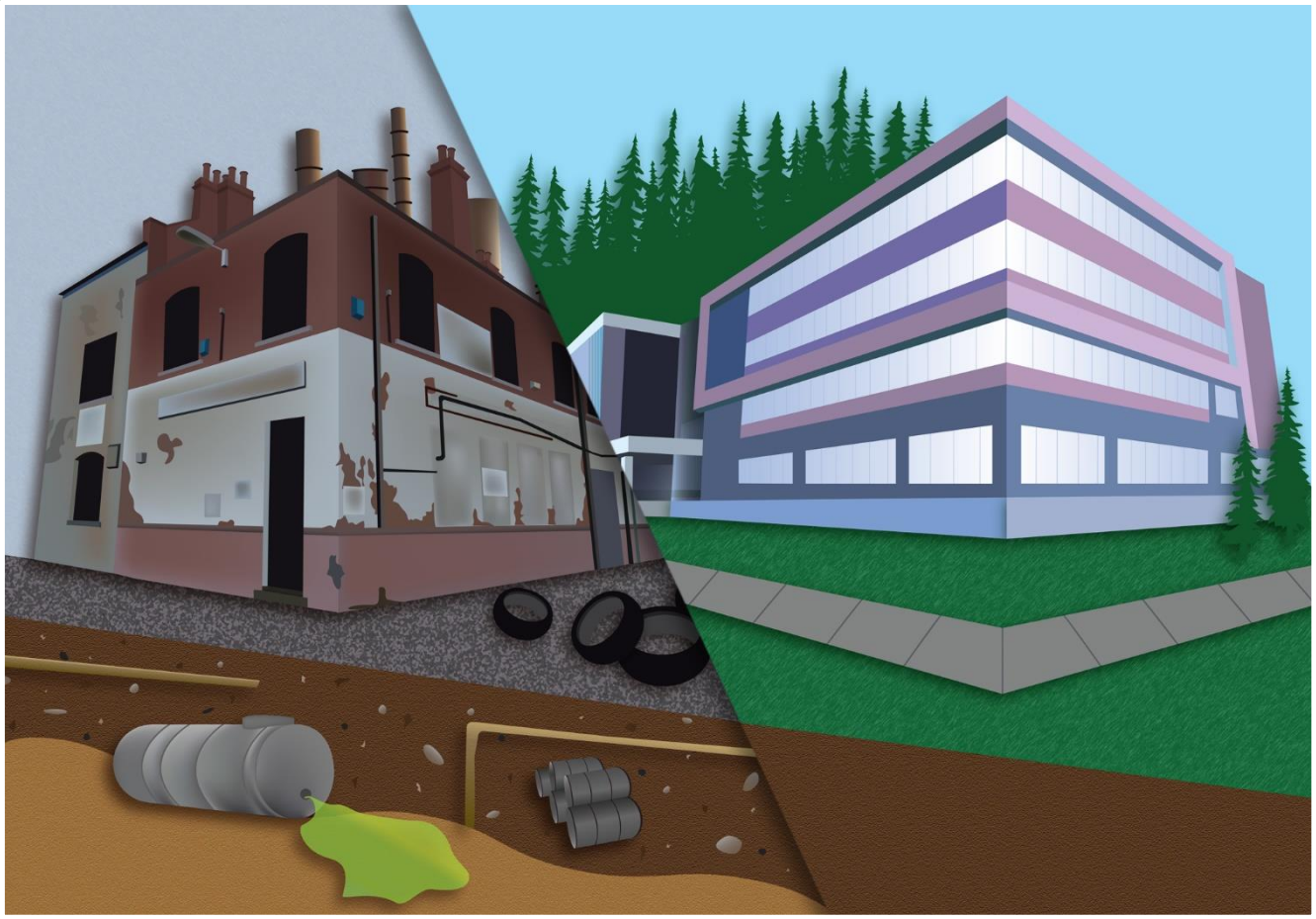
West Virginia

Voluntary Remediation Program



GUIDANCE MANUAL

West Virginia Department of Environmental Protection

June 2020

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Introduction

The *West Virginia Voluntary Remediation Program Guidance Manual* outlines the procedure and requirements of the West Virginia Voluntary Remediation Program (VRP) and provides clarification and guidance for implementing the Voluntary Remediation and Redevelopment Act (W. Va. Code § 22-22-1, et seq.) and Voluntary Remediation and Redevelopment Rule (W. Va. Legislative Rule 60CSR3).

This guidance manual is provided to assist Licensed Remediation Specialists (LRS) and Applicants participating in the VRP, as well as educate citizens and stakeholders, through the process. However, it is not intended to and does not replace or change any part or provision of the Voluntary Remediation and Redevelopment Act, the Voluntary Remediation and Redevelopment Rule, or other statutes, rules, and laws of West Virginia.

The West Virginia Department of Environmental Protection (WVDEP) recognizes that every site is unique and that no one guidance manual will be able to contain all the scientifically valid methods of assessing and remediating contaminated properties. This document provides a framework within which WVDEP can exercise its administrative discretion. Technical and scientific methods included with this guidance are acceptable to WVDEP; however, the LRS may submit alternative or recently developed methods to WVDEP for evaluation and approval before implementing those in the program. WVDEP specifically reserves the right to deviate from this guidance manual where circumstances may warrant such action.

Contact Information

The West Virginia Voluntary Remediation Program is administered by the Office of Environmental Remediation (OER) within the Division of Land Restoration (DLR) at the West Virginia Department of Environmental Protection (WVDEP).

The mission of the Office of Environmental Remediation is to provide for clean, safe, and productive West Virginia communities by assessing and remediating environmental resources and restoring contaminated properties to beneficial use.

Questions about the Voluntary Remediation Program may be directed to:

Office of Environmental Remediation

601 57th Street SE
Charleston, WV 25304

304-926-0499

DEPVRP@wv.gov
DEPLRSProgram@wv.gov

www.dep.wv.gov

Acronym List

AAI	All Appropriate Inquiries
ALM	Adult Lead Methodology
AST	Aboveground Storage Tank
ASTM	American Society for Testing Materials
ATSDR	Agency for Toxic Substances and Disease Registry
AUL	Activity and Use Limitation
BOD	Biological Oxygen Demand
BTEX	Benzene, Toluene, Ethylene, Xylene
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
COC	Certificate of Completion
COC	Contaminant of Concern
COD	Chemical Oxygen Demand
COPC	Contaminant of Potential Concern
CSF	Cancer Slope Factor
CSR	Code of State Rules
DLR	Division of Land Restoration (WVDEP)
DNAPL	Dense Non-Aqueous Phase Liquid
DQO	Data Quality Objective
DWWM	Division of Water and Waste Management (WVDEP)
EPC	Exposure Point Concentration
Eh	Redox Potential
EQB	Environmental Quality Board
ERASG	USEPA Region 4 Ecological Risk Assessment Supplemental Guidance
ESV	Ecological Screening Value
FOIA	Freedom of Information Act
FSP	Field Sampling Plan
GC-MS	Gas Chromatography—Mass Spectrometry
GIS	Geographic Information System
HASP	Health and Safety Plan

ACRONYM LIST

HAZWOPER	Hazardous Waste Operations and Emergency Response
HEAST	Health Effects Assessment Summary Tables
IDW	Investigation Derived Waste
IEUBK	Integrated Exposure Uptake Biokinetic Model
IRIS	Integrated Risk Information System
K_{oc}	Organic-Carbon Partition Coefficient
K_{ow}	Octanol-Water Partition Coefficient
LDR	Land Disposal Restriction
LNAPL	Light Non-Aqueous Phase Liquid
LOAEL	Lowest Observed Adverse Effect Level
LRS	Licensed Remediation Specialist
MDL	Method Detection Limit
MNA	Monitored Natural Attenuation
MOA	Memorandum of Agreement
MTBE	Methyl Tertiary Butyl Ether
NAICS	North American Industrial Classification System
NAPL	Non-Aqueous Phase Liquid
NJDEP	New Jersey Department of Environmental Protection
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No Observed Adverse Effect Level
NPDES	National Pollution Discharge Elimination System
NPL	National Priorities List
OER	Office of Environmental Remediation (WVDEP)
OSHA	Occupational Safety and Health Administration
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PCE	Tetrachloroethene
PCP	Pentachlorophenol
PELs	Permissible Exposure Limits
PID	Photoionization Detector
PPE	Personal Protective Equipment
PQL	Practical Quantitation Limit
PRP	Potentially Responsible Party

ACRONYM LIST

QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RAF	Relative Absorption Factor
RAGS	USEPA Risk Assessment Guidance for Superfund
RBC	Risk-Based Concentration
RCRA	Resource Conservation and Recovery Act
RfC	Reference Concentration
RfD	Reference Dose
RP	Responsible Party
RSLs	USEPA Regional Screening Levels
RSV	Refinement Screening Value
SAP	Sampling and Analysis Plan
SQL	Sample Quantitation Limit
SQuiRTs	Screening Quick Reference Tables
SPLP	Synthetic Precipitation Leaching Procedure
TCE	Trichloroethene
TCLP	Toxicity Characteristic Leaching Procedure
TIC	Tentatively Identified Compound
TNT	Trinitrotoluene
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
TRV	Toxicity Reference Value
TSCA	Toxic Substances Control Act
UCL	Upper Confidence Limit
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UST	Underground Storage Tank
VISLs	USEPA Vapor Intrusion Screening Levels
VRA	Voluntary Remediation Agreement
VRP	Voluntary Remediation Program
VRRA	Voluntary Remediation and Redevelopment Act
VOCs	Volatile Organic Compounds

ACRONYM LIST

WVDEP	West Virginia Department of Environmental Protection
WVDNR	West Virginia Division of Natural Resources
XRF	X-ray Fluorescence

1.0 Program Overview

The West Virginia Voluntary Remediation Program (VRP) encourages companies, communities, and other stakeholders to voluntarily remediate contaminated properties and return them to productive use by providing certain environmental liability protections under West Virginia law. Through the program, Applicants identify and address potential contamination at sites using a series of steps, including:

1. Completing an environmental site assessment
2. Performing a risk assessment
3. Selecting and implementing a remedy
4. Conducting long-term oversight, as necessary

Decisions on how to remedy a site in the VRP are made based on risks the site may pose to human health and the environment. Established cleanup standards are used to decide if a site represents an unacceptable risk. Remedies such as removal, treatment, and control of contamination are used, alone or in combination, to address these risks.

