum release site. A petroleum release site may be discovered and reported to DEQ under a variety of circumstances. These include, but are not limited to, citizen complaints, investigations conducted as a part of real estate transactions, environmental impacts observed in surface water bodies, and notification of accidents and spills. It is the owner/operator's responsibility to ensure that DEQ is notified.

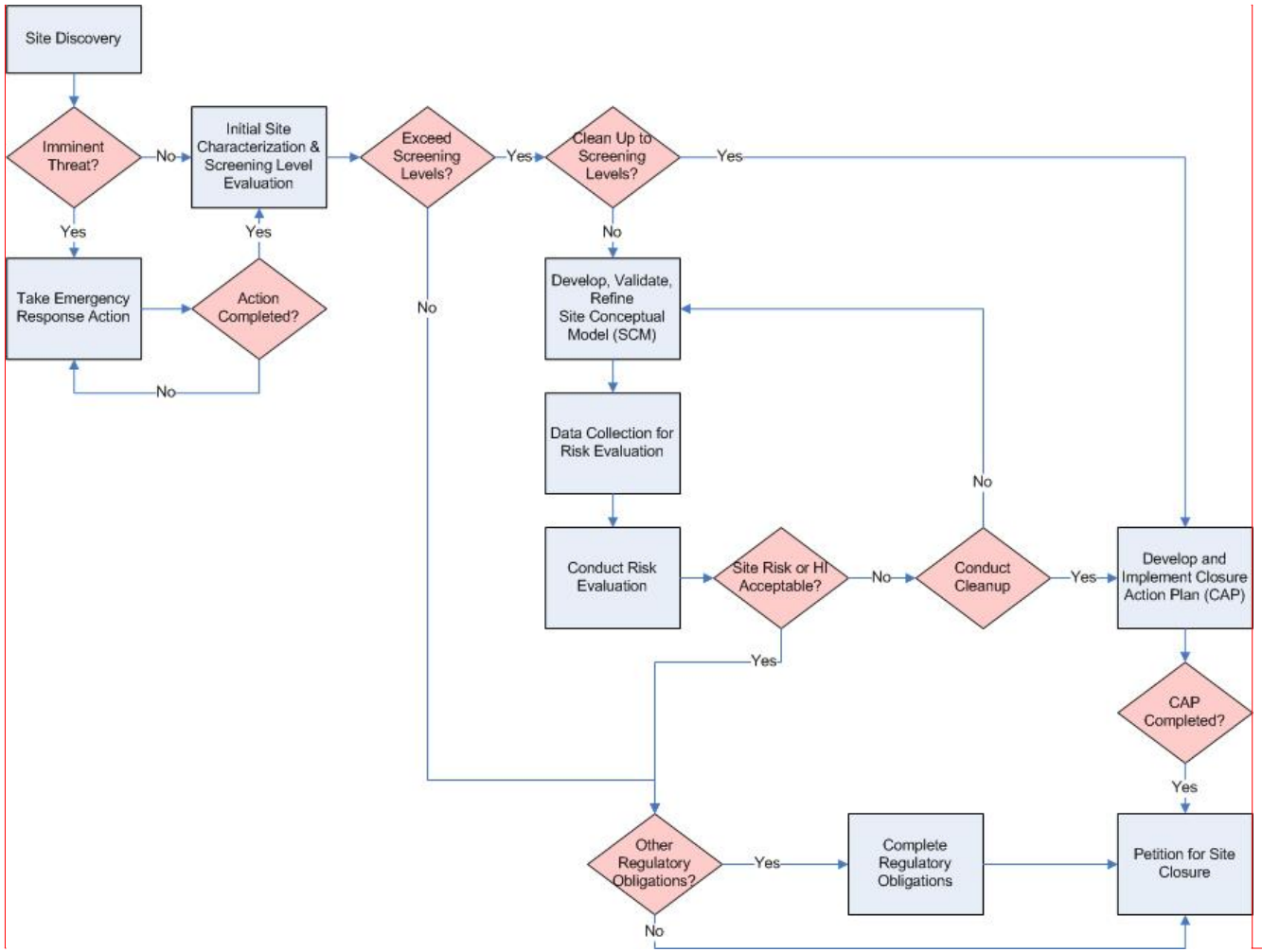

Figure 1. Idaho Petroleum Release Risk Evaluation Process Flowchart. This process allows for moving directly to a detailed risk evaluation without first completing a general screening level evaluation.

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Table 1. Comparison of Risk Evaluation Options

Factors	Screening Level Evaluation	Site-Specific Risk Evaluation
Exposure Factors	Default	Site-specific/default
Toxicity Factors	Rule-specified values	Rule-specified values
Physical and Chemical Properties	Default	Default or DEQ accepted values
Fate and Transport Parameters	Default	Default/Site-specific
Unsaturated Zone Attenuation	None	None/Site-specific
Fate and Transport Models	Default	Default or other models acceptable to DEQ
Exposure Point Concentrations	Maximum	Statistical evaluation: Conservative Estimate of Mean:
Acceptable Target Risk	1×10^{-6}	Cumulative effects considered; target of 1×10^{-5}
Acceptable Target Hazard Quotient/Hazard Index	Hazard Quotient = 1	Cumulative effects considered; Hazard Index Target of 1
Groundwater Protection	Maximum contaminant level or risk based target levels	Maximum contaminant level or risk based target levels
Outcome of Evaluation	Either: • Petition for Site Closure, or • Risk Evaluation, or • Corrective Action Plan	• Petition for Site Closure, or • Refine RE, or • Corrective Action Plan
Soil Concentration Protective of Groundwater	Default model with point of exposure at source	Default model with point of exposure determined as per Section 4. Flexibility in model may be used subject to DEQ approval
Surface Water Classification	See Section 4	See Section 4
Point of Exposure	Source	See Section 4
Activity and Use Limitations	None	See Section 6

1.1.2 Determination of Imminent Threat

Upon site discovery, the owner/operator should carefully evaluate the available information to determine whether the site poses any imminent threat to human health or safety, or to the environment. Threats include, but are not limited to, impacts to water wells; vapors or odors in residential and commercial structures; concentrations approaching explosive levels; impacts to a surface waterbody; and impacts to human health and the environment. If any imminent threats are identified, the owner/operator should notify DEQ or State Communications Center (STATECOMM) immediately (see Section 2) and take immediate steps to abate the threat. Documentation of abatement activities and confirmation that imminent threats have been removed should be provided to DEQ. Further details of this step are provided in Section 2.

1.1.3 Initial Site Characterization and Evaluation

Upon completion of the emergency response action, if any, it is necessary to perform an initial site characterization and evaluation (ISCE). As a part of the ISCE, media-specific data (for soil, soil vapor, and groundwater media) should be collected to characterize the source. This step is intended to identify the maximum contaminant concentrations for the identified petroleum products in soil and groundwater. Since a site may be a candidate for closure after the completion of the screening level evaluation (see Section 1), it is very important that the data collected at this time identify the maximum media-specific concentrations. Further details of this step are provided in Section 2.

1.1.4 Comparison with Screening Levels

This step involves the comparison of the maximum media-specific concentration of each contaminant, identified in the ISCE, with the screening levels developed by DEQ and presented in Table 2. There is a screening level for each contaminant in each media. The screening level is the lowest of the media-specific (soil, soil vapor, and groundwater) risk-based concentrations for the applicable exposure pathways. Screening levels are considered criteria that, if met (that is, maximum contaminant concentrations are below the screening levels), will allow unrestricted (residential) use of the property. Since exposure to these low concentrations (below the screening levels) of contaminants does not pose a threat to human health, if the owner/operator chooses to meet these criteria, they will not be required to evaluate site-specific exposure pathways and develop a site conceptual model (SCM), and no land use restrictions will be needed on the property.

When DEQ and the owner/operator agree that a petroleum release has been adequately characterized, DEQ will not require any further action of the owner/operator related to the release if the maximum contaminant concentrations in soil, surface water, and groundwater do not exceed the screening levels, ~~subject to applicable requirements as referenced in IDAPA 58.01.24.001.02~~. If any of the maximum soil, groundwater, or soil vapor concentrations exceed the screening levels, the owner/operator may either:

- adopt the screening levels as cleanup criteria and develop a corrective action plan (CAP) to achieve these levels, or
- perform a site-specific RE. Further details of this step are provided in Sections 3 and 4.

1.1.5 Development and Validation of a Site Conceptual Model

If the screening levels are exceeded, and the owner/operator chooses to conduct a more detailed (site-specific) RE, it is first necessary to develop and validate an SCM. An SCM provides the framework for the overall management of the site and should help guide data collection and risk management activities while the RE is being performed. The key elements of the SCM are:

- release scenario(s),
- source description,
- petroleum chemicals of interest (COI),
- an exposure model that incorporates the appropriate receptors,
- exposure pathways and routes of exposure (ROE),
- the site stratigraphy and hydrogeology, and

- the spatial and temporal distribution of the petroleum COI.

An important part of this step is to validate the SCM based on site-specific data. Further details of this step are provided in section 4.1.

1.1.6 Identify and Collect Data for Risk Evaluation

Depending on the site-specific conditions, the RE may require the collection of additional site-specific data. To prepare for conducting an RE, the owner/operator should review the SCM, identify requirements for filling data gaps, and collect additional data if necessary. This data will be used to calculate estimates of site-specific exposure point concentrations (see section 4.3.4 and Appendix I) and an estimate of the site-specific cumulative risk (see section 4.5) and, potentially, to develop RATL concentrations using the guidance provided in this document. Further details of this step are provided in section 4.2.

1.1.7 Site Specific Risk Evaluation

Conducting the RE requires developing site-specific estimates of exposure point concentrations for soil and groundwater, estimating site-specific cumulative risk, comparing these with acceptable target risk levels and, if necessary, developing media-specific RATL concentrations. RATLs are target concentrations developed by the owner/operator using a combination of conservative default and site-specific parameters. These concentrations depend on the receptor, media, pathway, and ROE and are developed for each petroleum COI and each media identified in the SCM. Using RATL concentrations instead of the defaults (the screening level criteria) may require that limitations be placed on activities and land uses that are allowed on the property. This step is discussed in section 4.6 and Appendix F.

1.1.8 Comparison with Acceptable Target Risk Levels and Decision Making

Once the site-specific cumulative risk has been estimated, it is compared to acceptable target risk levels, as specified in the Rule. If acceptable target risk levels are not exceeded, the site is eligible for closure~~, subject to applicable requirements within the Water Quality Standards, IDAPA 58.01.02.851 and 852~~. If the site-specific cumulative risk exceeds the acceptable target risk levels, two options are available:

- Calculate and adopt media-specific RATL concentrations for each petroleum COI and develop and implement a CAP to achieve these concentrations.
- Refine the SCM and RE. It is possible that the site-specific cumulative risk is lower than initially estimated and may not pose an unacceptable risk, but this can only be determined with a more refined SCM and RE. This may involve the collection of additional data or the use of other models. Before collecting these additional data, it is optional to develop a work plan that outlines additional data needs and the overall approach for the refined evaluation. The plan may be submitted to DEQ for review and approval before proceeding with data collection and the evaluation. Although optional, the work plan and suggestions from DEQ may help with completing the required work more efficiently than might be the case without a DEQ-reviewed work plan. Details of this step, including the basic contents of a work plan, are included in section 4.7.

Upon completion of the RE, the owner/operator should provide recommendations to DEQ. In most cases, it is anticipated that DEQ and the owner/operator will work together to identify the best alternative. Note that it is not necessary to complete a screening level evaluation before conducting an RE, however, it is recommended that the owner/operator inform DEQ whether they will do a screening level evaluation or not. Often, DEQ can make suggestions to improve efficiency in the overall process.

1.1.9 Development and Implementation of a Corrective Action Plan

Based on the results of the RE process, the owner/operator proposes a set of remediation standards and prepares a CAP describing the measures that will be used to achieve the standards. The CAP is submitted to DEQ for approval. The CAP may include a combination of options for active remediation and passive remediation along with limitations on activities and land uses that were assumed in the RE step. Details of this step are included in Section 5.

1.1.10 Evaluation of Progress Toward Remedial Goals and Modification of the Corrective Action Plan if Necessary

The data collected during implementation of the CAP must be evaluated by the owner/operator and submitted to DEQ so that DEQ can determine whether the CAP is progressing as anticipated. Modifications to the CAP may be necessary in some circumstances. Circumstances that might require modifying the CAP include identification of significant deviations from the remedial strategy or unacceptable risk levels to receptors, by either DEQ or the owner/operator. Modification of the CAP also might be required if the data indicate that site cleanup is not progressing at the rate anticipated. In these cases, appropriate modifications to the CAP should be considered and an amended CAP should be submitted to DEQ for approval. The specific modifications to the CAP that are needed will vary from site to site.

1.1.11 Site Closure with a Corrective Action Plan

The primary objective of the CAP at any site is to ensure the long-term protection of human health and the environment, taking into consideration the current conditions at the site and conditions that are reasonable to expect in the future. When the regulatory obligations specified in the DEQ-approved CAP have been achieved, the site is eligible for closure. Closure typically involves the owner/operator submitting documentation that all the work specified in the CAP has been completed and all remedial action goals have been achieved accompanied with a request for site closure.

1.1.12 Certification by a Registered Professional

If work is performed that the State of Idaho requires a professional geologist or professional engineer (Title 54 Chapters 12 and 28) to perform, the owner/operator shall employ the use of, and obtain certification from, a professional geologist or professional engineer registered in Idaho for that work.

Section 2. Site Discovery and Initial Steps

2.1 Determining Imminent Threats

The first step, once an impacted site has been identified or a release is known to have happened, is to determine whether contamination poses any imminent threat to human health or the environment. If so, abatement measures must be completed before any other activities. Examples of abatement measures include taking action to prevent further release into the environment, providing an alternate water supply if drinking water supplies are impacted, evacuating residents/commercial workers if they are or could be exposed to vapors at high concentrations, installing booms on surface waterbodies that have a sheen, or ventilating utility facilities where vapors are present. If there is an imminent threat, or uncertainty regarding potential threats, associated with a release, call DEQ or STATECOMM at 1-800-632-8000 or (208) 846-7610. Releases that do not pose an imminent threat do not have to be reported to STATECOMM, but do have to be reported to DEQ. Owner/operators shall follow the Petroleum Release Reporting, Release Response and Initial Abatement Measures as provided in IDAPA 58.01.02.851 and 852.

2.2 Initial Site Characterization

2.2.1 Site Characterization Introduction

Within the RE process, initial site characterization is performed after any necessary emergency response actions are completed. The overall objective of the initial site characterization is, at a minimum, to identify the maximum chemical concentrations on the site in each of the affected media. These maximum concentrations are then compared with screening level criteria to determine the need for any further action.

A brief description of the initial site characterization process is presented below.