The VRP is a structured and predictable—yet flexible—mechanism to achieve compliance with applicable state and federal environmental requirements. The program is protective of communities and the environment, while promoting economic development and quality of life in WV.

1.1 PROGRAM ESTABLISHMENT

In 1980, U.S. Congress passed the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as the Superfund law, in response to growing concerns over health and environmental risks posed by hazardous waste sites. This law authorizes the United States Environmental Protection Agency (USEPA) to respond directly to releases or threatened releases of hazardous substances that may endanger public health or the environment, seek reimbursement of cleanup expenses from potentially responsible parties (PRPs), and order PRPs to abate releases or threatened releases.

A key element of CERCLA is that whenever possible, the party responsible for contamination must pay for cleanup work performed at a Superfund site. Persons, including buyers, lessors, and even lenders, can be held strictly liable for contamination at hazardous waste sites that they either currently own or operate, or owned or operated in the past, even if a prior owner caused the contamination. Strict liability under CERCLA means that liability for environmental contamination can be assigned based solely on property ownership.

In the years after CERCLA passed, developers and lenders became increasingly risk averse to investment in formerly used properties, citing a fear of becoming a PRP. By the early to mid-1990s, a growing inventory of contaminated—or perceived to be contaminated—properties were left abandoned and untouched throughout the country. In response to this mounting dilemma and to encourage

redevelopment of properties which developers were hesitant to acquire, states began establishing voluntary response programs for brownfields.

The WV VRP was established in 1996 through the Voluntary Remediation and Redevelopment Act (W. Va. Code § 22-22-1, et seq.). An administrative process for the program, outlined in the Voluntary Remediation and Redevelopment Rule (W. Va. Legislative Rule 60CSR3), became effective in 1997. Revisions to the Rule have occurred multiple times since 1997 to reflect scientific progress and incorporate administrative changes.

1.2 USEPA RECOGNITION OF PROGRAM

In 2002, the Small Business Liability Relief and Brownfields Revitalization Act, commonly known as the Brownfields Amendments, amended CERCLA to promote the cleanup and reuse of brownfields. The Act clarified liability defenses, required All Appropriate Inquires (AAI) for liability protections, provided financial assistance for brownfields revitalization, and recognized state response programs. The VRP is a recognized state response program.

In 2010, WVDEP signed a Voluntary Remediation Program Memorandum of Agreement (MOA) with USEPA Region 3 to help property owners, developers, consultants, public officials, and the general public understand the roles and responsibilities of USEPA and WVDEP and the utilization of the VRP to assess and address environmental contamination. The MOA affirms that the agencies "intend to work together to ensure that adequate and timely investigation and cleanup of brownfield sites are conducted, consistent with reasonably anticipated future use, to ensure that the necessary environmental response actions are taken in accordance with applicable federal and state law and are protective of human health and welfare and the environment." Furthermore, it states that the agencies "seek to facilitate the productive redevelopment and sustainable reuse of industrial and commercial properties in WV by minimizing regulatory impediments to the acquisition, cleanup, transfer, and appropriate use or reuse of those properties."

In the 2010 MOA, USEPA states that it supports the use of the VRP at properties where this approach is appropriate for achieving timely and protective cleanups and has determined that the processes in the VRP will result in cleanups that meet the objectives of CERCLA for "eligible response sites". CERCLA § 128(b) provides limitations regarding federal enforcement actions at "eligible response sites", as defined in CERCLA § 101(41), that are being addressed in compliance with a state program that (a) specifically governs response actions for the protection of public health and the environment and (b) maintains and updates a public required, as required by CERCLA. The MOA also specifically states:

> *"USEPA does not anticipate taking an administrative or judicial enforcement action under CERCLA §§ 106(a) or 107(a) against a person regarding a specific release at an eligible response site that is being addressed by that person in compliance with the VRP requirements."*

1.3 ELIGIBLE SITES

Any site is eligible to participate in the VRP, except the following:

- Any site that is subject to a unilateral order issued by the USEPA pursuant to §§ 104 through 106 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. §§ 9604-9606.
- Any site that has been listed or is proposed to be listed on the National Priorities List developed by USEPA pursuant to Title I of CERCLA, unless USEPA has formally delisted it.
- Any site that is subject to a unilateral enforcement order under § 3008 or § 7003 of the Resource Conservation and Recovery Act (RCRA), 42 U.S.C. § 6928 or § 6973.
- Any site that is subject to a unilateral enforcement order for corrective action issued pursuant to any provision of Chapter 22 of the WV Code.
- Any site where the release that is subject to remediation was created through gross negligence or willful misconduct by the Applicant.

Most sites that participate in the program are considered brownfields, which are abandoned or under-utilized properties where expansion, redevelopment, or reuse is complicated by the presence or potential presence of contamination. However, the VRP is available for currently operating sites as well, even when the Applicant has caused or contributed to the site contamination. Sites that fall under this category may include:

- Leaking Underground Storage Tank (LUST) Program sites
  - *If an open leak case related to the site exists, the Applicant must obtain approval for the alternative cleanup program from the WVDEP Tanks Corrective Action Unit (TCAU).*
- RCRA Corrective Action Program sites
  - *The Applicant must assure that requirements for both the RCRA Corrective Action Program and VRP are satisfied throughout the assessment and remediation process.*
- Sites that are covered by a federal or state consent order
  - *The Applicant must assure that requirements for both the consent order and VRP are satisfied throughout the assessment and remediation process.*

1.4 KEY ELEMENTS

The VRP is a unique program within WVDEP, with key elements that set it apart from traditional environmental enforcement programs.

1.4.1 Risk-Based Remediation

Risk-based remediation standards for soil, sediment, and groundwater are used to determine cleanup actions in the VRP. These allow for current and future land and water uses to be considered in the

cleanup process, while providing adequate protection of human health and the environment. The incorporation of site-specific information also allows for more cost-effective remediation based on identified site risks.

For any voluntary remediation, one or more remediation standards may be utilized. At some sites, the property may have areas ranging from severely contaminated to nearly pristine; under these circumstances, different standards may be appropriate for different sections of the property.

The following standards may be utilized as appropriate for any particular site:

- De Minimis
- Uniform Risk-Based
- Site-Specific Risk-Based
- A combination of these remediation standards

1.4.2 Licensed Remediation Specialists

Remediation of a site in the VRP must be supervised by a Licensed Remediation Specialists (LRS). An LRS is an individual certified by WVDEP as qualified to supervise the assessment and remediation of contaminated sites. Licensed Remediation Specialists must meet minimum education and experience requirements, pass an examination administered by WVDEP, and obtain continuing education.

The LRS is employed by the VRP Applicant at usual and customary professional rates. However, the LRS must be completely objective in developing and reviewing work plans, reports, and opinions. The LRS represents the interests of the public, in additional to providing technical supervision of all remedial activities. It is the Licensed Remediation Specialist's duty to protect the safety, health, and welfare of the public in the performance of his or her professional duties.

One LRS is responsible for supervision of all site remediation activities. However, due to the nature of complex contaminated sites, it is unlikely that a single individual will have the skills and knowledge to perform all activities associated with the remediation. In these circumstances, the LRS must only perform assignments for which he or she is qualified by training and/or experience in those specific technical fields. The LRS will seek assistance from other qualified professionals as needed in performing work at the site.

For more information about the LRS Program, refer to the *WVDEP Licensed Remediation Specialist Program Guide*.

1.4.3 WVDEP Oversight

The Office of Environmental Remediation (OER), an office within the Division of Land Restoration (DLR), at WVDEP administers the VRP and performs an oversight function with respect to work that is performed through the program. The OER Project Manager, Technical Analyst, and Environmental Toxicologist will work closely with the LRS to evaluate and verify completion of remediation activities at

each site. The oversight function extends to review and approval of work plans and reports; periodic inspection of sites accepted into the program; access to and review of all records relating to activities under the program; and performing sampling at sites in the program. The degree of OER oversight will increase with the size and complexity of the site.

1.4.4 Public Involvement

WVDEP encourages Applicants to communicate with local government and interested community members regarding data collected, current conditions, remediation plans, and expected impacts to the surrounding community. Early, frequent, and meaningful involvement with the interested public can create a strong and cooperative project that meets the needs of both the developer and the public.

In cases where many stakeholders have strong interest in a site, a multi-pronged approach to public involvement is recommended to provide facts and resolve conflicts. Methods such as speaking at public meetings, presenting to community organizations, establishing advisory committees, and visiting the site are useful for identifying and addressing public concerns.

At a minimum, the following public involvement activities are required for all VRP projects:

1. In compliance with the WV Freedom of Information Act, WVDEP makes all documents related to the VRP project available to the public, unless the information or parts thereof is designated confidential and, if made public, would divulge methods, processes, or activities entitled to protection as trade secrets.
2. The Applicant provides a copy of the VRP application to the municipal or county commission office where the remediation is proposed and where any member of the public may view and/or copy the application. The municipal/county clerk may designate an alternative location, such as a public library, development office, or other easily accessible county facility.
3. WVDEP publishes a summary of the VRP application in a press release distributed through the agency's Public Notice Mailing List and to media outlets serving the general area where the remediation is proposed.
4. WVDEP publishes a summary of the application in a public notice in a newspaper of general circulation in the area where the site is located.

In addition, when an Applicant proposes a carcinogenic risk greater than $1x10^{-6}$ for individual carcinogens for development of residential remediation goals, or greater than $1x10^{-5}$ for development of industrial remediation goals, the Applicant is required to notify and engage the public in development of the remediation goals through a 30-day comment period and informational meeting. Specific steps for this process are outlined below.

1. The Applicant notifies the public of the start of the comment period by publishing an advertisement in a local newspaper of general circulation in the county where the remediation is

occurring. The advertisement includes information from the original public notice, as well as the date, time, and location of the informational meeting; measures at least 4" x 4"; and is published once a week for 4 consecutive weeks.

2. The Applicant sends a copy of the advertisement to the municipality, the county commission, and either the county and/or municipal land use agency or the area's Regional Planning and Development Council created under W. Va. Code § 8-25-2.
3. The Applicant holds an informational meeting in the community where the remediation is occurring by day 21 of the 30-day comment period to address how remediation concerns apply to the site, including site risk issues such as key exposure assumptions, uncertainties, populations considered, and the context of site risk to other risks, and how the remedy will address site risks.
4. The Applicant responds to all comments received during the comment period and submits both the comments and the responses to WVDEP.
5. WVDEP reviews the comments and Applicant's responses to determine a final decision on the remediation goal and communicates the decision to all parties who commented.

1.5 BENEFITS

Remediation of sites through the VRP is mutually beneficial to Applicants and communities.

1.5.1 Applicant Benefits

From the time of application until the Voluntary Remediation Agreement (VRA) is signed, the Applicant receives protection from any enforcement action related to the subject contamination, so long as the Applicant acts in good faith to negotiate a reasonable Agreement. Under the VRA, WVDEP agrees to not initiate any enforcement action against the Applicant for the contamination that is the subject of the Agreement, unless there is an imminent threat to the public.

The most attractive benefit for Applicants is the ultimate relief from all liability to the state for the release that caused the contamination that was subject of the voluntary remediation. The state will not institute any civil, criminal, or administrative action or claim arising from the release and resulting contamination. This relief is provided in the Certificate of Completion that is issued by WVDEP upon completion of the remediation. Furthermore, the covenant bars actions from all public and private claims arising under Chapter 22 of the WV Code or rules adopted thereunder in connection with the subject contamination.

For sites that meet the CERCLA § 101(41) "eligible response site" definition, Applicants also receive the relief from USEPA taking administrative or judicial enforcement actions for the subject contamination.

In addition to liability relief, Applicants experience benefits such as:

- Structured and predictable regulatory process
- Prompt guidance and oversight from WVDEP

- Time and cost savings by remediating a site to risk-based standards
- Enhanced property value due to elimination of risks for lenders or buyers
- Possible access to financial incentives, including grants and loans

For entities establishing, relocating, or expanding their operations, remediating and redeveloping a brownfield through the VRP provides additional benefits:

- Access to ideal property locations previously utilized by industry:
  - Concentrated urban settings
  - Highway, rail, and river access
- Cost savings from use of existing utilities and infrastructure

1.5.2 Community Benefits

Cleanup and redevelopment of contaminated properties reinvigorates communities and stimulates local economies. Communities experience many environmental, social, and economic benefits, including:

- Eliminated or reduced exposure to contamination
- Improved public health and safety
- Conservation of greenspaces
- Decreased blight and crime
- Preservation of historic landmarks
- Increased private investment
- Created and retained jobs
- Enhanced property values and resulting tax base
- Increased revenue for public services

1.6 ASSOCIATED COSTS

The VRP is a self-funded program, and fees are associated with participation.

- Application Fee
  All VRP Applications must be submitted with the appropriate application fee of $1,000, $3,000, or $5,000. The application fee amount is determined based on the property size, years of operation for any non-residential activity, and historical use of the site (identified by NAICS Codes).
- Administrative Costs
  When signing a VRA, the Applicant agrees to reimburse WVDEP for all of its reasonable administrative costs associated with the project, at the rate of 3.5 times the hourly rate of the primary employee assigned to the site, plus any actual and direct expenses associated with the project (e.g., laboratory analysis).

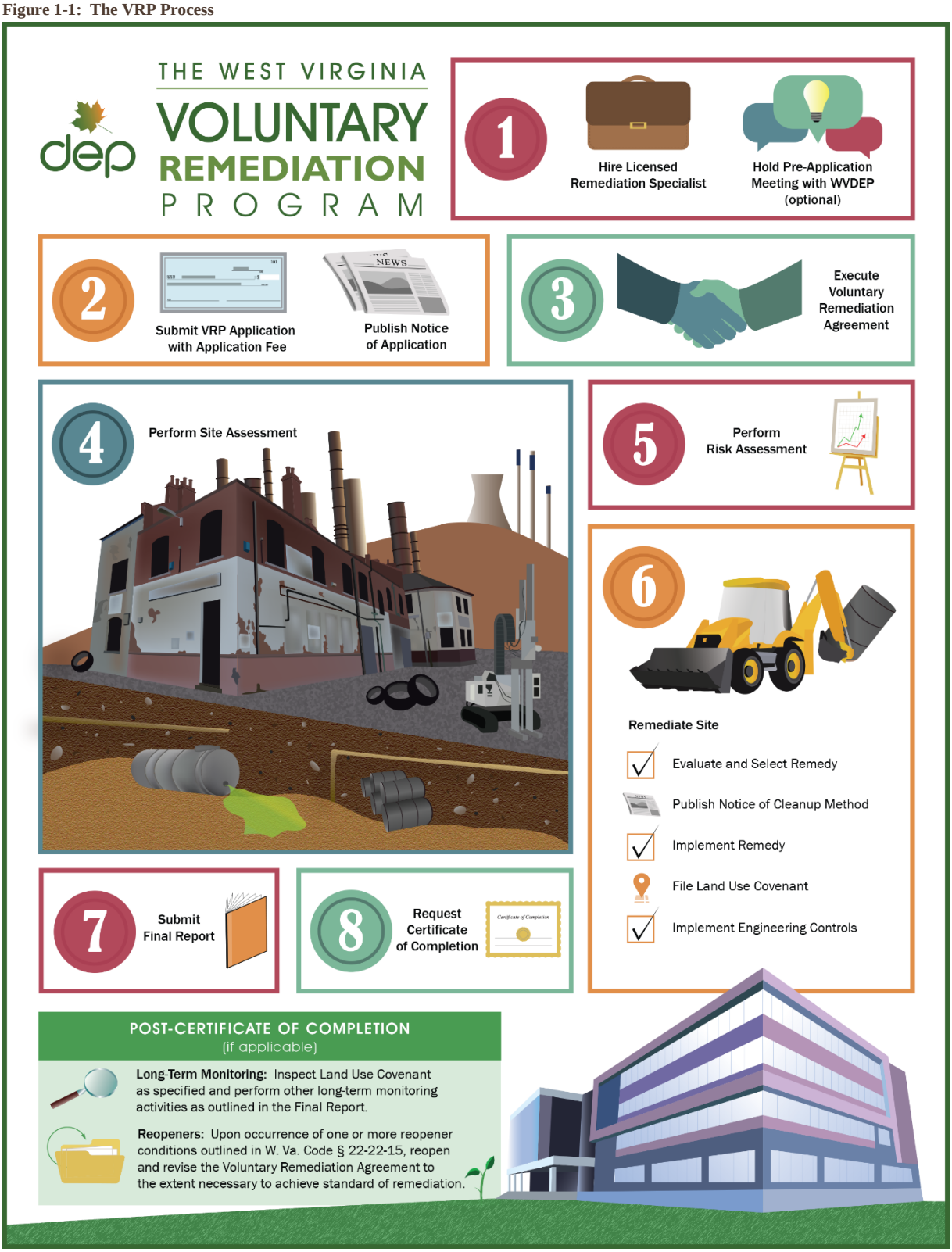
WVDEP will send the Applicant an itemized list of estimated in-house costs that WVDEP expects to incur under the VRA within 60 days of approval of the initial work plan. In addition, WVDEP will allow the Applicant to review and comment on the scope of work and associated cost estimates for any outside contractors (i.e., any individuals, partnerships, or corporations paid to assist in oversight activities such as risk assessment) prior to WVDEP's authorization of the contractor to proceed with the associated work.

Site assessment, remediation, and LRS services costs are negotiated separately between the Applicant and the LRS.

1.7 PROCESS

Figure 1-1 illustrates the VRP process, and the remaining sections of this *VRP Guidance Manual* outline these processes in further detail. All program forms and templates can be found on the OER website.

Figure 1-1: The VRP Process



2.0 Application and Agreement

Participation in the program may be initiated by the owner or operator of a site, a developer, prospective purchaser, or other interested party. After eligibility for the program has been determined, the potential Applicant should hire an LRS to supervise site assessment and remediation activities and, if desired, request a pre-application meeting with WVDEP.

2.1 PRE-APPLICATION MEETING

The pre-application meeting is not mandatory but is strongly recommended to discuss the site's current and future uses, timelines associated with the VRP process, site features, and contaminants of potential concern with the Applicant, LRS, and WVDEP staff. Previous site investigation documents may also be helpful to discuss the scope of the project at the pre-application meeting.

2.2 APPLICATION

The application cannot be reviewed by the OER Project Manager until both the application and application fee are submitted to WVDEP. The application fee can be paid via check made payable to the West Virginia Department of Environmental Protection. The fee is calculated based on the points assigned to the property using the following criteria:

- Size of property
- Years of operation for any non-residential activities
- Historical use of site (NAICS code(s))

The total number of points will determine the application fee of $1,000; $3,000; or $5,000. If the application covers two or more non-contiguous locations, the application fee is $5,000, provided that the locations display similar contaminant profiles and surface and subsurface characteristics.

The OER Project Manager has 45 days from receipt of the application to review the application and either approve the application, reject the application, or accept the application subject to correction. If the OER Project Manager needs more than 45 days to review the application, both the Applicant and the OER Project Manager must agree to the extension and confirm in writing. Should the OER Project Manager accept the application subject to correction, the application should be corrected and resubmitted to WVDEP generally within 60 days.

2.3 VOLUNTARY REMEDIATION AGREEMENT

Upon approval of the Application, the Applicant and WVDEP have 31 days to negotiate a Voluntary Remediation Agreement (VRA). The Rule specifies content requirements for VRAs; Appendix 60-3A of the Rule is provided as a standard VRA format for No Further Action Investigation Activities, and Appendix 60-3B of the Rule is provided as a standard VRA format for Investigation and Remediation

Activities. Agreements to be completed and submitted for participation in the VRP should be downloaded from the OER website.