2.2.2 Site Description and Adjacent Land Use

The owner/operator should conduct a thorough site reconnaissance and a historical review of site operations to identify source(s) of contamination on site. Sources may be identified based on knowledge of a known or documented release; location of certain structures that typically represent a contamination source such as underground storage tanks (USTs), pipes, pumps, etc.; interviews with current and former site employees who may have knowledge of source areas.

In addition to identifying sources, the owner/operator should collect data related to historic, current, and future land use on and adjacent to the site. A chronology of relevant site activities is often useful in understanding the site.

Based on this information, the owner/operator should identify the type of petroleum that may have been released at the site. Data collected during initial site characterization should, at a minimum, satisfy the following requirements:

- Quality Assurance/Quality Control (QA/QC) measures recommended by the United States Environmental Protection Agency (EPA) have been met,
- Analyte quantitation limits (the minimum amount that can be detected by the laboratory), where feasible, do not exceed screening levels,

- Appropriate petroleum COI have been identified and included for analysis,
- Source areas have been adequately characterized to identify the maximum concentration, and
- Analytical methods used are appropriate for petroleum COI at the site.

2.2.3 Soil Source Characterization

The owner/operator should collect soil data representative of the release's maximum concentration of petroleum COI. The exact number of samples, the analytical methods used, and the specific technology used to collect data will vary among sites. It is recommended, but not required, that the owner/operator develop a work plan and have it reviewed and approved by DEQ before beginning the work. At a minimum, the owner/operator should verbally confer with DEQ before collecting any data.

The overall intent of initial site characterization is to identify maximum concentrations of petroleum COI. However, for sites that will likely require further characterization, it may be efficient and cost-effective to collect additional data at this stage of the evaluation. Additional data may be used to identify the nature and extent of contamination and potential for exposure. For example, if contamination is suspected to exist in both surficial and subsurface soil zones, samples representing maximum concentrations in both zones should be collected.

2.2.4 Groundwater Source Characterization

In the initial site characterization, if there is evidence of possible groundwater impact from the site release, the owner/operator should collect groundwater samples below or immediately adjacent to the source. For sites with a very localized source, it may be sufficient to collect only one groundwater sample using a temporary well. Sites with multiple sources may require multiple wells and samples. For sites that will require further characterization, it may be more efficient and cost-effective to install at least three monitoring wells so the magnitude and the direction of groundwater flow can also be established.

2.2.5 Documentation of Initial Site Characterization

The owner/operator should document the initial site characterization results in a brief report that is submitted to DEQ. The chemical data collected should initially be evaluated using the screening levels as discussed in Section 3, all of which should be described in this report. The report should discuss:

- Site history,
- Site description,
- Current site use,
- Sources and petroleum COI identified at the site,
- Methods used to collect and analyze soil samples,
- Locations of all samples (identified on a site map), including sample depths,
- Results from soil chemical data analyses,
- Methods used to collect and analyze groundwater samples,
- Location, construction, and lithology of all wells,
- Results of groundwater chemical data analyses,
- Other site hydrogeological test data results, and
- QA/QC information.

Section 3. Screening Level Evaluation

Data collected during the initial site characterization is typically initially evaluated using screening levels. This evaluation is intended to achieve the following objectives of the screening level evaluation:

- Demonstrate that the site or portions of the site do not pose a threat to human health and hence does not require any further evaluation, and
- Identify areas of the site that need further evaluation.

These objectives are achieved by comparing the maximum site concentrations with the screening level values.

3.1 Screening Levels

The screening levels for the petroleum COI in the Rule have been developed by DEQ and are included in Table 2. The screening levels are risk-based target concentrations developed with the following:

- the assumption that receptors will be residential,
- conservative input parameter values,
- an acceptable target risk of 10^{-6}, and
- a hazard quotient (HQ) of 1.

Specific exposure factors and models used to develop screening levels are presented in Appendices A and E. Screening levels are the lowest target concentrations for the following exposure pathways and ROE for soil, soil vapor, and groundwater.

Specifically, screening levels for soil are the lowest of the following concentrations:

- Surficial and subsurface soil concentrations protective of exposure via groundwater ingestion at maximum contaminant levels (MCLs) or risk-based concentrations at the downgradient edge of the source or
- Subsurface soil concentrations protective of exposure via indoor inhalation of vapors emanating from soil for a residential scenario, or
- Surficial soil concentrations protective of combined ingestion, dermal contact, and outdoor inhalation exposures for a residential scenario.

Screening levels for groundwater are the lowest of the following concentrations:

- MCLs for chemicals that have them or calculated values for ingestion of water in a residential scenario, or
- Groundwater concentrations protective of exposure via indoor inhalation of vapors emanating from groundwater for a residential scenario.

Screening levels for soil vapor are protective of exposure via indoor inhalation of vapors emitted from contaminated soil or groundwater. Screening levels in sub-slab and deeper (3-5 feet below ground surface) soil vapor are derived by applying attenuation factors of 0.1 and 0.01, respectively, to the EPA Regional Screening Levels (RSLs) for residential ambient air.

Table 2 lists the screening levels for unrestricted use. For comparison, Table 2 provides the risk-based concentrations in soil and groundwater for all the pathways and ROE listed above. The screening level values incorporated in the Rule are indicated in bold.

Because of the methods and assumptions used in the development of the screening levels and the current limitations of laboratory analytical methods, the calculated screening levels may be lower than the practical quantitation limit reported by a laboratory for selected chemicals. In cases where the screening level and the PQL cannot be achieved by present analytical technology, the screening level established is a goal and a DEQ-approved PQL will be established as the default screening level. When analytical technology improves such that the screening level goals are achievable, the screening level goal will apply. In these situations, where the PQL is elevated due to sample-specific effects (such as sample dilution factors) site-specific review by DEQ will be required based on the criteria provided in Section 500 of the Rule and Appendix K.

Table 2. Screening Level Concentrations for Soil, Groundwater, and Soil Vapor

	SOIL (mg/kg)			GROUNDWATER (mg/L)		DEEP SOIL VAPOR (ug/m3) (>3- 5 feet bgs)	
						Unrestricted Use	Commercial/ Industrial
CHEMICAL	**Vapor Intrusion**	**Direct Contact**	**Groundwater Protection**	**Vapor Intrusion**	**Ingestion**	**Vapor Intrusion**	**Vapor Intrusion**
Benzene	0.08	8.3	**0.025**	0.044	**0.005**	31	160
Toluene	1300	62000	**6.6**	340	**1**	520000	2200000
Ethylbenzene	**0.25**	39	7.4	**0.05**	0.700	97	490
Xylenes	**27**	8500	91	**8.7**	10	10000	44000
Naphthalene	**0.12**	44	9.2	**0.07**	0.73	7	36
MTBE	2.4	340	**0.08**	6.8	**0.04**	940	4700
1,2-Dichloroethane	0.02	3.7	**0.013**	0.03	**0.005**	9	47
Ethylene Dibromide	0.001	0.27	**0.00014**	0.004	**0.00005**	0.4	2
Acenaphthene	NA	37000	**200**	NA	**2.2**	NA	NA
Anthracene	NA	190000	**3200**	NA	**11**	NA	NA
Benz(a)anthracene	NA	**0.19**	0.09	NA	**0.00003**	NA	NA
Benzo(a)pyrene	NA	**0.02**	2.1	NA	**0.0002**	NA	NA
Benzo(b)fluoranthene	NA	**0.19**	0.31	NA	**0.00003**	NA	NA
Benzo(k)fluoranthene	NA	**1.9**	3.1	NA	**0.0003**	NA	NA
Chrysene	NA	19	**9.5**	NA	**0.003**	NA	NA
Fluoranthene	NA	25000	**1400**	NA	**1.5**	NA	NA
Fluorene	NA	25000	**240**	NA	**1.5**	NA	NA
Pyrene	NA	19000	**1000**	NA	**1.1**	NA	NA

Values in bold are current screening level values specified in the Rule. Screening level values for deep soil vapor are equivalent to EPA Regional Screening Levels (EPA, 2010b) for residential and industrial ambient air multiplied by an attenuation factor of 100.

NA: not applicable because the chemical does not meet EPA volatility criteria.

Comment [MAB3]: We need to develop RUSLgs for selecetd compounds in which the value is below a reasonabe PQL

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3.2 Comparison of Site Concentrations with Screening Levels

Based on the initial site characterization (discussed in Section 2), the owner/operator should identify the maximum soil and ground water petroleum COI concentrations at the site. These maximum concentrations are then compared with screening levels, obtained from Table 2.

If the maximum site concentration does not exceed the screening level for any petroleum COI in any media, the site is eligible for closure ~~subject to other regulatory obligations (IDAPA 58.01.24.200)~~ The owner/operator may request DEQ approval for site closure. If the maximum site concentration for any petroleum COI exceeds the screening level, the owner/operator must select one of the following options:

- Option 1: Adopt screening levels as cleanup remediation standards and develop a CAP (see Section 1).
- Option 2: Perform a more detailed, site-specific RE.

The owner/operator should clearly indicate to DEQ which option has been chosen.

3.3 Screening Level Evaluation Report

The owner/operator must submit a screening level evaluation report to DEQ if they have chosen option 1 above. The report should include, at a minimum:

- Site maps indicating land use, structures on site, locations and depths of samples, and locations of contaminant sources,
- A description of site history and activities leading to the release,
- A description of current land use adjacent to the site,
- A summary of initial site characterization results for soil and, as appropriate, groundwater,
- A discussion of data quality,
- A comparison of maximum soil and, as appropriate, groundwater concentrations with screening levels,
- A list of recommendations, and
- Laboratory reporting sheets, including QA/QC data.

Section 4. Site-Specific Risk Evaluation

Site-specific RE is needed only if the owner/operator chooses not to conduct a screening level evaluation or to use the default screening levels as the remediation standards.

Conducting a site-specific RE requires the completion of several important steps. These include developing an SCM, identifying the chemicals present in environmental media, assessing exposure and exposure pathways, assessing the toxicity of the chemicals present, characterizing human risks, and characterizing the impacts on or risks to the environment. This section describes each of these steps and also provides the suggested format for some of the deliverables (most of which are reports) that assist in developing and documenting the evaluation.

4.1 Site Conceptual Model

An SCM provides an overall understanding of the site and an SCM report can be a convenient format for compiling all the relevant data associated with a release. The SCM provides a framework for the entire project and can help identify specific data needs (the correct quality and quantity of data that will be needed). An SCM is necessary in the development of any data collection work plan and is also an important communication tool for regulators, owner/operators, and stakeholders.

In addition to basic site information (discussed in section 4.1.1), there are three key elements that should be included in the SCM. Each element will require certain types of data in order to validate the SCM. The amount of data required is typically based on site-specific considerations. The SCM is a dynamic entity that should be revisited and potentially refined any time additional data is collected for a site. The resulting SCM refinements should be incorporated, if necessary, into the RE.

The three key elements are:

- **Sources**: Contaminant source areas (nature, magnitude, and extent of release) and COI (see section 4.1.2).
- **Pathways**: Release fate and transport mechanisms, exposure pathways, and ROE (see section 4.1.3).
- **Receptors**: Characteristics of land use and likely receptors (see section 4.1.4).

More detailed information on these elements is provided below and in the sections on data requirements (section 4.2) and exposure assessment (section 4.3).

4.1.1 Site Characteristics

The following basic site characteristics should be included in the RE; each is described in the following sections:

- Site history and map,
- Ground surface conditions,

- Location of utilities on and adjacent to the site, and
- Location and description of site structures.

4.1.1.1 Site History and Map

The SCM should include a comprehensive chronology of events including remediation projects, tank removal activity, reported releases, etc. The chronology of events must be clearly and accurately documented.

All maps should be made to scale, with a bar scale and a north arrow. As appropriate, multiple site maps should be prepared to show sample collection points and locations of various site structures. A detailed facility map showing the layout of USTs, above ground storage tanks (ASTs), pipes, loading and unloading areas, sumps, paved and unpaved areas, canopy buildings, etc. should be prepared. A second facility map should be prepared to show locations of all on-site monitoring wells, water use wells, soil borings, soil vapor extraction wells, and soil excavation areas. All on-site structures should be clearly identified.

4.1.1.2 Ground Surface Conditions

Before conducting an RE, DEQ highly recommends the owner/operator and any other parties that will be involved make a site visit and walk through. It is important to document areas of the site that are paved, unpaved, landscaped, or covered with buildings. It is also highly useful to note the type, extent, slope, and general condition of the ground surface, and current land uses.

4.1.1.3 Location of Utilities on and Adjacent to the Site

Due to potential for preferential flow of contaminated groundwater and vapors into underground utility lines and conduits, a thorough documentation of the location of and potential impacts to underground utilities should be performed. Utilities may include phone lines, water lines, sanitary sewers, storm sewers, and natural gas lines. A combination of site observations, knowledge of buried utilities, and discussions with utility representatives and the site owner should reveal the utility locations.

At a minimum the following activities should be performed:

- Locate all underground utility lines and conduits within the area of known or potential soil and groundwater impact, both on site and off site, where the release may have migrated, or may migrate in the future.
- Determine the direction of flow in the utilities (water, storm water, and sewage).
- Identify utility lines/conduits on a base map that illustrates the extent of soil and groundwater impacts.
- Determine depth of utility lines/conduits relative to the depth of groundwater. Seasonal fluctuations of groundwater levels should be carefully evaluated. As appropriate, a cross-sectional diagram should be provided illustrating the depth to groundwater and the locations and depths of the lines/conduits.
- Determine any past impacts to utilities and any pertinent complaints that may have been previously filed with DEQ.

4.1.1.4 Existing Structures

The location, condition, and construction characteristics of each structure on and adjacent to the site should be described.

4.1.2 Contaminant Source Areas

This element of the SCM should include a discussion of the nature, location, timing, and magnitude of petroleum products spilled at the site. The petroleum COI should be determined. Any actions performed as a part of emergency response should be delineated and their impact on the source evaluated. The residual size of the source after any emergency or interim actions should be determined.

Knowledge about the nature, magnitude, and extent of the release is necessary to identify the petroleum source in soil and/or the groundwater at the site as well as to identify the petroleum COIs. The following information regarding a release, if available, is critical:

- Release location,
- Release quantity,
- Petroleum product released, and
- Interim corrective action measures performed.

Release-related information can be obtained by reviewing inventory records, interviewing current and past employees, and checking any spill incident reports filed with DEQ. Information related to site activities can also help identify source location and petroleum COIs.

4.1.2.1 Location of Release

The location of the release defines the source of the petroleum that is in the soil and potentially the groundwater. Likely release locations include, but are not limited to, corroded or damaged tanks, pipe bends and joints, and loading and unloading areas.

The owner/operator should review operational history to determine the likely location of the source. The assessment should focus on the identified release area; however, the exact location and timing of the spill source area may not be known. In these cases, soil and groundwater sampling should be used to identify the extent (vertical and horizontal) of residual soil and/or groundwater source. The exact number and location of necessary samples shall be determined on a site-specific basis using professional judgment. It will be important to understand the location and timing of past spills and releases in making decisions regarding assessment needs related to current releases. It is recommended, but not required, that the owner/operator consult with DEQ before conducting sampling. DEQ may be able to provide information at this point that can help the owner/operator improve the overall efficiency of sample collection or the entire RE.

4.1.2.2 Quantity of Release

The RE process does not necessarily require knowledge of the exact release quantity. However, an estimate of the amount released may help evaluate the severity of the impact and extent of contamination, and may help in planning site characterization measures. Estimation of release quantities is typically based on inventory records.

4.1.2.3 Chemicals of Interest and Spatial and Temporal Trends

This section should include a discussion of chemicals detected in each media and their spatial and temporal distribution. As appropriate, contour maps indicating concentrations of individual petroleum COIs may be useful. Graphs of petroleum COI groundwater concentrations in individual wells and concentration along the flow line (concentration vs. distance plots) may be useful as well. Based on data collected over time, it should be determined whether the chemical concentrations are stable, declining, or expanding.

Identification of specific petroleum product(s) spilled or released is important to identify the petroleum COIs. Evaluation of non-petroleum chemicals in addition to those in Subsection 800.01 (Table 1) may be required by DEQ when there is a reasonable basis based on site-specific information. A reasonable basis shall be demonstrated by DEQ when it can show documentation of releases or suspected releases of other non-petroleum chemicals. The environmental behavior (mobility, persistence, bio-degradation, and inter-media transport) of the petroleum product and its adverse environmental and human health effects depend on chemical properties and their concentrations in the petroleum product.

If a release can be identified as a single petroleum product based on a documented release, free product analysis, or location of impact (e.g., tank bottom of a particular product tank), only the COIs for that petroleum product need to be analyzed. If the product released cannot be conclusively identified, it is recommended that monitoring samples be analyzed for all petroleum COIs associated with the products suspected to have been stored at the site. Additional assessment may be required to identify the source of the release.

If previously collected data did not include all suspected site petroleum COIs, additional sampling may be necessary for petroleum COIs before an RE can be performed.

4.1.3 Pathways and Transport Mechanisms

The objective for this portion of the SCM is to describe site characteristics and mechanisms which have influenced or will influence the release, fate, and transport of chemicals of interest and to determine which exposure pathways and ROE will be most likely to occur.

4.1.3.1 Site Stratigraphy and Hydrogeology

The owner/operator should conduct a review of published literature and any investigations conducted on adjacent sites to determine regional hydrogeology, soil types, and aquifer characteristics. This evaluation should be used to determine the type and depth of aquifers in the area and whether they are confined, semi-confined, or unconfined. Regional information will help the owner/operator in efficiently collecting site-specific soil and groundwater information. The SCM should include a detailed discussion of site-specific stratigraphy and hydrogeology. Site stratigraphy should be determined based on boring logs and an adequate number of geologic cross sections.

The hydrogeologic discussion should include estimates of horizontal and vertical hydraulic gradients, seasonal variations in groundwater elevations and flow direction, and hydraulic conductivity of relevant water-bearing zones. How these characteristics may influence the fate and transport of chemicals to potential receptors should be discussed.

The survey should also locate potentially impacted surface waterbodies located within one-half (1/2) mile of the site. If a surface water body is identified, information including the type (perennial or intermittent), water flow rate, flow direction, depth of water, width or surface area of the water body, and water use should be provided. The location of the water body must be indicated on an area map.

4.1.3.2 Complete Exposure Pathways and Routes of Exposure

A complete exposure pathway involves a source of petroleum products, release and transport mechanisms, ROE, and potential receptors. The definition of complete exposure pathways starts with knowledge of the release, petroleum COIs, and site physical conditions (described above), then combines these with assumptions about land use and likely receptors. Exposure pathways and ROE are described and discussed in more detail in section 4.3.3.

The SCM should identify each of these components in its descriptions of exposure pathways. One example of a common exposure pathway would be leaching of petroleum chemicals from a gasoline release in soils (release) to the groundwater with subsequent transport (fate and transport) to a residential well where water is extracted for drinking water and ingested by residents (land use and likely receptors). Another would be volatilization of petroleum chemical vapors from a soil source with subsequent transport through the soil and into the air in an occupied structure where they are inhaled.

Another part of defining the complete or potentially complete exposure pathways and ROE in an SCM is identifying the locations where exposure to petroleum chemicals can occur and the media of concern at those locations. These known or potential exposure locations are commonly called exposure units. The exposure unit for each complete pathway and receptor should be described. The exposure unit may consist of a specific location such as a well or it may be an area, such as a parcel, over which receptors move. For large sites, it may be useful or necessary to subdivide the site into multiple exposure units. This may also be true at sites where impacts of the release have moved offsite.

Exposure pathways defined in the SCM are subsequently used in the exposure assessment phase of the RE, which is described in detail in section 4.3.

4.1.3.3 Protection of Groundwater

During the development of the SCM, it should be assumed groundwater may be used for drinking water. Consequently, if groundwater is not remediated to levels suitable for ingestion, the CAP must also include provisions in the final remedy for implementing limitations on activities and land uses. Such limitations are achieved through environmental covenants (activity and use limitations [AULs]) to prevent exposure via groundwater ingestion throughout the horizontal and vertical extent of the plume that has concentrations exceeding the criteria for groundwater ingestion presented in Table 2.

The SCM, as it relates to the use of groundwater, should include characterization and evaluation of the following groundwater aspects.

- The current and historical use of the groundwater for drinking water or irrigation.

- The location and approved use of existing groundwater wells within a one-half (1/2) mile radius from the release point at the contaminated site.
- The potential for communication between the impacted groundwater and other groundwater-bearing zones or surface water.
- The location of delineated source water protection areas for public drinking water systems.

This information, along with other data collected for the evaluation, will be used to determine if groundwater ingestion is a complete exposure pathway in the SCM, and will guide the selection and use of appropriate remedial target concentrations, measures, timeframes, and compliance conditions.

A water well survey should be conducted to identify all water use wells within a one-half (1/2) mile radius. Information sources include the U.S. Geological Survey, the Idaho Department of Water Resources (IDWR), water system operators, and local residents. If available, well characteristics including depth, water use, and screened interval should be documented. It is necessary to identify any dewatering wells located within a 1,000-foot radius of the site (or greater if the groundwater plume is extensive).

Land use considerations include, but are not limited to:

- Current zoning and land use. Consultation with local planning and zoning officials regarding future land use planning direction and interpretation of planning and zoning policies.
- Land use development trends. Conversion of agricultural land to residential land uses requires development of drinking water sources. The proximity of these conversions to urban centers and available public drinking water supplies should be taken into account.
- Local ordinances that include agreements with IDWR governing well drilling or state-designated restrictions or specifications for constructing wells into groundwater in a locality for drinking water purposes.
- The existence of source water assessment delineations and source water protection plans and ordinances associated with public drinking water supplies.
- The availability of alternative water supplies.

4.1.4 Land Use and Receptors

This portion of the SCM describes the current and future assumptions about land use as they relate to identifying potential receptors. The identification of land uses includes both the site of the release as well as adjacent properties which may be impacted by the release.

4.1.4.1 Land Use

Evaluating current and reasonably likely future land uses at and adjacent to the release site is a critical component when determining potential exposure points, exposure pathways, receptors, and exposure factors during the RE process and when determining cleanup concentrations.

Residential land use generally requires lower target concentrations. Cleanup to residential standards will usually allow unrestricted land use. Whenever assumed land use is other than

residential and cleanup is not to residential standards, DEQ may require that an AUL be imposed on the property through the use of an environmental covenant.

Residential land uses include use by sensitive subpopulations. Examples of land uses with sensitive subpopulations include but are not limited to hospitals, nursing homes, schools, childcare centers, farms with houses, and any other areas/structures with sensitive human activity.

The owner/operator should submit to DEQ illustrated land use maps clearly identifying current land uses at the site and the adjacent properties. One map should clearly show the area within one-half (1/2) mile of the known or likely extent of contamination. At sites where there is likelihood that the extent of impacts may be greater, due to the magnitude of the spill or other site-specific conditions, a land use map covering the entire impacted and potentially impacted area is necessary. A walking land use survey should be conducted for the area within a 500-foot radius of the source, with an emphasis on the down-gradient direction and potential offsite impacts. The survey should clearly identify the following: schools, hospitals, residences (apartments, single-family homes, and others), day care centers, nursing homes, and types of businesses. In addition to this survey, efforts should be made to identify structures with basements (which may enhance the transport of contamination) in areas in closer proximity to the source and where site conditions warrant it, such as where shallow groundwater or non-aqueous phase liquid (NAPL) is present. The map should also identify surface water bodies, parks, recreational areas, wildlife sanctuaries, wetlands, and agricultural areas.

Current land use refers to land use as it exists today and that can be readily determined by a site visit. A site visit should identify homes, playgrounds, parks, businesses, industries, or other land uses at, and in close proximity of, the release site. As appropriate, state or local zoning boards; the U.S. Census Bureau; zoning, topographic, land use, housing and other types of maps; and aerial photographs can provide information for determining land use.

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Undeveloped land should be characterized by the most likely future use of that property, considering current zoning restrictions. If the undeveloped parcel is located in a predominantly nonresidential area, nonresidential classification may be appropriate. However, if the setting is more rural or land-use is mixed, the undeveloped land should be considered residential unless the owner/operator develops and implements an AUL as a part of a DEQ-approved CAP.

The exposures to be evaluated in an RE depend upon the activities that could occur under likely future uses of land and groundwater at the site. The future groundwater use should be consistent with the most likely future land use.

For example, consider property that is currently used as farmland. If the impacted farmland includes a residence, the current land use is residential. However, if the owner/operator provides information establishing clear plans to develop the residence into a nonresidential building in the near future, the likely future use may be evaluated as nonresidential.

While evaluating likely future land use(s) presents uncertainties, DEQ has identified certain factors that assist in this evaluation. These factors include, but are not limited to, local zoning ordinances; knowledge of current land use and changing land use patterns; zoning decisions; community master plans; interviews with current property owners; nonresidential appraisal

reports; proximity to wetlands, critical habitat, and other environmentally sensitive areas, such as source water protection areas; and the use of remedial action institutional controls at a site.

Assumed future land use designations other than residential must be justified and there should be a high likelihood that the land will be used for those purposes. Absent such a justification, DEQ will consider the residential land use scenario as the default future land use.

Site characterization will include a determination of the on-site and off-site areas of impact. These areas are considered in determining the pathway-specific exposure units for each type of receptor. Exposure units are discussed in more detail in section 4.3 and Appendix I.

4.1.4.2 Receptors

The objective of the RE is to quantify the adverse health effects to current and potential future receptors both onsite and offsite. For simplification, the following definitions should be used:

- On-Site −The area located within the legal property boundaries within which the source of the release is located. This includes soil, groundwater, surface water, and air within those boundaries. Adjacent property purchased subsequent to the release will be considered off-site.
- Off-Site −The areas of concern located outside the boundaries of the property where the release source is located. This includes soil, groundwater, surface water, and air located outside the property boundaries.

In a residential exposure scenario, risk is evaluated for either a child receptor or a composite receptor, depending on the specific exposure route, and whether the petroleum COI is noncarcinogenic, carcinogenic, or carcinogenic with a mutagenic mode of action. The composite receptor is based on an exposure duration of 30 years, and for some chemicals and exposure routes risk calculations incorporate modifications based on exposure occurring at different life stages.

For land uses other than residential, a typical receptor might be a commercial or industrial worker where the risk to adults is considered. Finally, under a construction scenario adult construction workers are considered. If warranted by site-specific conditions, other types of receptors may need to be defined and evaluated.

4.1.4.3 Ecological Risk Considerations

In addition to identifying potential impacts to human receptors the SCM should also attempt to identify potential pathways by which sensitive habitats, such as wetlands, surface water bodies, or other ecologically significant environments near the site, may be impacted by the release where wildlife may be the potential receptors.

Threatened and endangered species that may be exposed to site-specific chemicals should be identified. Note that within the RE process, protection of surface waters and streams is independent of ecological RE. As appropriate, a walking survey in the vicinity of the site may be necessary to identify ecological receptors.

Contact DEQ to obtain additional guidance on these issues.

4.2 Data Requirements and Evaluation

Once the SCM has been developed, an evaluation of data collection needs, data quality needs, and data collection methodology should be conducted. Depending on the amount and complexity of the proposed data collection effort, a work plan may be needed to guide the data collection process. The suggested contents of this work plan are discussed in section 4.7.

This section describes general data collection objectives and requirements for the RE process. This includes the general QA/QC considerations to help ensure the data collected is of sufficient quality and quantity to meet desired objectives, the categories of data necessary to meet these objectives, and data collection techniques.

Data collection objectives for RE include, but are not limited to:

- Accurately characterize the magnitude, nature, and extent of contamination, including the characterization of petroleum chemical concentrations for all impacted media, as appropriate,
- Allow the development and/or validation of an accurate SCM, and
- Develop sound estimates of risks posed by the release.

4.2.1 Data Collection Planning

Sound data collection planning involves a careful review of all available site information and data for its suitability in the RE. This process, in the context of the SCM, should identify any data gaps with the goal of determining the types, locations, quality, and numbers of samples or measurements needed.

Depending on what stage of the RE process is in for a given site, the relative importance of each objective described above will vary and specific data requirements will also vary. The goal of data collection for RE should be to efficiently reduce uncertainty in those areas which may contribute the most to potential or actual risk and for which the greatest uncertainty exists.

For example, it may be determined through the SCM that vapor intrusion represents the largest potential source of risk at a site, but little is known about subsurface conditions which may impact exposure point concentrations and only soil or groundwater data are available. In order to more realistically model this pathway, it may be most effective to better characterize subsurface stratigraphy and properties, document the conditions supporting biodegradation, and collect soil vapor data.

At many impacted sites, data collection efforts may have been conducted multiple times over an extended period of time. For example, interim corrective action measures may have been undertaken prior to planning for the RE. Soil and groundwater data collected prior to such activities may not be representative of current conditions and generally should not be used in RE. At such sites, collection of additional soil and groundwater concentration data may be needed after completion of interim corrective measures.

The exact number of samples required is a site-specific decision based on the balance between cost and representativeness and requires professional judgment and expertise. Numerous tools are available to assist in estimating the number of samples required for statistical analysis, but

none provide a definitive number and statistical analysis may not be practical in many cases. These tools include, but are not limited to, data quality objectives (DQO) and statistical and geo-statistical evaluation. Selected references to assist in developing and completing sound data collection efforts are listed in section 7.2.

4.2.2 Quality Assurance/Quality Control Considerations

The RE process relies on site-specific data to make decisions related to the magnitude of site risk, nature and extent of remedial activity, and site-closure. Thus it is very important that data be reliable, representative, complete, and of known quality.