Where the Applicant is a person other than the current owner of the site and the imposition of a Land Use Covenant (LUC) is contemplated, the VRA shall include a provision signed by the current site owner(s) authorizing and agreeing to cooperate in the execution and filing of an LUC.

If an agreement is not reached within 31 days, either party may withdraw from the negotiations, and WVDEP would retain the application fee. By mutual agreement, if it becomes impractical to reach agreement within 31 days, the time may be extended in writing.

Once the VRA is executed, WVDEP is barred from beginning any enforcement actions against the Applicant for the site and contamination under the agreement, unless there is an imminent threat to the public or either party withdraws from the VRP. The VRA establishes limitations on liability under environmental laws and rules for those persons who remediate sites in accordance with applicable standards. This protection does not cover releases occurring during ordinary business activities after application of the site into the VRP and not covered under the VRA.

At the Applicant's discretion and in the interest of minimizing environmental contamination, soil and groundwater cleanup may begin before the VRA is signed and fully executed so long as the Applicant notifies WVDEP in writing.

3.0 Site Assessment

A site assessment must be performed to identify actual or potential contaminants at the site. Although a site assessment is required to be submitted with the VRP Application, the requirements for that site assessment are limited, and the information available from that assessment is not typically adequate to meet the minimum requirements for characterizing site contamination that are set forth in the Rule:

- Collection and analysis of a sufficient number of environmental media samples so as to provide a reasonable characterization of the nature and distribution of site contaminants.
- Collection of samples to be of sufficient quantity and quality to calculate appropriate exposure point concentrations (EPCs) for purposes of risk assessment.
- Collection and analysis of samples from those media that are reasonably anticipated to have been impacted from contaminants at the site, considering the nature of the site operations and the nature of the contaminants of potential concern at the site.
- Analysis of the samples of environmental media for those contaminants that are reasonably anticipated to be encountered, considering the nature of the site operations and the nature of the substances used or disposed of at the site.

The scope of any additional site assessment will be developed during the initial site visit attended by the LRS, Applicant's risk assessor, OER Project Manager, and OER Environmental Toxicologist. The site visit will include discussion and observations regarding potential sources of contamination on and adjacent to the site, contaminants of potential concern, and potential receptors and exposure pathways. Following the initial site visit, the LRS will develop a Site Assessment Work Plan (SAWP).

For purposes of this section of the *VRP Guidance Manual*, the terms site assessment, site characterization, and site investigation all refer to the activities undertaken to identify and investigate actual or potential contaminants at the site.

3.1 SITE ASSESSMENT PROCESS

The site assessment process is illustrated in Figure 3-1 and includes the following components:

(a) Preliminary Site Characterization

A thorough description of historical operations and regulatory status must be provided in the VRP Application to evaluate likely sources and locations of contaminated media. The site history should describe land and water resource uses on and adjacent to the site, any historical environmental investigations, site physical characteristics, and identification of potential human and ecological receptors. Descriptions of historical site investigations should include the number and location of samples from each media and pathway and the validation level of the data. The preliminary site characterization will be used to determine the need for further site assessment.

Factors that impact the need for further site assessment include having enough data from each media and pathway to calculate a Reasonable Maximum Exposure (RME), meeting the VRP data validation requirements for each media and pathway, and delineating the nature and extent of contamination sources and plumes.

(b) Conceptual Site Model (CSM)

The CSM is the most fundamental and critical component for the development of site assessment, risk assessment, and remedial action. The preliminary CSM, developed as part of the preliminary site characterization and provided with the VRP Application, is based on historical site usage and any available analytical data from sampling of soils and other media and pathways of concern (i.e., surface soil, subsurface soil, groundwater, surface water, soil vapor, indoor air, and sediments). The CSM identifies actual and/or expected contaminants of potential concern (COPCs), the nature and extent of contamination to the degree known, the potential pathways for migration of contamination, and the potential receptors. WVDEP promotes the use of a project lifecycle CSM that may be used to support project and site decisions unique to each stage of a cleanup project. The CSM is continuously updated as more information becomes available.

(c) Site Assessment Work Plan (SAWP)

If the preliminary site characterization indicates that further site assessment is required to meet the requirements of the VRP regulations, the LRS will develop a SAWP. The SAWP must be designed to determine if a release has occurred, the concentrations of COPCs in each environmental medium, and the physical characteristics of the media. The SAWP must address three primary elements: a description of the rationale and processes used in collecting and analyzing samples (the Field Sampling Plan or FSP), site-specific processes for ensuring data quality in both the field and laboratory (the Quality Assurance Project Plan or QAPP), and site-specific processes for ensuring the health and safety of site workers during the assessment work (the Health and Safety Plan or HASP). All three elements of the SAWP (FSP, QAPP, and HASP) must be approved by WVDEP before any site assessment field work can begin.

(d) Site Assessment

Once the SAWP has been approved by WVDEP, the LRS may conduct the site assessment following procedures outlined in the SAWP. In addition to the concentrations of COPCs in the applicable media and pathways, the site assessment should include physical descriptions of soil types and textures, staining and/or odors, moisture content, grain size, etc. Soil borings should include a detailed log prepared by someone experienced or trained to identify soil types and textures.

(e) Site Assessment Report (SAR)

After the collection and analysis of samples as outlined in the SAWP, the LRS will submit a SAR. The LRS may recognize the need for supplemental site assessment before submitting the SAR, or

WVDEP review of the SAR may reveal the need for supplemental site assessment. Any additional assessment will need to follow the same site assessment procedures beginning with a Supplemental SAWP. Once WVDEP has approved the SAR and any Supplemental SARs, the LRS may proceed with the next step in the VRP process (either risk assessment or remedial action).

In many cases, site assessment is an iterative process that will continue until adequate data are collected to allow for evaluation of potential risks posed by the site and/or appropriate remedial alternatives for the site.

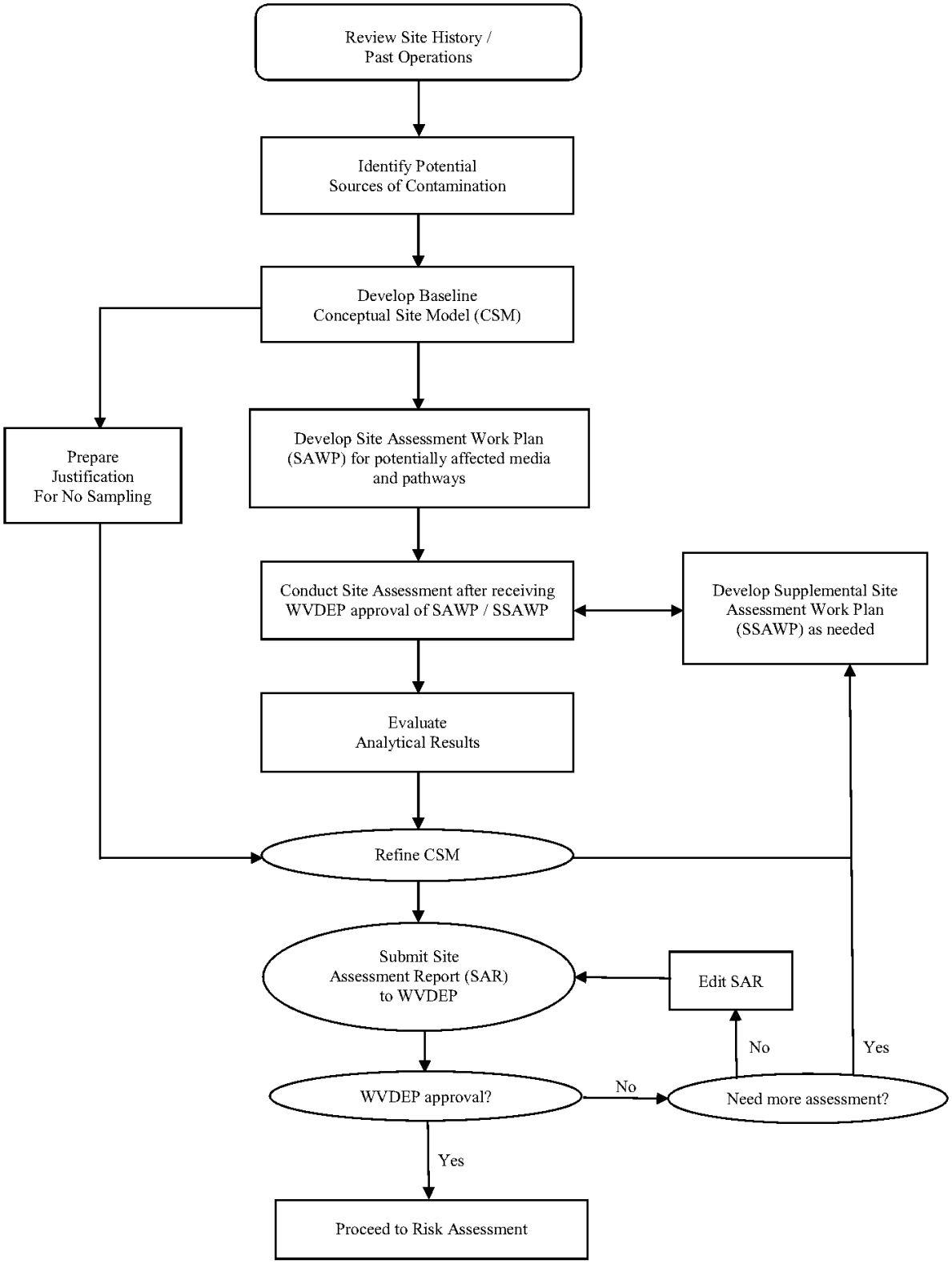
The following subsections describe in more detail the components of the site assessment. However, the *VRP Decision Trees* (Attachment 3) should be reviewed before beginning the site assessment process to ensure they understand the decision points that will guide the need for data from site investigations.

3.2 SITE CHARACTERIZATION OBJECTIVES

The objectives of site characterization are as follows:

- Identify potential site-related contaminants (COPCs) reasonably expected to be at or near the site.
- Identify potential pathways for contaminant migration.
- Determine the presence or absence of those contaminants in the media and pathways of concern.
- Identification of the nature and extent of contamination.
- Identification of the potential receptors of the contamination.