In order to assure the data will be of appropriate quality, QA/QC activities must be applied throughout the site characterization and environmental data collection process.

Elements of QA/QC include:

- Using approved methodologies to collect data,
- Decontaminating field equipment as appropriate,
- Using EPA approved methods for laboratory analysis, and
- Including QA/QC samples, such as equipment blanks, trip blanks, etc.

While the level of QA/QC applied to data collection efforts will vary (depending on factors such as site complexity, size of the release, and the immediacy of the response) all the elements of QA/QC described above that were used during a given data collection effort should be provided to DEQ when reporting the results of environmental sampling. This will allow an adequate review of the quality of the data used in the analysis.

If a work plan is submitted to DEQ for approval, it should include a QAPP. The QAPP integrates the appropriate technical and quality aspects of a project, including planning, implementation, and assessment. The purpose of the QAPP is to document planning for the collection of environmental data and to provide a project-specific "blueprint" for obtaining the type and quality of data needed for a specific decision or use. The QAPP documents the QA/QC procedures applied to various aspects of the project to assure that the data obtained are of the type and quality required.

The EPA has developed guidance for the development of QAPPs which can be obtained at: *http://www.epa.gov/quality/qs-docs/g5-final.pdf*

To further assist in the development of a QAPP, DEQ has also developed an abbreviated QAPP form. The purpose of the abbreviated QAPP form is to provide the user with an annotated outline format of a QAPP with all the required information headings. From there, it is a simple matter to fill in appropriate site-specific information applicable to each heading or section. The abbreviated QAPP form is reproduced in Appendix L.

Documentation of all QA/QC efforts implemented during data collection, analysis, and reporting phases is important to data users, who can then consider the impact of these control efforts on data quality.

The QAPP is implemented during the data collection process. Problems can be identified and corrected at this stage. The impact of field and laboratory techniques and sampling and analysis

conditions on data quality are determined using field and laboratory QC samples and periodic audits. Oversight and corrective action can prevent improper procedures or techniques from continuing.

Data verification, validation, and assessment should be performed to validate data quality and assess data quality and usability. Data verification and validation is particularly dependent on compliance with field and laboratory procedures for sample collection, identification, handling, preservation, chain of custody management, shipping, analysis, and reporting.

EPA provides guidance for performing verification and validation of contract laboratory program (CLP) data, which may also be used as guidance for non-CLP data verification and validation. This guidance is in the EPA Contract Laboratory Program National Functional Guidelines for Organic Data Review (EPA, 1999).

4.2.3 Documentation of the Data Collected

Once data have been collected, a field investigation report should be prepared and include:

- Dates when data were collected and names of individuals who collected the data.
- A list of data collected and reference to any work plan that may have been followed.
- All data collected, clearly tabulated, and contoured (if necessary),
- All boring logs and relevant cross-sections, where appropriate, to depict site stratigraphy,
- All QA/QC data, laboratory results, and chain of custody forms,
- Contour maps of groundwater potentiometric surface indicating the predominant direction of groundwater flow, and
- A discussion of the SCM.

4.2.4 Data Collection Methods

The common categories of data that are the focus of data collection efforts for RE include:

- Vadose zone soil characteristics,
- Saturated zone characteristics, and
- Distribution of petroleum COIs in soil, soil vapor, groundwater, and surface water bodies.

DEQ has developed default values for many of the vadose and saturated zone characteristics that affect the fate and transport of petroleum COIs. These values are presented in Appendix B. For site-specific REs, these default values can be used or site-specific values can be established. This appendix describes typical collection methods for those properties of the vadose zone and saturated zone important for RE. It also addresses the collection of chemical concentration data from these media.

4.2.5 Vadose Zone Soil Characteristics

The vadose zone or unsaturated zone soil is the media through which petroleum COIs can migrate to the groundwater and vapors can move upward to the surface and into an enclosed space. Thus, characteristics of vadose zone soils have considerable impact on risk estimates and target concentration calculations. Relevant vadose zone characteristics include:

- Vadose zone thickness and depth to groundwater,

- Bulk density,
- Porosity,
- Water and air content, and
- Fractional organic carbon content.

In addition to parameters mentioned above, additional site-specific, pathway-specific parameters that may be valuable to measure include:

- Vapor permeability, effective diffusion coefficient, and building characteristics where indoor inhalation is a potentially complete pathway, and
- Infiltration rates for developing a detailed evaluation of the potential for leaching to groundwater.

4.2.5.1 Thickness of Vadose Zone and Depth to Groundwater

Vadose zone thickness is determined from boring logs. This thickness is the distance from the ground surface to the depth at which the water table is encountered, less capillary fringe thickness.

Depth to groundwater is used in estimating vapor emissions from groundwater. For indoor inhalation, depth to groundwater below the “floor” of an existing structure of concern or the most likely location of a future structure should be used.

For sites with considerable seasonal fluctuation in water table level, depending on the data available and the nature of the fluctuations, a yearly average depth or a time-weighted depth may be used. The vadose zone depth that is estimated should also form the basis for the selection of soil samples to be used in evaluation of subsurface soil vapor emissions to indoor air. Shallower water table depths often result in groundwater target levels set at lower concentrations to be protective of inhalation pathways.

4.2.5.2 Porosity

Porosity is the ratio of the volume of voids to the total undisturbed field volume of soil. Many laboratories use dry bulk density and specific gravity data to determine porosity using the following equation:

$$n = 1 - \rho_b / \rho_s \qquad (4\text{-}1)$$

where,

n	=	porosity (cubic centimeter per cubic centimeter [cc/cc])
ρ_b	=	dry bulk density (grams per cubic centimeter [gm/cc])
ρ_s	=	specific gravity or particle density (gm/cc)

Dry bulk density is the dry weight of a soil sample divided by the field volume of the soil sample. An accurate measurement of bulk density requires determining the dry weight and volume of an undisturbed sample. This method involves collecting a core of known volume, using a thin-walled sampler, such as a Shelby tube or similar coring device, to minimize

disturbance of the sample, and transporting the core to a laboratory for analysis. This method is described in American Society for Testing and Materials (ASTM) Method D2937-00, Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method (ASTM, 2000a).

The Standard Test Method for Specific Gravity of Soil, ASTM Method D854-00 (ASTM, 2002), may be used to determine specific gravity. If specific gravity is not assessed, then 2.65 gm/cc can be assumed as the particle density.

Consideration should be given to collecting multiple samples if multiple lithologies are present that might affect COI transport.

If site-specific values of porosity are not available, it should be estimated based on values provided in an appropriate literature source.

4.2.5.3 Volumetric Water Content/Moisture Content

Volumetric water content is the ratio of water volume to the total soil volume. The ASTM Method D2216-98, Standard Test Method for Laboratory Determination of Water [Moisture] Content of Soil and Rock by Mass (ASTM, 1998) is a gravimetric oven-drying method; however, the water content value used in most models is the volumetric water content.

Hence, it may be necessary to use the following equation to convert gravimetric water content to a volumetric basis:

$$\theta_{wv} = \theta_{wg} * \frac{\rho_b}{\rho_l} \qquad (4\text{-}2)$$

where,

θ_{wv}	=	volumetric water content (cc water/cc soil)
θ_{wg}	=	gravimetric water content, typically reported by the laboratory (gm of water/gm of soil)
ρ_b	=	dry bulk density (gm of dry soil/cc of soil)
ρ_l	=	density of water (gm/cc)

Volumetric water content can also be measured in the field through the use of a variety of instruments such as a neutron probe, time domain reflectometer, or gypsum block sensors. For more information on these methods, see Part VII of Wilson et al. (2000).

4.2.5.4 Fractional Organic Carbon Content in Soil

Fractional organic carbon content is the organic carbon weight in the soil divided by soil weight and is expressed either as a ratio or as a percent. The Walkley Black Method (Page et al., 1982) is a chemical oxidation method (rapid dichromatic oxidation) while ASTM Method 2974-00 is a furnace method (ASTM, 2000b) for determining fractional organic carbon content in soil.

Results are usually reported as percent organic carbon content. The reported value can be converted to a fraction by dividing by 100.

If measurements of total organic matter content are available, they should be divided by 1.724 to estimate the fractional organic carbon content. This adjusts for the portion of soil organic matter that is actually carbon. Typically, total organic carbon content is estimated using ASTM Method 2974-00. Organic carbon content should be determined using soil samples not impacted by the release.

4.2.6 Saturated Zone Characteristics

Petroleum COIs that reach the water table typically travel horizontally through the saturated zone. However, if a vertical gradient is present, chemicals may also move vertically in the direction of the gradient. Saturated zone characteristics that determine the travel time and direction for the petroleum COIs include:

- Horizontal hydraulic conductivity,
- Horizontal and vertical hydraulic gradients (magnitude and direction), and
- Saturated zone soil characteristics (fractional organic carbon content and porosity).

4.2.6.1 Hydraulic Conductivity

Hydraulic conductivity is the discharge of water per unit area per unit hydraulic gradient in a subsurface formation. Estimates of site-specific hydraulic conductivity can be obtained by conducting aquifer tests such as slug or pump tests. Data gathered during the tests are then analyzed using appropriate methods. Slug tests are easier to conduct than pump tests, generate no wastewater for treatment, and may be more appropriate for low-permeability formations. The primary disadvantages are the small aquifer volume that is explored, resulting in the need to conduct multiple tests across the site. Properly conducted pump tests will often provide better estimates of hydraulic conductivity. The simplest pump tests are single-well short-duration (2 to 4 hours) tests. The best pump tests employ a pumping well and multiple observation wells and are of longer duration (12 hours or more). These tests will identify boundary effects. Regardless of the type of test conducted, different methods of data analysis will often yield different estimates of hydraulic conductivity. ASTM Method D4043 provides guidance on the selection of aquifer test methods (ASTM, 1996).

In the absence of these tests, estimates of hydraulic conductivity may be obtained from literature, with values corresponding to the type of soil in the saturated zone, using empirical equations based on the grain size distribution of the porous formation, or they may use specific capacity data from well logs of wells in the vicinity of the site that are representative of the aquifer being investigated. In either case, adequate references and justification for the value chosen should be provided.

4.2.6.2 Hydraulic Gradient

The magnitude and direction of the hydraulic gradient is estimated by comparing water levels measured in the monitoring wells. Typically, water level contour maps are prepared based on measured data using a computer program or manual calculations along with professional judgment. Calculations done using automated procedures should be spot-checked with hand

calculations. Three wells or more are needed to adequately estimate the direction of flow and magnitude of the gradient. When drawing the contour maps, care should be taken to ensure that the measurements used are from monitoring wells that are screened in the same interval or hydrologic unit.

For sites that have seasonal variation in hydraulic gradient, estimate the average hydraulic gradient for each season. Consideration should also be given to determining any vertical gradients. This requires a comparison of adjacent water levels in wells screened in different intervals.

In areas where the shallow aquifer has been impacted and a deeper aquifer is used for drinking water, the vertical gradient should be determined. When drilling deep wells, care should be taken to avoid cross contamination.

4.2.6.3 Saturated Zone Soil Characteristics

In addition to hydraulic conductivity, other important saturated zone soil characteristics include fractional organic carbon content, porosity, and bulk density. These parameters are required to quantify the movement of chemicals within the saturated zone. The laboratory methods to measure these parameters were discussed in section 4.2.5.

4.2.7 Indicators of Biodegradation

Biodegradation of petroleum chemicals occurs in all media (soil, soil vapor, groundwater). Depending on the media, different indicators (chemical concentrations, geochemical indicators, microorganisms, oxygen, and carbon dioxide) can be measured at a site to demonstrate the occurrence of biodegradation of these organic substances.

When evaluating the potential for biodegradation in groundwater, these indicators are commonly classified into three groups: primary, secondary, and tertiary lines of evidence. Data collected under each line of evidence can be evaluated qualitatively or quantitatively to determine the occurrence of biodegradation.

The primary line of evidence demonstrates spatial stability or a reduction in chemical concentrations at a site by evaluating measured concentrations within monitoring wells, groundwater velocity, rates of contaminant transport, and time of the release.

The secondary line of evidence refers to measurement of geochemical indicators including reduction-oxidization (REDOX) potential, dissolved oxygen, dissolved nitrates, manganese, ferrous iron, sulfate, and methane. These indicators should be measured in at least three wells located along the flow line, one of which should be located at a background or up-gradient location, one within the plume near the source, and one within the plume down-gradient from the source.

The tertiary line of evidence involves microbiological studies such as identification of types of subsurface microbial populations and microbe cell counts.

Commonly used methods to estimate biodegradation rates include mass balance analysis for expanding, stable, or shrinking plumes and plots of plume concentration vs. distance. Additional details on biodegradation for petroleum COIs in groundwater are provided in Appendix H.

When evaluating the potential for, or presence of, biodegradation in soil or soil vapor, the most common indicators used are soil vapor concentrations, oxygen, and carbon dioxide. These are commonly measured at multiple depths in the subsurface and related to a potential source. More information on evaluation of biodegradation of petroleum vapors in relation to the vapor intrusion pathway is provided in Appendix G.

4.2.8 Distribution of Petroleum Chemicals of Interest

Petroleum COI may be distributed between soil, soil vapor, groundwater, surface water, and sediments present at a release location. Knowledge of contaminant distribution entails a determination of the spatial extent and magnitude of concentrations in each of these media, where they are present.

4.2.8.1 Distribution of Petroleum Chemicals of Interest in Soil

Adequate soil concentration data are necessary to estimate risk to receptors, compare representative concentrations for each complete pathway to target levels, and define the soil source dimensions. Sufficient data should be collected to define horizontal and vertical extent of impacts. The vadose zone investigation(s) should be organized to:

- Identify the horizontal and vertical extent of soil impacts. Unless otherwise directed by DEQ, the extent of impact should be defined as those areas where petroleum COI concentrations exceed screening level concentrations.
- Identify areas of maximum concentration of petroleum COIs.
- Collect samples adequate to estimate exposure point concentrations for the potentially complete exposure pathways that have been defined based on the SCM.

To determine the spatial extent of contamination, soil borings should be drilled starting from the known or suspected source area and drilling outwards until borings with sample concentrations at or below screening levels are reached in all directions. To determine the vertical extent of contamination, soil borings should be extended to the base of petroleum impact and samples collected from surface and subsurface soil zones as explained in the following sections.

The soil analytical data should help identify the soil source area. If more than one source area is identified at a site, each source area should be evaluated separately. Once the soil source(s) is identified, source dimensions can be estimated. These dimensions are used in the computational software which accompanies the guidance and rule, along with other input parameters, to estimate risk and RATL concentrations protective of indoor inhalation and to evaluate the soil to groundwater leaching pathway. Depth to subsurface soil source (used to estimate the target concentrations) should be the depth, in the source area, from the surface to the zone where concentrations are above quantification limits. Professional judgment should be used in choosing the representative depth.

4.2.8.1.1 Surficial Soil Sampling

The RE process distinguishes between surficial soil and subsurface soil zones. Surficial soil is defined as the soil zone from the ground surface to 1 foot below ground surface. Pathways that may apply to the surficial soil zone include direct contact exposure via incidental ingestion,

inhalation of vapors and particulates, dermal contact, and leaching of petroleum COIs to groundwater and surface water.

Evaluation of soil exposure pathways within the surficial soil zone requires collection of an adequate number of soil samples to estimate both maximum and representative concentrations of all potential petroleum COIs. Given the small vertical depth interval of this soil zone, close attention should be given to vertical variations in contamination. The acceptability of vertical depth-composite samples versus samples from discrete depth intervals is a site-specific decision. Criteria that influence this decision include the type of petroleum COIs, vertical extent of contamination, and areal extent of the contaminated zone. Sampling within the surficial soil zone is typically done from test pits using hand samplers such as trowels or corers.

The presence of impervious (paved) surfaces poses difficulties for sampling. In some cases, very permeable material may be located 2 inches below the pavement. Residues from the paved surface may also be present. When sampling beneath impervious surfaces, sampling should begin 2 inches or deeper below concrete or asphalt pavement. Cracked areas in impervious surfaces may represent conduits for chemical migration or leaching and should be evaluated during the selection of sampling locations.

4.2.8.1.2 Subsurface Soil Sampling

Soil below the surficial soil zone (more than one foot below ground surface) and extending to the water table is termed the subsurface soil zone. Pathways evaluated for this zone include volatilization from soil to indoor air and leaching to groundwater and surface water. Most receptors will not have direct exposure to this soil. However, some construction workers may be involved in excavation activities below the surficial soil zone and subsurface soil removed during excavation may be deposited at the surface allowing greater exposure. This possibility should be considered during the development of the SCM.

To test for indoor inhalation of vapors from subsurface soils, it is preferable to collect soil vapor data however soil data can also be used. Soil samples should be collected to characterize the complete horizontal and vertical extent of contamination. Soil moisture conditions and soil vapor permeability are also important parameters affecting soil vapor transport. If petroleum contamination exists adjacent to existing structures, additional sampling should be focused in these areas. More information on evaluation of the vapor intrusion pathway is provided in Appendix G.

To test for exposure to a construction or utility worker during excavation activities, soil samples should be collected from both surface and subsurface soil zones to depths where construction-related activities are likely to occur.

To test for leaching of petroleum COIs in soil to groundwater, it is critical to determine the thickness of the contaminated soil zone, the distance from the bottom of the contaminated zone to the water table, if any, and representative concentrations of petroleum COIs within the contaminated zone.

Soil sampling must be done in accordance with the following guidelines and procedures:

- Samples must be collected from the source area(s). Samples must be collected to determine the full horizontal and vertical extent of soil contamination. Sampling should

strive to characterize any horizontal or vertical stratigraphic variation at the site that could impact petroleum COI fate and transport. Where required to fully characterize the vertical extent of contamination, borings should be extended to the water table and features such as the capillary fringe and any smear zone, if encountered, should be characterized. Vertical sampling intervals generally should not be greater than 5 feet.

- Soil borings should be logged and samples for laboratory analyses collected in accordance with current industry practice.
- All samples must be adequately preserved according to requirements of the laboratory analyses and analyzed within holding times required by each method. Sample analyses must be conducted in accordance with current, EPA Office of Solid Waste and Emergency Response SW-846 Methods, or other accepted methods.
- Adequate QA/QC procedures must be used to ensure sample quality and integrity. Section 4.2.2 contains additional information on QA/QC considerations.
- All sampling equipment must be decontaminated using current state of industry practice such as described in ASTM D-5088-90, Practice for Decontamination of Field Equipment Used At Nonradioactive Waste Sites (ASTM, 1990).
- Abandonment of boreholes that extend to the water table, which are considered wells by IDWR, should follow IDWR abandonment procedures (IDAPA 37.03.09.16). Appropriate methodology for abandoning other boreholes is described in detail in the Standard Guide for Decommissioning Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities, Standard Guide D5299-99 (ASTM, 1999a).

Comment [MAB4]: Relevant to PQL discussion

4.2.8.1.3 Subsurface Soil vapor Data

At sites where petroleum COIs in soil or groundwater are volatile and there is concern about potential indoor inhalation of vapors, it may be useful to assess soil vapor concentrations. For details about these samples, refer to Appendix G (Evaluation of the Vapor Intrusion Pathway).

4.2.8.1.4 Logging of Soil Boreholes

Each soil boring must be logged to record depths correlating with changes in lithology (with lithologic descriptions), soil vapor (e.g., photo-ionization detector) analyses, occurrence of groundwater, total depth, visual and olfactory observations, and any other pertinent data.

When a monitoring well is installed, as-built diagrams with depth to groundwater and construction details must be submitted for each well. A continuous soil profile from at least one boring with detailed lithologic descriptions may be useful. Particular emphasis should be placed on characteristics that control chemical migration and distribution, such as zones of greater or lesser permeability, changes in lithology, correlation between soil vapor concentrations and different lithologic zones, obvious areas of soil discoloration, organic content, fractures, and other lithologic characteristics.

4.2.8.2 Distribution of Petroleum Chemicals of Interest in Groundwater

Adequate groundwater samples should be collected to delineate the extent of free product, dissolved contaminant plumes in all directions, maximum petroleum COI concentrations, and

representative concentrations based on the SCM. This sampling should take into account knowledge of the soil source and the direction of groundwater flow.

4.2.8.2.1 Groundwater Sampling

If groundwater has been impacted, temporary sampling points may be used to screen levels of groundwater impacts and to assist in determining optimal locations of permanent monitoring wells. A sufficient number of monitoring wells should be installed to identify source areas and to document petroleum COI migration and groundwater flow. The monitoring wells should be installed in accordance with current IDWR rules (IDAPA 37.03.09) and industry standards such as ASTM D 5092-95, Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers (ASTM, 1995b). EPA documents such as the Resource Conservation and Recovery Act (RCRA) technical guidance for groundwater monitoring (EPA, 1986, 1992a) are also useful references.

Adequate numbers of monitoring wells must be installed to sufficiently delineate the horizontal and the vertical extent of the groundwater plume. The number and location of wells should also allow a site-specific estimate of the direction of groundwater flow. Well placement and design must consider the concentration of petroleum COIs in the source area, and the occurrence of NAPL at the site.

Well casing and screen materials must be properly selected. The screen interval length should be minimized to the extent possible but should be set at least 2 to 3 feet above the expected high water table and encompass the range of expected variation in water table depth. EPA (1992) recommends screen interval lengths of 10 to 15 feet except where specific monitoring objectives or site knowledge result in other requirements. Wells must be properly developed and gauged after installation. A site survey must be conducted to establish well casing elevations. Based on the groundwater elevations, groundwater flow direction and gradient should be determined and plotted on a map.

Groundwater samples must be collected in accordance with the following guidelines and procedures:

- Monitoring wells must be purged of an adequate number of well volumes prior to collecting a sample (usually 3 to 5 volumes). Low-flow purging and sampling techniques (EPA, 2002) may also be acceptable when included in a DEQ-approved QAPP.
- Samples must be collected using EPA approved methods and equipment.
- All samples must be adequately preserved according to the requirements of the laboratory analyses and analyzed within holding times required by each method.
- Sample analyses must be conducted in accordance with EPA Office of Solid Waste and Emergency Response SW846 Methods, or other accepted methods.
- Adequate QA/QC procedures must be used to ensure sample quality and integrity. See section 4.2.2 for additional information on QA/QC considerations. All sampling equipment must be decontaminated using current state of industry practice such as described in ASTM D-5088-90, Practice for Decontamination of Field Equipment Used At Nonradioactive Waste Sites (ASTM, 1990).

Comment [MAB5]: Relevant to PQL discussion

- If the plume is not delineated in all directions, locations of new monitoring wells must be chosen based on groundwater flow direction and location of the soil source area.

4.2.8.3 Surface Water and Sediment Sampling

Appropriate samples should be collected when petroleum COI migration is known or suspected to have impacted surface water. Water samples should be collected from upstream and downstream of a groundwater discharge point. Sediment samples should be collected if the SCM indicates a potential for releases to surface water.

In places where a groundwater plume may discharge into a stream, it is necessary to estimate the discharge concentration into the stream. This can be achieved by installing one or more monitoring wells or temporary wells within the plume adjacent to the stream.

4.3 Exposure Assessment

The goals of the exposure assessment portion of the RE are to:

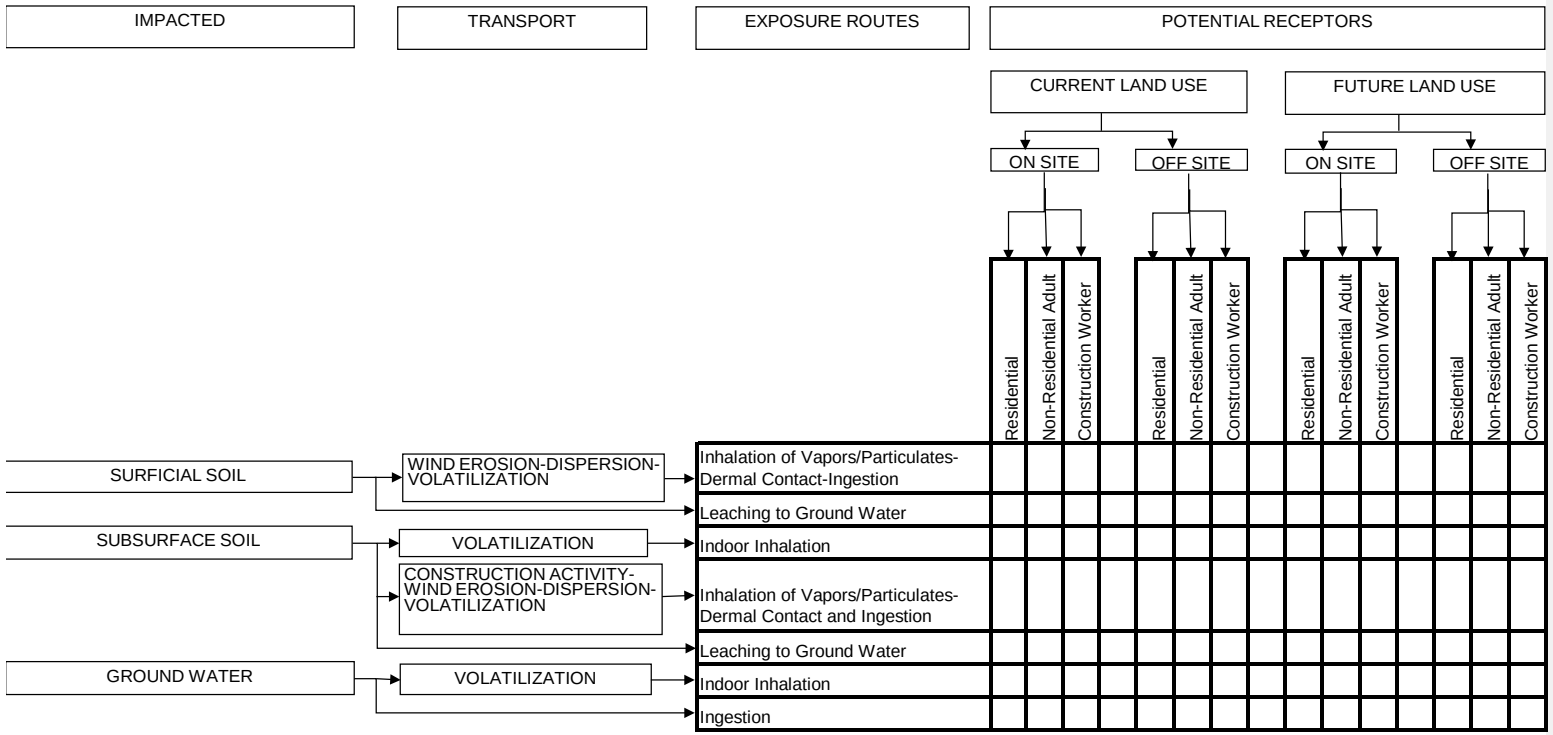
- Characterize the physical setting,
- Identify potentially exposed populations,
- Identify complete or potentially complete exposure pathways,
- Estimate exposure concentrations, and
- Estimate petroleum chemical intakes.

The exposure assessment uses much of the data collected in support of and assumptions contained in the SCM (described earlier in section 4.1). A graphical display of the SCM like the sample shown in Figure 2 is helpful for assessing exposure.

4.3.1 Physical Setting

Characterization of the physical setting for exposure assessment identifies those site factors which may influence the fate and transport of chemicals from the source to a receptor. These factors include climate, meteorology, geologic and hydrogeologic setting, soil types, biodegradation potential, and surface water hydrology. When these factors are considered in the context of the media from which petroleum COIs are released (surficial soils, subsurface soils, groundwater, surface water, etc.), the transport mechanisms for the petroleum COIs from each media (leaching, groundwater transport, volatilization, etc.), and the chemical concentrations and distribution of the petroleum COIs in each media, the potential for a chemical to reach a receptor can be assessed. A more thorough discussion of the data needs related to description of the physical setting can be found in section 4.1 (Site Conceptual Model).

If the migration of petroleum chemicals to a receptor or contact by a receptor is not possible (e.g., due to formal engineering controls such as a paved site that will prevent human contact with petroleum-contaminated soil) under current and most likely future land use conditions, the site-specific petroleum COI concentrations may not pose a risk.



	YES	NO
FREE PRODUCT?		
UTILITIES THREATENED?		
POTENTIAL SURFACE WATER IMPACT?		
ECOLOGICAL RECEPTORS?		

Figure 2. Sample Graphical Display of a Site Conceptual Model

4.3.2 Potentially Exposed Populations/Receptors

Potential exposure populations/receptors should be identified from the information contained in section 4.1 (Site Conceptual Model).

4.3.3 Exposure Pathways

A receptor comes in contact with petroleum COIs through a complete exposure pathway. If some but not all of the following elements are present, the pathway is incomplete. For a pathway to be complete, all of the following must be present:

1. a source of petroleum,
2. a mechanism by which the petroleum is released,
3. a transport medium through which petroleum travels from the point of release to the receptor location,
4. an ROE by which the petroleum chemical enters the receptor's body (ingestion, inhalation, or dermal contact) and
5. a potential receptor.

If the migration of petroleum chemicals to a receptor or contact by a receptor is not possible (e.g., due to formal engineering controls such as a paved site that will prevent human contact with petroleum-contaminated soil) under current and most likely future land use conditions, the site-specific petroleum COI concentrations may not pose a risk.