Figure 3-1: Site Assessment Process



3.3 PRELIMINARY SITE CHARACTERIZATION

A site characterization provided with the VRP Application should generally be initiated with literature review and a comprehensive site visit by the LRS. The three primary areas of research during the preliminary investigation should include a review of the following, which are then used to develop the preliminary CSM:

1. Information about the site history to identify the COPCs and anticipated areas where those chemicals have been handled
2. Information about the physical characteristics of the site that may influence the distribution and migration pathways of the COPCs
3. A listing of the potential environmental receptors and associated exposure pathways.

3.3.1 Evaluation of Historical and Current Land Uses to Identify COPCs

The scope of work for the historical investigation will depend on the nature of the property (e.g., gasoline station vs. chemical manufacturing plant) and the requirements of the potential property buyer/developer. The American Society for Testing and Materials (ASTM) has developed a generally accepted standard for historical research of properties, *ASTM E1527 Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process*. This practice is intended primarily as an approach to conducting an inquiry designed to identify recognized environmental conditions in connection with a property. One or more site visits should be performed by the LRS or authorized representative to confirm the accuracy of available mapping; confirm information obtained during the historical reviews and interviews; and look for visual evidence of potential contamination sources (e.g., stained soils, fill/vent pipes from underground or aboveground storage tanks, stressed vegetation, drums, waste piles, etc.). It is beneficial to have a knowledgeable current or former site employee participate in the site visit to identify potential areas of concern to the LRS.

3.3.2 Preliminary Evaluation of Site Physical Characteristics

The site location should be shown on a large-scale map (e.g., USGS 7.5-minute quadrangle) as well as a smaller scale map that shows major site features (e.g., buildings, streets, tanks, water wells, gas wells, etc.). For large and complex sites, it may be appropriate to have a surveyed topographic base map prepared for the site.

In addition to documentation of the surficial site features, available information about subsurface conditions should be documented. This information should include, but not limited to:

- Characteristics of the site soils (e.g., grain size, permeability)
- Depth to and lithology of bedrock
- Presence of bedrock structural features (e.g., faults, folds, fractures, solution features)
- Depth to groundwater, aquifer thickness, and direction of groundwater flow

- Relative permeability of the site formations
- Presence of water bodies (e.g., lakes, ponds, streams, springs, wetlands)
- Relationship between groundwater flow and surface water features
- Preferential migration pathways (e.g., subsurface utilities)

This information can be developed by review of existing reports and published literature, as well as information gathered during the site reconnaissance by a geologist or qualified LRS.

3.3.3 Use of Historic Analytical Data

Analytical data collected prior to enrolling a site in the VRP (e.g., Phase II ESA data) may be used to characterize the nature and extent of contaminants at a VRP site and determine EPCs, as long as the data was collected and analyzed using procedures and methods that ensure data quality and approval by OER. At a minimum, historic data should be used qualitatively to guide the location of samples collected as part of a VRP site assessment. To be utilized quantitatively in the VRP to determine EPCs, historic data must meet the minimum requirements of the VRP Rule, such as having been analyzed by a WVDEP Certified Laboratory and 10% of the data to be used in the risk assessment achieving Stage 4 validation. If historic data does not meet VRP requirements based on data validation requirements, additional samples may be collected for validation, or unvalidated samples can be validated retroactively if adequate records are available from the analytical laboratory.

3.3.4 Preliminary Identification of Potential Human and Ecological Receptors

A preliminary identification of potential human and ecological receptors must be performed prior to evaluating potential risks. The CSM Worksheet located in the VRP Application assists with identifying appropriate receptors. This initial evaluation should consist of a literature review and site visit by the LRS or their representative. During the site visit, the following general items should be observed:

- Current and likely potential future land uses
- Any visible signs of trespassers
- Location, distance to, and description of on-site and adjacent water bodies (e.g., streams, rivers, lakes, wetlands)
- Visible signs of contamination and contaminant source areas (e.g., stained soils, stressed vegetation, tanks, etc.)
- Potential migration pathways off-site and/or to sensitive environments (e.g., drainage patterns, topography, utilities)
- Source Water Protection Areas and Wellhead Protection Areas

After this information is gathered, it is important to combine this data with information collected during the evaluation of historical and current land uses and preliminary evaluation of site physical characteristics to determine if contaminant migration pathways to receptors or sensitive environments are possible.

3.3.4.1 Human Receptors

In addition to the general items presented above, specific items related to human receptors should be evaluated. Specific items to be evaluated include:

- Describe the current and reasonably foreseeable future use of the site (e.g., residential, commercial, industrial) and the closest off-site receptors.
- Identify sources of local drinking water, particularly Source Water Protection Areas, Wellhead Protection Areas, and Zones of Critical Concern. A door-to-door well survey may be necessary in some instances (e.g., if drinking water is obtained through private wells).
- Identify any known or anticipated recreational activities (e.g., recreational fields, playgrounds, fishing, swimming, boating) that may result in an increased potential for human exposure.

The above data can be obtained through a site visit, review of the zoning records, conversations with residents, and correspondence with the appropriate state or local government offices. In addition, this information may be available from previous investigations for the site or surrounding areas, USGS topographic maps, and other literature/maps.

3.3.4.2 Ecological Receptors of Concern

Ecological receptors of concern are defined as specific ecological communities, populations, or individual organisms protected by federal, state, or local laws and regulations, or those local populations which provide important natural or economic resources, functions, and values. The ecological assessment portion of this preliminary evaluation consists primarily of a literature review and a site visit to determine the potential for ecological receptors of concern that may be impacted by contaminants originating from the site.

More detailed ecological investigations, discussed in Section 4, may be required if the preliminary evaluation concludes that there may be impacts to potential ecological receptors of concern such as:

- Surface water bodies or wetlands that function as feeding, breeding, nesting, resting, or wintering habitat for migratory waterfowl or other aquatic birds, or that function as spawning or nursery areas critical for the maintenance of fish/shellfish species
- Critical habitat for federal or state designated threatened, endangered, or otherwise protected species as defined in 50 Code of Federal Regulations (CFR) 424.02

- Habitat known to be used or potentially used by federal or state designated threatened, endangered, or otherwise protected species including those listed in the State Wildlife Action Plan
- Area designated as a National Preserve, Federal Wilderness Area, National or State Parks or Forests, National or State Wildlife Refuges, or other wildlife management areas
- Federal or State scenic or wild river, or trout-stocked streams or wild trout streams with verified trout production
- Federal or State fish hatcheries
- Other Federal, State, or local Designated Critical Biological Resource Areas or Conservation Areas

During this preliminary evaluation, most of this information may be obtained by contacting WVDEP and/or the following agencies. It should be noted that this list is not inclusive of all agencies that may be able to provide information about valued environments.

- National Park Service, Washington DC
- Nature Conservancy, Washington DC
- U.S. Fish and Wildlife Service, Elkins, WV
- WV Land Trust
- WV Division of Natural Resources (WVDNR), Charleston, WV
- WVDNR, Natural Heritage Program, Elkins, WV

A site visit is necessary to initially evaluate the presence of items that may not be identified in the literature (e.g., small water bodies or wetlands). The site visit also is important to better identify potential contaminant migration pathways from the site to ecological receptors of concern and valued environments. Refer to Section 4 for details on ecological site characterization and management goals.

3.3.5 Development of Conceptual Site Model

The CSM is an iterative, "living interpretation" of a site that summarizes and assists the project team in visualizing and understanding available information. The creation and revision of a CSM is a critical project planning and management tool that is used for development of the sampling program, risk assessment, and remedial design. Because of the importance to all aspects of the project, the CSM should be developed at the beginning of the project, prior to preparing the SAWP. The USEPA now advocates the use of a "project lifecycle conceptual site model" as a best management practice. A complete project lifecycle CSM contains six stages: Preliminary CSM, Baseline CSM, Characterization CSM, Design CSM, Remediation/Mitigation CSM and Post-Remedy CSM. Although each of the six phases are not necessary to every VRP project, the iterative and transitional nature of the CSM is applicable.

Generally, the LRS should develop a Preliminary/Baseline CSM prior to preparing the SAWP; develop a Characterization CSM after all site assessment is complete; develop a Remediation CSM following risk

assessment; and, develop a Post-Remedy CSM after all remediation is complete and the VRP site meets the selected remediation standards. The Preliminary/Baseline CSM is provided in the SAWP; the Characterization CSM is included in the SAR; the Remediation CSM is presented in the risk assessment; and the Post-Remedy CSM is presented in the Remedial Action Completion Report or the Final Report, as applicable.

The purpose of any CSM is to provide a visual representation and to identify the following:

(a) Contaminants and source areas (residual chemicals in abandoned tanks, lagoons, sumps, contaminated soils, etc.)

(b) Release mechanisms (leaking tanks, infiltration of precipitation through contaminated soils, etc.)

(c) Impacted media (soil, groundwater, surface water, sediments, air, building materials, etc.)

(d) Migration pathways (groundwater, windblown dust, river transport, utility conduits, former sewer/storm water system, subsurface vapor migration, etc.)

(e) Ecological and human receptors

(f) Exposure routes (inhalation, ingestion, or direct contact)

The LRS generally can develop a reasonably complete Preliminary/Baseline CSM after completion of historical and geological research about the property and after conducting site reconnaissance. Much of this information may be available in the Phase I ESA, if one has been prepared for the site. Note that it is important that the Preliminary CSM include all current and future sources, media, and migration pathways that are of plausible concern.

As the investigation proceeds and additional data are generated, the lifecycle CSM will be refined, and pathways added or excluded as appropriate. When additions/exclusions occur, the rationale must be documented in the text of the CSM.

Figure 3-2 is an example of a pathway analysis diagram for a hypothetical site that has completed some initial phases of investigation. Figure 3-3 illustrates a more complex site, which has more data available for consideration in the CSM.