DEQ has identified the most commonly encountered exposure pathways for various environmental media for which an evaluation must be conducted. These pathways are discussed below. At sites where receptors, exposure pathways, or ROE other than those discussed below are important, the owner/operator must identify them and discuss their quantitative evaluation with DEQ. In some cases it may be determined that one or more of the pathways are incomplete and therefore do not need to be quantitatively evaluated. Adequate justification for exclusion of these pathways must be provided to and approved by DEQ.

4.3.3.1 Pathways for Surficial Soils (0–1 foot below ground surface)

Surficial soils are defined as soils extending from the surface to 1 foot below ground surface. For construction worker exposure, however, the applicable depth is the depth of excavation. The exposure pathways associated with impacted surficial soils include:

- Groundwater protection (leaching of petroleum chemicals from soil to groundwater with subsequent potential ingestion of groundwater),
- Surface water protection (leaching of petroleum chemicals from soil to groundwater with subsequent migration to a surface waterbody), and
- Ingestion of soil, outdoor inhalation of vapors and particulate emissions from soil, and dermal contact with soil.

4.3.3.2 Pathways for Subsurface Soils (1 foot below ground surface to the water table)

Subsurface soils are defined as soils extending from 1 foot below the ground surface to the water table. The exposure pathways associated with subsurface soils include:

- Indoor inhalation of vapor emissions from soil,
- Groundwater protection (leaching of petroleum chemicals from soil to groundwater with subsequent potential ingestion of groundwater), and
- Surface water protection (leaching of petroleum chemicals from soil to groundwater with subsequent migration to a surface waterbody).

4.3.3.3 Pathways for Groundwater

Potentially complete exposure pathways for impacted groundwater include:

- Indoor inhalation of vapor emissions from groundwater, and
- Current and/or future ingestion of water on or off site.

Appendix G describes in detail the process used to evaluate potential exposure via indoor inhalation of vapors from soil and groundwater.

4.3.3.4 Pathways for Surface Water and Sediments

Depending on the beneficial use designation of impacted surface waters, complete pathways for surface water include:

- Intentional ingestion of surface water and ingestion of fish when surface water is used as a drinking water supply, and
- Ingestion of fish from surface waters designated for recreational use.

4.3.3.5 Other Exposure Pathways

Other complete or potentially complete exposure pathways, such as ingestion of produce grown in impacted soils, ingestion of fish, contact with contaminated sediments, or use of groundwater for irrigation purposes, should be evaluated on a case-by-case basis. The owner/operator should contact DEQ for further guidance.

4.3.4 Exposure Point Concentrations

Exposure point concentrations are the average petroleum chemical concentrations to which receptors could be exposed over a specified duration within a specified geographical area. The geographical area about which a receptor moves and within which a receptor contacts contaminated media during the specified exposure duration is termed an exposure unit (EPA, 2001). The exposure unit of all receptors must be considered and described. The exposure unit, or spatial area over which a given receptor is likely to be exposed, must be established for on-site receptors as well as any off-site impacted or potentially impacted receptors and for each exposure pathway or ROE. The same site may have different exposure units for current and future use scenarios.

A detailed discussion of the estimation of exposure point concentrations and the use of exposure units for RE is provided in Appendix I. This appendix describes the sources of uncertainty which affect the estimation of exposure point concentrations, strategies to reduce this uncertainty, and methodologies to evaluate data quality. It also provides guidance on the selection of appropriate data for various ROE and appropriate statistical methods for analysis of available data.

The RE report should clearly identify specific data and methods used to estimate the exposure point concentrations, and provide a rationale for the method used. The following information should be provided in a table:

- Media
- ROE/pathway
- Receptor
- Data used
- Method of estimation

Table 3 shows how such a table might be constructed with examples of the type of information that would be supplied.

Table 3. Example Table Describing Derivation of Exposure Point Concentrations

Media	Route of Exposure	Receptor	Data Obtained From	Method
Surficial Soil	Direct Contact	Construction Worker	Unpaved Area	Average
Subsurface Soil	Indoor Inhalation	Commercial Worker	Building Footprint	Maximum
Groundwater	Ingestion	Residential	Source Area	Upper Confidence Limit
Soil Vapor	Indoor Inhalation	Commercial Worker	Sub-slab or deep soil vapor samples	Maximum

As presented in Table 3, an exposure point concentration is estimated for each complete ROE. Various methods available to estimate the exposure point concentrations are discussed in Appendix I. Use of the maximum concentration as the exposure point concentration is most conservative and also the easiest to calculate when compared with other ways of calculating exposure point concentration (average, area-weighted average, upper limit of the confidence interval around the mean). Thus, if the risk that is calculated using the maximum concentration is acceptable, considerable computational effort can be avoided.

4.3.4.1 Soil

Exposure point soil concentrations used to evaluate protection of the groundwater pathway should be calculated based on soil data collected within the source area only.

Soil data from the most recent investigation (assuming it was a comprehensive investigation) should be used. The use of older soil data (more than 4 years old), while discouraged, may be

acceptable if site conditions that would result in an increase in petroleum COI concentrations (such as a new release) have not changed. If a new release has or may have occurred, additional soil assessment activities that adequately characterize current conditions should be performed. New data collection efforts may be documented in a work plan and submitted for approval by DEQ.

4.3.4.2 Groundwater

Based on the SCM, several exposure point groundwater concentrations at a site may have to be estimated. These could include exposure point concentrations for the source area, at compliance locations, for protection of indoor inhalation on site and offsite, and for off site areas. Estimation of these concentrations will often require the use of fate and transport models, discussed in section 4.3.5.

Comment [MAB6]: inconsistent use of hyphen

In order to account for site-specific conditions such as source characteristics in relation to the depth to groundwater and the age of the release, it is typically necessary to perform multiple sampling events over time to ensure that the potential for the release to impact groundwater has been accounted for and that groundwater concentrations are representative. However, if these factors can be accounted for, it may be possible to perform an RE using data from one sampling event. If temporal data indicate significant variability, additional sampling events may be required prior to conducting the RE. Subsequent to RE, DEQ may require additional monitoring data to be collected. If recent groundwater data (less than one year old) is unavailable, current data may be necessary for the RE. The owner/operator may elect to document data collection objectives in a work plan submitted to DEQ for review and approval.

4.3.4.3 Point of Exposure and Point of Compliance

The point of exposure (POE) is the location where a receptor has or could come in contact with petroleum COIs under current and likely future conditions. A separate POE is associated with each complete exposure pathway-receptor combination identified in the SCM. For direct exposure pathways, the POE is located at the source of the petroleum COIs. For example, for the ingestion of surface soil, the POE is at the same location as the soil source. For indirect exposure pathways, the POE and the source of petroleum COIs are physically separate. For example, for the case of indoor inhalation of vapors from soil, the POE is inside the building (the breathing space) whereas the source is the soil below and adjacent to the building. The POE location for the protection of the groundwater for groundwater ingestion is discussed in section 4.3.3.3.

A point of compliance (POC) is a location where concentrations are measured to determine if compliance with remedial goals has been achieved. Concentration measurements at the POC may be in any media (e.g., soil, groundwater, soil vapor, etc.). The location of a POC may be identical to the POE or may be located between the source and the POE. In the latter case, the target concentrations at the POC are back-calculated to ensure that the concentrations at the POE do not exceed the target concentration at the POE. For example, for the protection of the groundwater pathway, the POC well may serve as a sentry well for protection of the POE. The calculated target levels for the POC are then compared to measured concentrations. POC locations may be predetermined based on program-specific requirements. Most sites, particularly those involving groundwater impacts, will have multiple POC locations.

4.3.4.4 Estimating Point of Compliance Well Concentrations

As a part of the RE process, it is necessary to designate and monitor appropriate POCs. The POCs, located onsite and/or offsite, are used to provide additional assurance that approved concentrations at a selected POE are not exceeded. Monitoring of POC locations is required, and data obtained are compared with approved RATL concentrations. Monitoring of POC locations must be continued until the concentrations stabilize below approved levels. Concentrations at the POC may also be used to determine the need for additional remedial activities.

4.3.5 Fate and Transport and Exposure Models

Different types of models or equations, uptake equations, risk equations, and fate and transport models, are required to calculate chemical intake, risk, exposure point concentrations, and target concentrations. Fate and transport models simulate the transfer of chemicals from one media (such as soil) to another (air). They also are used to simulate the movement of chemicals within a given media, such as the transport of chemicals in groundwater from a source area to a POE. They allow the estimation of concentrations at points distant from the source. A schematic and the equations for each of these models are presented in Appendix E. DEQ has selected the following default fate and transport models:

Indoor Inhalation of Volatile Emissions from Soil and Water: This pathway requires an emissions model and an indoor air-mixing model. These models are combined together and included in the Johnson and Ettinger Model (Johnson and Ettinger, 1991; EPA, 2003). The Johnson and Ettinger Model does not include the effects of attenuation by biodegradation, which may be significant for petroleum COI.

Comment [MAB7]: Should we discuss BioVapor as a future option

Surficial Soil Outdoor Inhalation: This pathway requires an emissions model for vapors, an emissions model for particulates, and an outdoor air-mixing model. The vapor emissions model used is based on the volatilization model developed by Jury et al. (1983) for an infinite source, the particulate emissions model is the Cowherd model (Cowherd, et al., 1985), and the outdoor air-mixing model is based on a simplified form of the Gaussian Dispersion model. These models are presented in Soil Screening Guidance: Technical Background Document (EPA, 1996a).

Leaching to Groundwater: This pathway uses a three-phase equilibrium partitioning equation to convert soil concentrations to leachate concentrations. These leachate concentrations are then used with a dilution attenuation model to simulate mixing of leachate with regional groundwater. Models used are described in Soil Screening Guidance: Technical Background Document (EPA, 1996).

Horizontal Migration in Groundwater: The Domenico steady-state analytical infinite-source model is used to quantify down-gradient migration of chemicals (Domenico, 1982, 1990). This model incorporates the processes of advection, sorption, three-dimensional dispersion, and degradation.

Alternative models may be used with prior DEQ approval.

4.3.5.1 Fate and Transport Parameters

Fate and transport parameters are necessary in the models used to estimate exposure point concentrations and compliance point concentrations for indirect pathways such as vapor intrusion and protection of groundwater. These parameters characterize the physical site properties such as depth to groundwater, soil porosity, and infiltration rate. DEQ has selected the conservative default values listed in Appendix B. Justification for these parameters is included in Appendix B. For RE, a combination of site-specific and default values for these parameters is typically used. However, the value of each parameter used, whether site-specific or default, must be justified based on site-specific conditions. Where fate and transport models other than those selected by DEQ are used, the specific fate and transport parameters required to calculate exposure point concentrations and risk may vary and have specific data collection requirements.

4.3.5.2 Physical and Chemical Properties of the Petroleum Chemicals of Interest

The development of target levels requires the selection of values for the physical and chemical properties of petroleum COIs. Values of these parameters are listed in Appendix C. To use different values, the owner/operator must provide sufficient justification to DEQ. The use of different values will be allowed only with prior DEQ approval. DEQ will update the data in Appendix C as new information becomes available.

4.3.6 Estimation of Chemical Intake

Risk evaluation requires quantifying the magnitude, frequency, and duration of exposure for the receptor populations and exposure pathways selected for analysis. Oral exposures are quantified on a dose per unit body weight basis while inhalation exposure is based on concentration in air.

4.3.6.1 Exposure Factors

In order to determine receptor and pathway-specific intake estimates, it is necessary to select values for a number of exposure parameters in the equations used to calculate intake. The selection of values for the following parameters is based on an assessment of recommendations in various guidance documents, as well as the open scientific literature. When determining these values, it is often necessary to make assumptions. Details and rationale regarding these assumptions are provided in Appendix A. Exposure assumptions for surface water related pathways are incorporated into the toxics criteria for surface water discussed in section 4.6.

Exposure factors describe the physiological and behavioral characteristics of the receptor. These factors include the following:

- Water ingestion rate,
- Body weight,
- Exposure duration for each ROE,
- Exposure frequency,
- Soil ingestion rate,
- Hourly inhalation rates for inhalation of vapors and particulates in outdoor air,
- Exposure times for indoor/outdoor inhalation,

- Dermal relative absorption factor,
- Skin surface area for dermal contact with soil,
- Soil-skin adherence factor, and
- Oral relative absorption factor.

A list of default exposure factors values selected by DEQ and justification for their choice is presented in Appendix A. Site-specific values of exposure factors, other than default values, may be used. However, the owner/operator must submit a proposal for the use of alternative values to DEQ for approval, and approval must be obtained before using alternative values for exposure factors.

4.4 Toxicity Assessment

4.4.1 Chemical-Specific Toxicological Factors

The toxicity of chemicals with carcinogenic adverse health effects is quantified using cancer slope factors (CSF) for oral and dermal ROE, or inhalation unit risk (IUR) for the inhalation route. A CSF is an upper-bound estimate of the probability of a response (developing cancer) per unit intake of a chemical over a lifetime. The IUR is the upper-bound excess cancer risk estimated to result from continuous exposure to a chemical at a concentration of 1 -µg/m^3 in air.

For chemicals that cause noncarcinogenic health effects, toxicity is typically quantified by reference doses (RfD) for oral and dermal ROE, and reference concentrations (RfC) for the inhalation ROE. The RfD is an estimate of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without risk of adverse health effects during a lifetime. Since RfDs are based on oral exposure, they are modified for use in dermal exposure assessment to take account of differences between gastrointestinal and dermal absorption. The RfC is an estimate of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of adverse health effects over a lifetime.

The primary source of information for toxicity factors for the petroleum COI is the EPA RSL tables (RSL) (EPA, 2011) found at:
http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm

Toxicity factors selected by DEQ for the petroleum COIs are presented in Appendix D.

4.4.2 Carcinogens with a Mutagenic Mode of Action

Current EPA guidance for risk assessment of carcinogens addresses the potential for increased susceptibility to cancer from exposure to carcinogens that occurs early in life (EPA, 2005a; EPA, 2005b). When information is available to establish the mode of action of a chemical for early-life and adult exposures, it may be appropriate to develop separate risk estimates for childhood exposure and exposure occurring later in life. When the mode of action cannot be established, risk estimates are based on a lifetime daily average exposure without adjustment. Currently, there is sufficient information to develop separate risk estimates only for chemicals having a mutagenic mode of action.

Specifically, when data indicate a mutagenic mode of action for a chemical, meaning that the chemical interacts directly with DNA, available studies indicate higher cancer risk for a given exposure when it occurs early in life compared to a similar exposure in adulthood. Among the petroleum chemicals of interest, the following carcinogenic chemicals are considered mutagens:

- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Benzo(k)fluoranthene
- Chrysene

For these chemicals, the following adjustments are made to risk estimates:

- For exposures between birth and two years of age, a ten-fold adjustment (multiplication factor) is applied. Toxicokinetic and toxicodynamic differences between children and adults are greatest for this age group.
- For exposures occurring to those in the age categories of two to six years of age and between six and sixteen years of age, a three-fold adjustment is applied.
- For exposures occurring after 16 years of age, no adjustment is applied.