Figure 3-2: Example Preliminary Conceptual Site Model for Hypothetical Abandoned Service Station

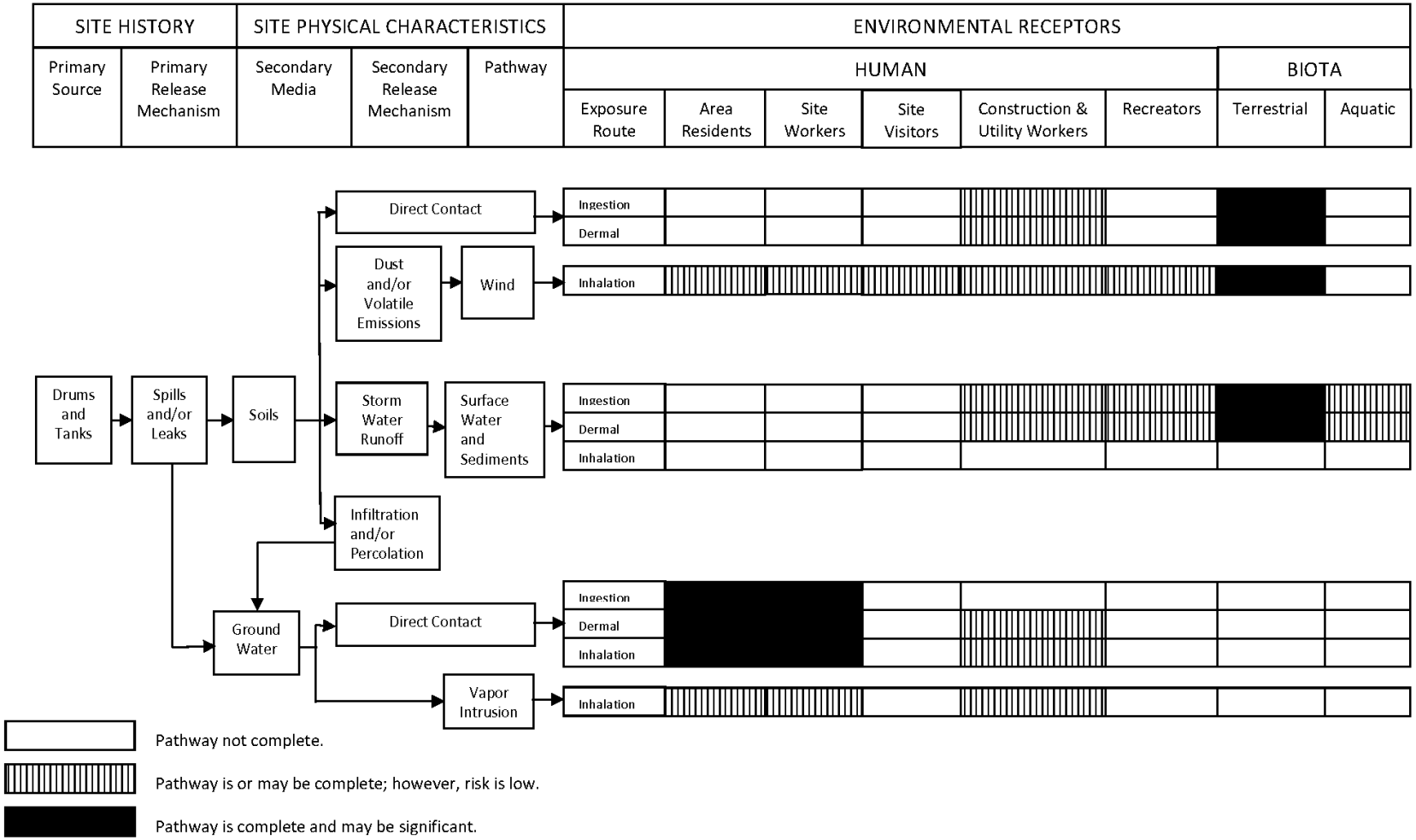
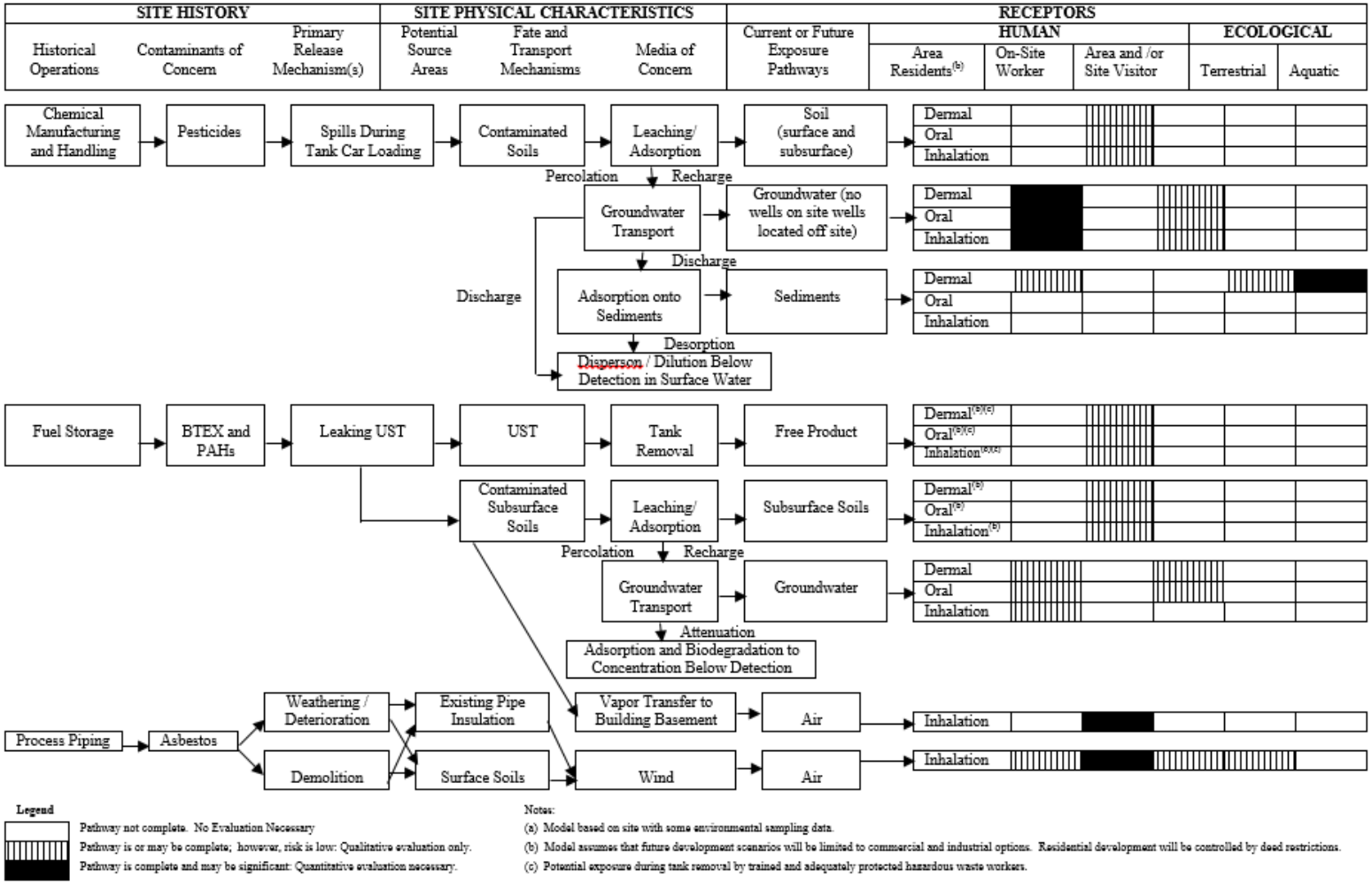


Figure 3-3: Example Characterization Conceptual Site Model for Hypothetical Abandoned Industrial Riverfront Property



3.4 SITE CHARACTERIZATION TECHNIQUES

Various site characterization techniques are available. Specific site characterization techniques and their potential applicability are discussed in the following subsections.

3.4.1 Non-Intrusive Characterization Techniques

There are several remote sensing methods that can be employed for site characterizations, including visible photography, infrared photography, ground penetrating radar, and thermal infrared scanning. In most cases, remote sensing techniques are used to identify changes in land use, determine groundwater preferential flow pathways, and detect near surface leachate/contamination.

Surface geophysical techniques are usually employed in the initial stages of the field program for locating subsurface anomalies (e.g., drums, debris, and pipelines) or characterizing the geology or contaminant plumes. The most routinely used techniques include ground penetrating radar, electromagnetic induction, electrical resistivity, seismic refraction, metal detection, and magnetometry.

The following guidance documents provide information on remote sensing and surface geophysical methods, and focus on the usability/limitations of each technique:

- USEPA. 1993. Subsurface Characterization and Monitoring Techniques. EPA/625/R-93/003a.
- USEPA. 1984. Geophysical Techniques for Sensing Buried Wastes and Waste Migration. EPA/600/7-84/064.
- USEPA. 1993. Use of Airborne, Surface, and Borehole Geophysical Techniques at Contaminated Sites: A Reference Guide. EPA/625/R-92/007.

3.4.2 Field Screening and Field Analytical Characterization Techniques

Field screening methods provide a qualitative or semi-quantitative indication of contamination in site media (primarily soil and groundwater) based on a threshold level for a given technique. In most cases, field screening techniques are performed during the initial phase of the site characterization to confirm suspected areas of concern, help locate an area of concern, or identify soil samples that may be contaminated. Standard Operating Procedures (SOPs) for field screening are presented in the WVDEP/DLR/OER QAPP; see SOP OER-0101 (PID) for volatile organic field screening and SOP OER-0102 (XRF) for metals field screening.

In most cases, field screening techniques are limited to volatile and metal contaminants, although field screening can also be performed for other suites of compounds (e.g., PCBs, PAHs, and pesticides). The most commonly used field screening and analytical techniques are photoionization detector (PID) screening of soil samples, soil gas surveys, field immunoassay test kits, and X-Ray Fluorescence (XRF).