These adjustments are combined with corresponding age-specific exposure parameters to assess cancer risk. For a standard residential exposure scenario of 30 years, a ten-fold adjustment is made for the first two years, a three-fold adjustment is made for the next fourteen years, and no adjustment is made for the final fourteen years of the exposure period.

The screening levels are based on unrestricted (residential) exposure; therefore they incorporate the adjustments described here. The effect of the adjustments will be a somewhat higher estimates of risk for a given exposure (and thus somewhat lower screening levels) compared to risk estimates without age-specific adjustment. Calculated risk estimates for residential exposure will incorporate these adjustments, but nonresidential risk estimates will not, as they are based on adult exposure.

4.5 Risk Characterization

The process of risk characterization consists of combining the intake estimates developed through the exposure assessment and toxicity information for the petroleum COIs and calculating carcinogenic risk and noncarcinogenic hazard. Calculations are made for each pathway-receptor combination and are summed to calculate a cumulative risk and a hazard index (HI) for each receptor. These risk results are then presented and discussed in a risk summary and are compared to acceptable target risk levels.

Risk and hazard calculations are completed using a standard set of risk equations provided by the EPA in their User's Guide for RSLs (EPA, 2011) and presented in Appendix E. Estimates made using these equations should be presented using one significant figure, although an additional significant digit should be carried through the supporting calculations, such as when summing risks from multiple petroleum chemicals or pathways, in order to minimize rounding errors. For example, calculated cancer risks would be presented as 1×10^{-4} and HQs or HIs would be expressed as 2, 0.7, or 0.03.

This risk-based decision-making process specifies the acceptable risk levels for both carcinogenic and noncarcinogenic health effects. For carcinogenic effects, risk is quantified using the individual excess lifetime cancer risk (IELCR) that represents an increase over background in the probability of an individual developing cancer due to exposure to a specific petroleum COI through a specific exposure pathway. Since a receptor may be exposed to multiple petroleum chemicals through multiple ROEs, the acceptable risk level should account for the effect of simultaneous exposure to multiple petroleum chemicals and multiple ROEs. Overall site carcinogenic risk is calculated as the sum of the individual chemical risk estimates. The probability of a receptor getting cancer is thus the sum of the probabilities of getting cancer from exposure to each petroleum chemical through each exposure route. In this calculation there is an assumption of independence of action of the individual chemicals. If the carcinogenic actions of different petroleum chemicals are not independent there is the possibility of synergistic interaction in which case risk may be underestimated. However, information is generally not available to address this possibility.

For noncarcinogenic effects, risk is quantified using an HQ that represents the ratio of the estimated dose of a petroleum chemical for a ROE to the reference or allowable dose. When a receptor is exposed to multiple chemicals and multiple ROEs, individual HQs are added together to estimate the HI.

For site-specific REs, the following target risk criteria must be satisfied at the POE:

Acceptable Target Risk Level: For combined exposure to all carcinogens and ROE, IELCR must be less than or equal to $1x10^{-5}$ for a receptor at a reasonable maximum exposure.

Acceptable HI: The summation of HQs for all petroleum chemicals that have noncarcinogenic health effects and ROE must be less than or equal to 1.

The target risk level and HI must be met for each current and potential future receptor at the site. If the initial calculated HI exceeds 1, further evaluation including analysis of mode of action and target organ for each petroleum chemical can be completed. If this analysis indicates sufficient independence of target organs and mode of action for different chemicals, it may be acceptable to present separate HQs, and/or one or more HI for subsets of the chemicals. This kind of analysis should be performed by a toxicologist.

In addition to the target risk levels, DEQ requires that MCLs, or comparable risk-based values for groundwater ingestion, be met at the POE when there is a high probability of groundwater use. When there is a low probability of groundwater use for drinking water, alternate risk-based groundwater target concentrations, based on the other potentially complete exposure pathways identified for the site, must be met at the POE. Similarly, for impacts to surface water bodies, calculated target concentrations must be met.

The risk summary should include an analysis and discussion of the sources of uncertainty so that the risk estimates can be placed in perspective. The uncertainty analysis can be qualitative or quantitative in nature. It is more important during the analysis to identify the key site-related parameters and assumptions in the SCM that contribute the most to the uncertainty than to precisely quantify the degree of uncertainty (EPA, 1989). It is typically the case that there is insufficient information available at a given site to be able to reliably quantify the uncertainty in

a given risk estimate, such as through conducting a probabilistic risk assessment or sensitivity analysis. The typical sources of uncertainty that are included in the analysis include the petroleum COIs selected and their estimated site concentrations, the toxicity values used, the fate and transport models used to estimate exposure point concentrations, the exposure parameter values used in the exposure assessment, and the summing of risks from multiple pathways or petroleum chemicals.

4.6 Risk-Based Target Levels

As described in the Risk Characterization section 4.5, if the calculated risk or hazard for all petroleum COIs and complete ROE for identified potential receptors exceeds the Acceptable Target Risk or Hazard Levels and corrective action is required, then risk-based target concentrations (RATLs) to achieve these targets should be calculated. Ingestion of water is not included in this calculation. The procedure used to calculate RATLs requires chemical-specific toxicological factors, receptor-specific exposure factors, fate and transport parameters, physical and chemical properties of the petroleum COIs, and mathematical models. In calculating risk-based target concentrations, all of these factors, properties, and models are typically the same as used for calculations of other risk-based levels.

Target concentrations should be estimated using an allocated risk process that apportions the acceptable target cumulative risk and HI among the different chemical-pathway combinations. The primary goal is to develop target concentrations in all media such that the acceptable target risk levels and hazard levels are met. There is no standard way to apportion the cumulative risk. To develop RATL concentrations, the default option selected by DEQ apportions cumulative risk and HI equally among all contributing petroleum chemical-pathway combinations such that those petroleum chemicals which contribute the greatest proportion of the total risk have the most stringent remediation standards. This methodology is described in detail, with examples, in Appendix D and is implemented in the computational software provided by DEQ to complement this guidance.

If a petroleum COI has toxicity that is based on both carcinogenic and noncarcinogenic effects, the applicable RATL for that chemical should be the lower of the two calculated allowable concentrations.

Site-specific considerations may result in an owner/operator choosing to utilize a different method for calculating target concentrations. For example, at a site having volatile and semi-volatile petroleum COIs contributing to the cumulative risk, the owner/operator may choose a technology that specifically reduces the volatile chemical’s concentrations but marginally reduces the concentration of the semi-volatile chemical. A different owner/operator may choose to significantly reduce the concentration of the semi-volatile chemical and marginally reduce the concentration of the volatile chemical. The two strategies will result in different cleanup levels for each chemical; however, both will be acceptable provided cumulative risk meets the acceptable target risk criteria.

4.6.1 Developing RATL Concentrations for Groundwater and Surface Water Protection

For groundwater and surface water protection, target concentrations are calculated using somewhat different procedures, described below.

4.6.1.1 Groundwater Protection

The RATL concentrations for groundwater ingestion are equivalent to the federal MCLs or a risk-based calculated equivalent. MCLs are health-protective target concentrations promulgated by the EPA and adopted by the state of Idaho for the protection of drinking water and specified groundwater resources. For any petroleum COI that has an MCL, the RATL concentration for groundwater ingestion is equal to the MCL. For any petroleum COI that does not have an MCL, the risk-based equivalent level is calculated using the following input values and equations:

- A target risk level of $1x10^{-6}$ for carcinogenic effects and an HQ of 1 for noncarcinogenic effects,
- The residential exposure factors in Appendix A,
- The toxicity values in Appendix D, and
- Risk equations for the direct ingestion of water.

Calculations are made for residential receptors.

The RATL concentrations will apply at the POE. The POE will be the down-gradient property boundary, as it existed when the release occurred, or the nearest down-gradient location where a well exists or could be reasonably placed. Depending on site-specific conditions it is also possible to have multiple points of exposure.

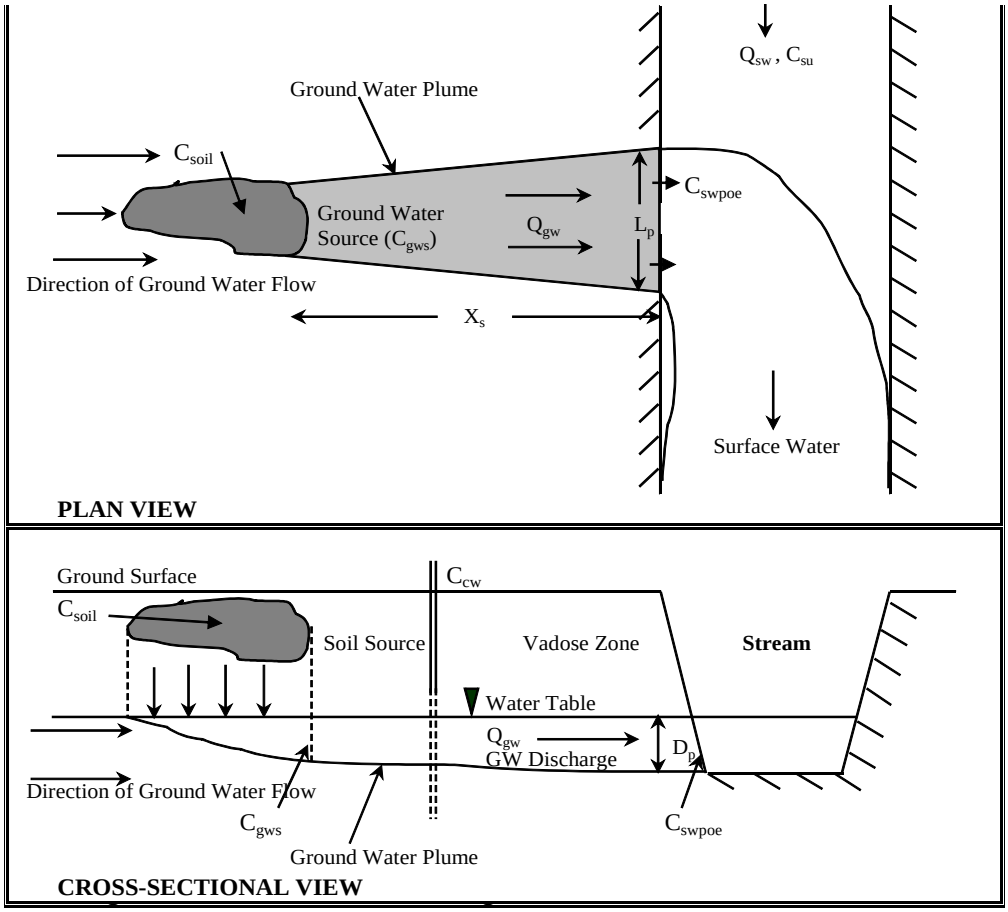
4.6.1.2 Surface Water Protection

Potential impacts to streams and other surface waterbodies from a petroleum release must be evaluated and surface water quality must be protected as per IDAPA 58.01.02 (Water Quality Standards and Wastewater Treatment Requirements). The primary receptors and ROE for potentially impacted surface waters evaluated in the RE process are described in section 4.6.1.2.1. Other ROE, such as contact with contaminated sediments or overland flow discharge, are evaluated on a case-by-case basis.

This section describes the evaluation of potential impacts to surface water via discharge of impacted groundwater to a surface waterbody. A schematic illustrating this exposure pathway is shown in Figure 3. This figure shows the relevant compliance and exposure locations and associated concentrations. Within the RE process, protection of surface waterbodies requires the owner/operator to determine or calculate the applicable surface water standards at the point where groundwater discharges into a surface waterbody (C_{swpoe}). Once the appropriate surface water standard is determined, compliance with the standard may be achieved in a number of ways. These include measuring surface water concentrations at the point of groundwater discharge, measuring groundwater concentrations at the point of discharge into the surface waterbody, or determining appropriate alternate concentrations in other media and at POC locations. Selection of alternate locations may be most appropriate for those sites where contamination has not yet reached a surface waterbody. Alternate concentrations (or RATLs) and POC locations can include:

- Source area soils (C_{soil}), or
- Compliance points in groundwater at different distances between the surface water and the source (C_{cw}) other than the point where groundwater discharges into the surface waterbody.

The owner/operator can back-calculate allowable soil (C_{soil}) and compliance well concentrations (C_{cw}) using dilution attenuation factors (DAFs). Specific equations, combining the Summer's mixing model and the Domenico analytical groundwater transport model, are presented in Appendix E. If measured concentration(s) at the soil source or the compliance well exceeds corresponding allowable concentrations, cleanup to RATL concentrations or performance of a more detailed, site-specific evaluation to refine DAFs are options.



Explanation of Symbols

Q_{sw} = Stream flow upstream of the point of ground water discharge
C_{su} = Concentration upstream of the ground water discharge
Q_{gw} = Impacted ground water discharge into the stream
C_{sw} = Allowable downstream concentration after uniform mixing
C_{swpoe} = Allowable concentration at the point of ground water discharge to the stream
C_{gws} = Allowable concentration in the ground water at the edge of the soil source
C_{soil} = Allowable soil concentration at the source protective of the stream
C_{cw} = Allowable soil concentration in ground water at different distances between the stream and the source
L_p = Width of ground water plume discharging to the stream
D_p = Thickness of ground water plume discharging to the stream
X_s = Distance from the downgradient edge of the ground water source to the stream

Figure 3. Schematic of Leachate Migration from the Soil Source to the Stream

4.6.1.2.1 Surface Water Quality Standards

The allowable concentration at the point of groundwater discharge into the surface water (C_{swpoe}), or the surface water quality standard, depends on the beneficial use designations of the surface waterbody as per IDAPA 58.01.02.100 and criteria assigned to protect those beneficial uses (IDAPA 58.01.02.200-250).

Beneficial uses include:

- Aquatic life: Cold water, salmonid spawning, seasonal cold water, warm water, or modified.
- Recreation: Primary contact or secondary contact.
- Water supply: Domestic, agricultural, or industrial.

Each beneficial use has associated numerical and narrative criteria. Numerical criteria are specified values that are not to be exceeded. For narrative criteria, amounts of the pollutant are not specified, but must be low enough to ensure no negative impacts to the beneficial use.

Comment [MAB8]: We need a better description of what is not to be exceeded

The allowable concentrations for certain toxic substances associated with these beneficial uses are tabulated in Table 4. Criteria B1 and B2 apply to any aquatic life. Numeric criteria for the petroleum COI listed in Table 4 for aquatic life have not been established. Criteria D2 (organisms only) applies to recreation use, while the water and organisms human health criteria (D1) only apply to domestic water supply uses.

Table 4. Surface Water Toxics Criteria for Petroleum Chemicals of Interest.