A soil gas survey is designed to characterize vapors in pore spaces due to subsurface soil and groundwater contamination. Because the technique involves the testing of vapors within the soil pore space, the

technique is primarily suited for characterizing volatile organic compounds such as solvents and some components of petroleum products. The sampling operation is relatively quick and produces a small diameter boring (usually only a few feet in depth). The samples may be collected quickly by vacuum/suction, or through the use of passive absorbent media, that is left in the boring for a few days. The soil gas samples may be analyzed in the field using a gas chromatograph or submitted to a qualified laboratory to assess the presence of specific contaminants (e.g., BTEX, TCE, PCE). By producing the data in a rapid format, field decisions can be made with respect to delineation of contaminants during the initial phase of investigation.

Field test kits are used for on-site detection of contaminants. The test kits offer reasonably accurate results within a relatively short period of time. The tests are analyte-specific, and sensitive to levels necessary for regulatory compliance. Test systems can be purchased for characterizing PCBs, total petroleum hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAHs), pentachlorophenol (PCP), trinitrotoluene (TNT), and other chemicals in soil.

The following references provide additional information with respect to field screening and analytical techniques:

- USEPA. 1987. A Compendium of Superfund Field Operations Methods, Part 2. EPA/540/P-87/001 (OSWER Directive 9355.0-14).
- USEPA. 1988. Field Screening Methods Catalog: User's Guide. EPA/540/2-88/005.
- USEPA. 1991. Second International Symposium, Field Screening Methods for Hazardous Waste and Toxic Chemicals. EPA/600/9-91/028.

3.4.3 Intrusive Characterization Techniques

Intrusive characterization techniques are required to obtain surface or subsurface soil samples and primarily include drilling, direct push technology, test pit excavation, and hand-held methods. Standard Operating Procedures (SOPs) for several soil sampling techniques are presented in the WVDEP/DLR/OER QAPP; see SOP OER-0120 (Soil Sampling), SOP OER-0121 (Direct Push Sampling), and SOP OER-0122 (USEPA Method 5035 for VOCs).

Subsurface drilling is required to characterize subsurface soil and bedrock conditions, and to install piezometers and monitoring wells. Drilling methods should be selected based on availability, suitability for the type of geologic conditions at a site, and potential effects on sample integrity. The following references provide additional information pertaining to drilling and soil sampling methods:

- Aller, Linda, et al. 1989. Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells. National Water Well Association.
- ASTM. 1983. Standard Practice for Thin-Walled Tube Sampling of Soils. D1587-94, (Vol. 4.08).

- ASTM. 1991. Guide for Soil Sampling from the Vadose Zone. D4700-91. (Vol. 4.08).
- ASTM. 1992. Method for Penetration Test and Split-barrel Sampling of Soils D-1586 -84 (Vol. 4.08) – Reapproved 1992.
- ASTM. 1993. Draft Standard Guide for the Use of Air-Rotary Drilling for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices. D18.21 Ballot 93-03, April 28, 1993.
- ASTM. 1993. Draft Standard Guide for the Use of Direct Rotary Drilling for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices. D18.21 Ballot 93-03, April 28, 1993.
- ASTM. 1993. Draft Standard Guide for the Use of Hollow-Stem Augers for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices. D18.21 Ballot 93-03, April 28, 1993.
- ASTM. 1993. Practice for Diamond Core Drilling for Site Investigation D-2113-83 (Vol. 4.08) – Reapproved 1993.
- ASTM. 1993. Standard Guide for Investigating and Sampling Soil and Rock. D420-93, (Vol. 4.08).
- ASTM. 1995. Standard Practice for Soil Investigation and Sampling by Auger Borings. D1452-80, (Vol. 4.08) – Reapproved 1995.
- Federal Remediation Technologies Roundtable. 1998. Field Sampling and Technologies Matrix Version 1.0.
- USEPA. 1993. Subsurface Characterization and Monitoring Techniques – A Desk Reference Guide – Volumes 1 and 2. EPA/625/R-93/003a&b.
- USEPA CLU-IN Field Analytic Technologies – Direct Push Platforms, 2009.
- USEPA Region 4, 2014, *Operating Procedure – Soil Sampling*; SESD PROC-300-R3, USEPA Region 4, Athens, GA, 24 pp.

Direct push technology (e.g., cone penetrometers and Geoprobe[R],) is used to collect lithologic data and/or soil samples for chemical analyses. Direct push technology typically takes less time than conventional drilling and is less expensive. In addition, it results in less investigation-derived waste (IDW). The disadvantage of the direct push technology is that it has difficulty penetrating certain geologic conditions and is somewhat limited in depth.

The following references provide additional information on the use of the direct-push sampling technique:

- ASTM. 1986. Standard Test Method for Deep, Quasi-Static, Cone and Friction-Cone Penetration Tests of Soil. D3441-86. (Vol. 4.08).
- ASTM D6282 / D6282M-14, Standard Guide for Direct Push Soil Sampling for Environmental Site Characterizations, ASTM International, West Conshohocken, PA, 2014, www.astm.org.
- Chiang, C.Y. et al., Characterization of Groundwater and Soil Conditions by Cone Penetrometry. In: Proceedings (6th) National Water Works Association (NWWA)/American Petroleum Institute (API) Conference, Dublin, Ohio. Pp. 175-189.
- Christy, T.M. and S.C. Spradlin. 1992. The Use of Small Diameter Probing Equipment for Contaminated Site Investigations. Groundwater Management 11:87-101 (6th NOAC).
- USEPA Region 4, 2014, *Operating Procedure – Soil Sampling*; SESD PROC-300-R3, USEPA Region 4, Athens, GA, 24 pp (Chapter 5).

Hand-held sampling techniques include the use of scoops, shovels, and augers. Scoops and shovels are used in cases where the purpose of the sampling is to obtain surface soil samples (top 6-12 inches only). Hand or power augering is quick and less expensive than the other methods, but the technique is limited to the depth in which samples can be collected and geologic conditions. Additional information can be obtained from the following references:

- USEPA. 1987. A Compendium of Superfund Field Operations Methods, Part 2. EPA/540/P-87/001 (OSWER Directive 9355.0-14).
- USEPA. 1991. Description and Sampling of Contaminated Soils: A Field Pocket Guide. EPA/625/12-91/002.
- USEPA Region 4, 2014, *Operating Procedure – Soil Sampling*; SESD PROC-300-R3, USEPA Region 4, Athens, GA, 24 pp.

Test pit excavation offers the advantage of visually inspecting subsurface features and debris which may be contained under the ground surface. However, test pitting is limited to a depth of approximately 15 to 20 feet or until the water table is encountered. Test pitting is performed using a conventional hydraulic excavator.

3.4.4 Site Infiltration and Vadose Zone Characteristics

Contaminants released onto the land surface can infiltrate to the shallow subsurface above the water table and percolate to groundwater. The relative rates of infiltration and percolation can provide an indication of the likelihood that contaminants could descend to the groundwater. Information on infiltration and permeability rates can contribute to the feasibility evaluation or remedial design.

The appropriate field methods for permeability testing of the vadose zone, either at land-surface or in a borehole, are found in the ASTM and USDA-Soil Conservation Service references. Methods for

laboratory testing of consolidated and unconsolidated materials should follow the appropriate ASTM method. The following provides references for some of the field methods that may be selected for this investigation:

- ASTM. 1990. Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Perimeter. D-5084-90 (Vol. 4.09).
- ASTM. 1991. Guide for Soil Sampling from the Vadose Zone. D4700-91 (Vol. 4.08).
- ASTM. 1994. Practice for Thin-Walled Tube Sampling of Soils. D1587-94, (Vol. 4.08).
- ASTM. 1994. Test Method for Infiltration Rate of Soils (in Field) Using Double Ring Infiltrometer. D-3385-94 (Vol. 4.08).

3.4.5 High-Resolution Site Characterization

More sophisticated methods are also available for collecting environmental data, such as high-resolution site characterization (HRSC), which are designed to collect data on the scale at which heterogeneities in the subsurface control contaminant transport (centimeter to meter scale). By collecting data on the appropriate scale, HRSC more thoroughly identifies and addresses data gaps, which reduces uncertainty in the lifecycle CSM. HRSC methods are supported by the Interstate Technology & Regulatory Council (ITRC), Federal Remediation Technologies Roundtable (FRTR), and the Nielson Field Training School, among others. Prior to implementing HRSC methods, the OER Project Manager and OER Environmental Toxicologist should be consulted. More information on HRSC may be found on the USEPA's CLU-IN website.

3.4.6 Source Considerations

Many leaking underground storage tank (UST) sites are accepted into the VRP after significant site investigation and remedial actions have been completed. However, once in the VRP, all sources of potential contamination at the site must be investigated. For older service stations, this may include auto repair and maintenance areas as well as leaded gasoline releases. Surface soil samples (0-2 feet) are generally not collected when investigating UST releases, but are required once the site is accepted into the VRP. Dispenser areas are especially susceptible to surface spills and should be targeted for surface soil sampling. Spills and overfills in the tank basin area may also require surface soil investigation. Vapor intrusion into buildings and utilities may also be of concern and requires investigation. Specific areas associated with the UST system that should be investigated for releases include the tank, submerged turbine pump manholes, piping runs, dispensers and vent pipes.

Aboveground storage tanks (ASTs) present many of the same investigation challenges as underground storage tanks. Similar to other types of releases, all potential and actual sources of contamination must be investigated at the AST site once application to the VRP has been made and accepted. Unlike USTs, many sources of releases from ASTs may be visible and easily identified. However, releases may occur from the base of an in-ground or on-ground tank and travel directly to the subsurface, contaminating soil and groundwater. Releases from ASTs situated near surface waters have a high potential to impact those

waters, some of which may be sources for drinking water supplies. Specific areas associated with an AST system that may require investigation include the tank (especially supports and foundations), piping, fittings, flanges, sumps, valves, pumps, any dispensing equipment and secondary containment areas.

3.5 SITE ASSESSMENT WORK PLAN

Prior to data collection, a SAWP must be prepared by the LRS and approved by WVDEP. The SAWP is developed using information from the Preliminary/Baseline CSM and defines data collection necessary to develop the Characterization CSM. The SAWP must include a description of the rationale and processes used in collecting and analyzing samples (FSP), site-specific processes for ensuring data quality in both the field and laboratory (QAPP), and site-specific processes for ensuring the health and safety of site workers during the assessment work (HASP), and the requirements must be consistent and work together to control all sample collection, handling, laboratory analysis, and quality measures utilized to meet the project data quality objectives (DQOs).