Chemical of Interest	Fresh Water (B)[a]		Human Health (D) ($1x10^{-6}$ Risk for Carcinogens) for Consumption of:	
	Criterion Maximum Concentration (B1)	Criterion Continuous Concentration (B2)	Water and Organisms (D1)	Organisms Only (D2)
	[ug/L	[ug/L]	[ug/L]	[ug/L]
Benzene			1.2	71
Toluene			6800	200000
Ethylbenzene			3100	29000
Total Xylenes				
Naphthalene				
MTBE				
1,2-Dichloroethane			0.38	99
Ethylene Dibromide				
Acenaphthene				
Anthracene			9600	110000
Benzo(a)anthracene			0.0028	0.031
Benzo(a)pyrene			0.0028	0.031
Benzo(b)fluoranthene			0.0028	0.031
Benzo(k)fluoranthene			0.0028	0.031
Chrysene			0.0028	0.031
Fluoranthene			300	370
Fluorene			1300	14000
Pyrene			960	11000

a. Aquatic Life numeric criteria for these COI have not been established.

4.6.2 Determination of Applicable Risk Based Levels

The calculated allowable RATL concentrations for protection of groundwater and/or surface water and those calculated for other potentially complete exposure pathways are compared to determine which media-specific concentrations will guide the cleanup. Typically, the lower of these concentrations will be selected.

Using groundwater as an example, target POE concentrations will be based on the most limiting concentrations determined from evaluation of the complete or potentially complete pathways in addition to the groundwater ingestion pathway. These pathways may include indoor inhalation of vapors volatilized from groundwater, groundwater impacts to surface water, impacts to deeper groundwater systems with the potential for use as drinking water supplies, and also incidental ingestion of and dermal exposure from irrigation water. Also included is potential impairment of other beneficial uses of groundwater such as for agricultural or industrial water supplies.

The applicable POE will be based on the location of the plume (on-site vs. off-site) and which pathway(s) and receptors are limiting with respect to risk and allowable groundwater concentration. In many cases, particularly if a plume has migrated off-site, there may be multiple POE and pathways that will need to be considered.

For example, a petroleum-sourced volatile organic compound (VOC) plume may have migrated off-site into a residential area and have the potential to discharge to a down-gradient stream. Source area groundwater concentrations on-site must be controlled such that concentrations at the POE where groundwater discharges to the stream meet applicable criteria. In addition, unless vapor intrusion has been separately addressed, such as through the use of soil vapor, residential vapor intrusion criteria in groundwater would need to be met at the down-gradient boundary of the source property and commercial criteria for on-site POE.

4.7 Deliverables

The primary deliverables associated with conducting a site-specific RE typically include an optional work plan for the collection and evaluation of data, an optional data collection report, and the required RE report. In many cases, the results of a data collection effort are combined with the RE report. If the results of the RE report indicate the need for corrective action, a CAP must also be developed and submitted. The contents of CAPs are discussed in Section 5. This section describes the contents of a work plan.

4.7.1 Work Plan

A work plan may be desirable where extensive data collection activities or significant departures from default exposure assumptions or modeling are being proposed.

As appropriate, a work plan to fill identified data gaps may be prepared and submitted to DEQ for review. The amount of detail to be included in the work plan will vary among sites. At sites where a considerable amount of data has already been collected, the work plan may be a brief letter indicating activities to be performed to fill in the data gaps. For a complex or large site, a very detailed work plan, including the SCM, data collection methodology, analysis methods, a data QAPP, and a health and safety plan may need to be developed.

An RE work plan should address each item discussed in sections 4.7.1.1 through 4.7.1.11 as appropriate to the purpose and goals of the RE.

4.7.1.1 Purpose and Goals

The purpose and goals of the work plan should be clearly stated. If the purpose is to fill data gaps, then a listing and description of the data gaps should be provided along with an explanation as to why they constitute data gaps and how the work proposed will fill those gaps.

If the purpose of the work plan is to propose use of alternative models, exposure factors, physical and chemical properties, toxicity factors, or methods of calculating remedial target concentrations, then a rationale should be provided as to why the alternatives proposed are needed. A short description of the scope and nature of the work proposed should be provided.

4.7.1.2 Site Background

This portion of the work plan may refer to documents previously submitted to DEQ; it is not necessary to repeat the entire site background description. Reference should be made to document(s) that contain a comprehensive chronology of site investigations.

4.7.1.3 Site Conceptual Model

A concise summary of the existing SCM should be provided. In those cases where the goal of the work plan is to revise a previously completed RE, then an SCM already exists that can be referenced rather than repeated. If validation or revision of a previous SCM is necessary, those aspects of the current SCM that are the target of the work plan should be described. Refer to section 4.1 for the suggested content of the SCM.

4.7.1.4 Exposure Factors

If alternate exposure factors values are proposed in the work plan these factors must be justified and acceptable to DEQ. The default exposure factor values are listed in Appendix A.

4.7.1.5 Physical and Chemical Properties

Owner/operators should use the default physical and chemical properties for the petroleum COIs as listed in Appendix C.

4.7.1.6 Toxicity

The Rule specifies that toxicity values for petroleum chemicals listed in Appendix D must be used in the RE.

If additional chemicals need to be included in the RE, as provided for in Section 100.02 of the Rule, their physical chemical properties and toxicity values should be obtained from the EPA RSL website (EPA, 2011).

4.7.1.7 Fate and Transport Models

If alternative models are being proposed, the work plan should include reasons for using alternative models; it should demonstrate that the proposed models will better simulate site-specific conditions, and that the sufficient site-specific data are available or will be collected to

justify the use of the proposed model. Alternative models must be approved by DEQ before they are used.

4.7.1.8 Fate and Transport Parameters

Data collection may be proposed to collect site-specific values in lieu of using DEQ default values for fate and transport parameters (listed in Appendix B) used in models for the RE. The parameters for which values are to be obtained should be specified and the methodology used to obtain those values described.

DEQ accepts the use of chemical-specific biological decay rates or attenuation factors in the fate and transport models. Use of decay rates in a RE must use values supported by site-specific information. Refer to Appendices G and H for data necessary to demonstrate occurrence of natural attenuation and methods to calculate decay rates. Examples of this type of information include, but are not limited to:

- Consistent stable or decreasing concentration (above the Residential Use Screening Levels [RUSLs]) trends in properly located and constructed monitoring wells, and
- Measurements of natural attenuation parameters that provide evidence of biodegradation.

4.7.1.9 Calculating RATL Concentrations

The process of calculating target concentrations (RATLs) is described in section 4.6 and Appendix F. If a method of apportioning risk and calculating RATLs different than the DEQ default method is desired, the proposed methodology and rationale for the choice should be described.

4.7.1.10 Methodology and Quality Control

Work plans in support of data collection efforts should describe the methodology that will be used to obtain the data and provide a clear description of the level of data quality required to meet the stated objectives, and how this data quality will be achieved and ensured.

4.7.1.11 Schedule and Deliverables

The optional work plan should include an overall project schedule and deliverables that will be submitted to DEQ. The schedule should include any agency meetings necessary during work plan implementation.

4.7.2 Implementing the Work Plan

Upon receipt of a work plan approval, the owner/operator should implement the work plan according to the schedule in the work plan. In case there are delays, it is the owner/operator's duty to inform DEQ of the delay and revised schedule. If there were deviations in the work performed from that specified in the approved work plan, DEQ should be notified of the deviations and their impact on the goals and purposes of the work plan.

Upon completion of work specified in the work plan, the owner/operator should document the results and submit them to DEQ. If the purpose of the work plan included data collection, the data collection results can be summarized in a separate data collection report or incorporated into a revised RE report.

4.7.3 Risk Evaluation Report

The RE for a site must be clearly and concisely documented and submitted to DEQ for review. An example outline of an RE report is presented in Appendix J.

Section 5. Developing and Implementing Corrective Action Plans

Development and implementation of a CAP may be necessary if, after the screening level evaluation or site-specific RE, concentrations exceed screening levels or an unacceptable risk is identified and the owner/operator has chosen not to perform additional evaluation. The owner/operator must then develop cleanup criteria (also referred to as remediation standards) and create a CAP to achieve those standards or to ensure that the remaining risk is acceptable. The risk management strategy described in the CAP depends on the results of the RE (which pathways, petroleum chemicals, and media are responsible for the unacceptable risk) and other circumstances unique to the site.

5.1 Contents of a Corrective Action Plan

As required in the Rule, the CAP must include:

- A description of remediation standards selected, points of exposure, and points of compliance,
- A description of the remedial strategy and actions to be taken to achieve the remediation standards,
- Current and future land use and use of groundwater and surface water both onsite and offsite,
- AULs that will be required as part of the remedial strategy and the associated environmental covenants,
- Estimated timeline for completion of remedial actions,
- The monitoring plan to gauge effectiveness of the remedial strategy, and
- A description of practical quantitation limits and background concentrations as they apply to the remediation.

Additional elements that should also be a part of the plan include:

- A brief site description,
- A brief description of the RE approved by DEQ, including assumptions used for receptors and land use, and a list of approved cleanup levels for specific pathways, media, chemicals, and specific areas of the site (if applicable),
- A clear description of reasons a CAP is needed,
- An identification of the area(s) to be managed under the CAP,
- A description of the strategy selected to achieve cleanup goals, including a comparison and evaluation of remedial alternatives considered in development of the overall strategy. A rationale for the strategy selected should be presented; any data collected in support of

or to determine the feasibility of a particular remedial measure such as pilot testing, should be presented,
- A description of project closure requirements, and
- A reporting schedule to document progress of the corrective action.

5.2 Implementing a Corrective Action Plan

The CAP should not be implemented until approved by DEQ. Within 30 days of receiving a CAP, DEQ must provide an approval, an approval with modifications, or a rejection (specifying reasons for the rejection) in writing. Provisions are made in the Rule (Section 200.04) for extending this timeframe.

While DEQ is reviewing the CAP, implementation of interim corrective action measures may take place. However, as provided in IDAPA 58.01.02.852.06.c, owner/operators may, in the interest of minimizing environmental contamination and promoting more effective cleanup, begin cleanup of soil, surface water, and groundwater before the CAP is approved provided that they fulfill certain conditions including:

- Notifying DEQ of their intention to begin cleanup;
- Compliance with any conditions imposed by DEQ, including halting cleanup or mitigating adverse consequences from cleanup activities; and
- Incorporation of these self-initiated cleanup measures in the CAP that is submitted to DEQ for approval.

Typical interim corrective actions include excavating and disposing contaminated soil, removing free product, extracting soil vapor, and pumping and treating groundwater.

Upon approval of the CAP, the owner/operator must implement the plan according to the proposed schedule. All performance data should be submitted to DEQ in a timely manner. This data should be carefully evaluated by both the owner/operator and DEQ to determine if the CAP is progressing as anticipated. Major deviations in schedule or plan implementation should be communicated to DEQ for review and approval well in advance of proposed implementation, along with recommended modifications if necessary. The specific modifications that may be needed will vary from site to site.

When the CAP has been successfully implemented, the owner/operator should document these conditions in a completion report along with a petition to DEQ for site closure.

Section 6. Activity and Use Limitations

An AUL is a restriction or obligation, with respect to real property, that is created by an Environmental Covenant pursuant to the Uniform Environmental Covenants Act (UECA), Chapter 30, Title 55, Idaho Code. It is available at:
http://legislature.idaho.gov/idstat/Title55/T55CH30.htm

The purpose of AULs is to reduce the potential for exposure to contaminants at a release site. AULs are also commonly referred to as "institutional controls." AULs are typically proposed to DEQ for approval through the RE process. Non-remedial land use restrictions (e.g., local zoning ordinances) may reinforce the sustainability of AULs; however, they are not considered sufficient by themselves. These types of non-remedial land use restrictions, such as zoning ordinances, may change or be removed without DEQ approval and therefore are not approved by DEQ as part of a CAP. However, non-remedial land use restrictions may be relevant to evaluating current and reasonably likely future use and exposure scenarios at a site.

6.1 Environmental Covenants

Owner/operators may propose an Environmental Covenant as part of the CAP which will include the AUL language. Any proposed Environmental Covenant must be consistent with UECA. Each proposed Environmental Covenant is reviewed and evaluated on a site specific basis.

Following is a *non-exclusive* list of the types of activity and use limitations that may be included in an Environmental Covenant:

- Restrictions on Water Use:
  - Prohibit use
  - Limit use
  - Monitor use
  - Report use
  - Operation and maintenance procedures for physical controls and devices
  - Prohibit well installation and operation
  - Abandon an existing well.
- Restrictions on Land Use:
  - Prohibit, or require DEQ approval for, disturbance of soil, cap, or vegetation
  - Limit activities and land use
  - Limit structures and buildings.
- Actions Regarding Access:
  - Right of Access necessary to implement the activity and use limitation
  - Limit or deny public access.
- Obligations to perform certain actions in order to maintain the effectiveness of an approved corrective action. For example, this may involve the need to do periodic inspections and maintenance in order to ensure that a cover or barrier retains its primary

function. In this case there might be a specific reference in the Environmental Covenant to an Operations and Maintenance Plan, developed as part of the corrective action.

DEQ has an Environmental Covenant template that owner/operators can use when proposing activity and use limitations as part of a CAP. The DEQ website includes a copy of the latest Environmental Covenant template, at *http://www.deq.idaho.gov/media/658745-environmental_covenant_template.doc*, along with instructions for using the template, at *http://www.deq.idaho.gov/media/658749-environmental_covenant_instructions.pdf*. The owner/operator can propose an environmental covenant consistent with UECA for consideration and approval by DEQ.

Comment [MAB9]: We previously requested that this be in an appendix

6.2 Specific Application of Activity and Use Limitations at Petroleum Release Sites

Section 600.01 of the Rule outlines the circumstances under which AULs will be included as part of a CAP. These include:

- Where the assumed onsite land use for the purpose of the RE is not residential and either the maximum media concentrations exceed the screening levels or the calculated risk for a residential receptor is unacceptable
- Where off-site groundwater concentrations exceed RUSLs or risk-based concentrations, and
- Where DEQ determines, based on the proposed CAP, that such AULs are required to assure the continued protection of human health and the environment or the integrity of the cleanup action.

6.3 Use of Activity and Use Limitations at Impacted Neighboring Properties

Implementability and enforceability issues become more complicated when an owner/operator proposes use of AULs on impacted neighboring properties. It is the owner/operators's obligation to negotiate language and reach agreement with both the impacted property owner and DEQ.

6.4 Non-Remedial Land Use Restrictions

Non-remedial land use restrictions (e.g., local zoning ordinances) may reinforce the sustainability of AULs; however, they are not considered sufficient by themselves. These types of non-remedial land use restrictions, typically implemented by other governmental agencies, may change or be removed without DEQ approval and therefore are not approved by DEQ as part of a CAP. The presence of such non-remedial restrictions may be relevant when determining the current and likely future uses of impacted properties.

Section 7. References

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