Minimum requirements for a SAWP are provided in the *Site Assessment Work Plan Checklist* and *Quality Assurance Project Plan Checklist* (Attachments 2 and 3). Critical components include sample locations and number, sampling methods, analytical methods and detection limits, quality control samples, DQOs and level of data validation required, and health and safety procedures.

The primary driver for analytical data quality is typically risk assessment requirements. In particular, the site investigation will need to quantify the concentrations of COPCs in the media and pathways of concern at detection levels low enough to allow for evaluation of risks to potential receptors. The data may also be needed for preparation of a remedial action plan or to support contaminant transport modeling.

The assessment should be designed to collect sufficient data for the LRS to refine the Characterization CSM until adequate data are available for risk assessment, remedial selection/design, and/or it is determined that site media meet De Minimis Standards. The LRS should balance performing assessment in phases to avoid unnecessary investigations of certain media (e.g., groundwater) against minimizing the number of phases of assessment by anticipating data needs for risk assessment, remedial design, and modeling (as applicable) early in the site investigation process.

3.5.1 Data Quality Considerations

The DQOs for the project should be established prior to preparation of a SAWP. The DQOs are qualitative and quantitative statements that clarify the intended use of the data to be collected, define the type of data needed to support the decision, identify the conditions under which the data should be collected, and specify the acceptable limits on the probability of making a decision error based on the uncertainty of the data. Ten percent (10%) of the analytical data used to develop EPCs for risk assessment at VRP sites must be validated to Stage 4 (see Attachment 8 – *Data Validation Report Checklist* and "Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use," OSWER No. 9200.1-85, EPA 540-R-08-005). Data validation is an independent evaluation of the

analytical laboratory work product performed by a chemist who is not affiliated with the analytical laboratory and is knowledgeable of the preparatory and analytical test methods used. Submitting a laboratory data package does not constitute data validation.

The samples chosen for validation can be selected prior to field work. Standard USEPA protocols for validation (e.g., Contract Laboratory Protocol unless designated otherwise in the QAPP) should be used. However, these protocols may be modified with OER approval, depending on the type of analyses performed and DQOs. In some cases, data from previous non-validated investigations may be utilized in the site assessment in a qualitative manner. Data from previous investigations that has been validated at a lower level (i.e., Stage 2A, 2B and 3) can be used quantitatively in the risk assessment as long as all other requirements have been met, including 10% Stage 4 validation.

WVDEP must be able to verify that investigative work, risk assessment, confirmatory sampling, and other remediation tasks will be conducted in a manner that will provide reliable analytical results and an accurate life cycle CSM. Examples of quality requirements are:

- Analytical reporting limits should be at or below the remediation standards.
- Field screening techniques must include proper instrument calibration.
- Sample collection procedures must not impair the sample integrity.

Data generated under the VRP should meet requirements for precision, accuracy, representativeness, comparability and completeness (PARCC), and documentation. The PARCC DQOs are to be described and defined in the QAPP.

Quality assurance/quality control (QA/QC) procedures will be performed in accordance with the WVDEP/DLR/OER QAPP, applicable professional technical standards, government regulations and guidelines, and specific project goals. The QA/QC procedures are required for both on-site analyses (e.g., field screening) and laboratory analyses. The level of the QA/QC must be based on the project DQOs. Samples collected during assessment activities are to be logged on a chain-of-custody form. The following QC samples are generally applicable to VRP fieldwork:

- Field duplicate samples
- Equipment blank samples
- Trip blank samples (one per cooler containing VOC samples / trip blank may also serve as cooler temperature blank)
- Matrix spike/matrix spike duplicate samples
- *Split samples may also be appropriate at the discretion of WVDEP*

See Table 3 in the WVDEP/DLR/OER QAPP for frequency of collection of QC samples.

3.5.2 Selection of Analytical Methods

Routine analytical services used for VRP projects should use USEPA or other approved methods and applicable updates, such as those listed in:

- USEPA. 1983. Methods for Chemical Analysis of Water and Wastes, EPA 600/4-79-020, 1983 rev.
- USEPA. 2015. Test Methods for Evaluating Solid Waste, Office of Solid Waste and Emergency Response, Washington, DC, SW-846 Third Edition, Update V.

Non-standard methods must be approved by WVDEP.

At a minimum, a description of the analytical method, type and number of sample containers, preservation techniques, QA/QC requirements, and detection limits should be provided in the SAWP. This information should be presented by media and sample location in a table to facilitate efficient review. All required QA/QC, as specified in the analytical method, should be implemented during the analysis unless the laboratory can demonstrate that modifications to the method provide better results. The QA/QC information to be reported is based on the DQOs for the parameter.

Analytical methods used must be performed by a WVDEP Certified Laboratory under W. Va. Legislative Rule 47CSR32 (Environmental Laboratories Certification and Standards of Performance). The laboratory must develop and follow a current laboratory QAPP, including a SOP manual for chemical analyses, to meet the quality control requirements of W. Va. Code § 47-32-5. Certification also requires the laboratory meet proficiency testing requirements in W. Va. Code § 47-32-3.10 and WVDEP inspection requirements in W. Va. Code § 47-32-3.11.

3.5.3 Health and Safety Considerations

OER requires that a site-specific HASP be prepared and submitted with the SAWP. The Occupational Safety and Health Administration's (OSHA) Hazardous Waste Operations and Emergency Response (HAZWOPER) standards are applicable to VRP site investigations, and these standards require the development of a site or project-specific HASP. The HASP must include the following elements:

- Safety and health hazard analysis by task
- Employee training requirements (e.g., 40-hour initial training and 8-hour refreshers)
- Personal protective equipment (PPE) requirements by task
- Medical surveillance
- Air and personnel monitoring
- Site control program
- Decontamination
- Emergency response plan
- Confined space entry procedures (if applicable)
- Spill containment

The specifics of the elements listed above will vary for each site investigation based upon the site conditions and the planned activities. Other OSHA requirements must be addressed as applicable, such as permissible exposure limits (PELs), chemical-specific standards, respiratory protection program, lockout/tagout procedures, and proper excavation procedures.

3.5.4 Data Requirements

3.5.4.1 Data Requirements for Risk Assessment

Risk assessments may be conducted by a comparison to De Minimis Standards, Uniform Standards, or Site-Specific Standards. Typical data required to perform risk assessment are:

- Site-specific constituent concentrations by medium and pathway (surface soil, subsurface soil, groundwater, surface water, soil gas, indoor air, and sediment)
- Soil type and physical components (grain size, mineralogy, sorting, etc.)
- Background constituent concentrations by medium
- Sufficient data to evaluate statistical distributions of sampling data, considering both spatial and temporal variability

3.5.4.2 Data Requirements for Remedial Action Design (if applicable)

Physical and chemical characteristics of the media of concern that require remedial action should be compiled during the site assessment. Considering data requirements for remedial technology selection and design during preparation of sampling and analysis plans can reduce sampling costs by avoiding remobilization and inefficient data collection, while expediting the evaluation of appropriate remedial technologies. Evaluation of remedial alternatives early in the site characterization process will aid in identifying data gaps that may delay or prevent remediation and site closure. Data requirements for soils typically include the traditional engineering properties of soils, soil chemistry, vertical and horizontal contaminant profiles, and the overall range and diversity of contamination across the site. Analytical data requirements for water (usually groundwater) may include chemistry, oxygen demand, pH, flow volume, flow direction, and/or other parameters. Redox potential should be measured whenever groundwater samples are collected as a line of evidence regarding aerobic or anaerobic conditions.

The tables that accompany this section present some of the media characteristics that can impact the selection of a particular treatment alternative. Table 3-1 lists soil characteristics which can be investigated during site characterization to support technology selection, with a general interpretation of the meaning of high and low values for each characteristic. Table 3-2 provides similar information for water-related treatment categories.

Table 3-1: Soil Characteristics that Assist in Treatment Technology Preselection

Characteristic	Treatment Technology Group				
	Physical	Chemical	Biological	Thermal	S/S
Biochemical Oxygen Demand (BOD)			H		
Bulk Density	V			H	
Chemical Oxygen Demand (COD)		H	H		
Humic Content	L	L	L	V	L
Inorganic Contaminants					
Volatile metals		V		L	
Non-volatile metals	H	V	L	L	H
Moisture Content	V		H	L	L
Oil and Grease	V	L			
Organic Contaminants					
Halogenated	V	V	L	H	L
Non-halogenated	V	V	V	H	L
Particle Density	H				
Particle Size	H	V	V	H	H
Permeability	H		H		
pH and Eh		V	V	V	
Total Organic Carbon (TOC)		V	H	H	V

H = higher values support preselection of technology group
L = lower values support preselection of technology group
V = effect is variable among options within a technology group
S/S = soil stabilization

Table 3-2: Water Characteristics that Assist in Treatment Technology Preselection

Characteristic	Treatment Technology Group			
	Physical	Chemical	Biological	Thermal
Acidity and Alkalinity	V	V	L	
Biochemical Oxygen Demand (BOD)			H	
Chemical Oxygen Demand (COD)		H	H	
Dissolved Oxygen			H	
Dissolved Solids	V	H	V	
Metals	V	H	L	L
Nitrogen and Phosphorus			V	
Oil and Grease	V	L		
Organic Contaminants				
Halogenated	V	V	L	H
Non-halogenated	V	V	V	H
pH and Eh		V	V	V
Suspended Solids	H	L	V	
Total Organic Carbon (TOC)		V	H	H

H = higher values support preselection of technology group
L = lower values support preselection of technology group
V = effect is variable among options within a technology group
S/S = soil stabilization

3.5.4.3 Data Requirements for Natural Attenuation

Data requirements for natural attenuation are discussed in detail in Section 5. If natural attenuation is considered to be a potential remediation alternative, the LRS should review the Rule and Section 5 of this guidance manual to ensure that data can be used to support natural attenuation and avoid the need to collect additional samples or install additional monitoring wells at a later date.

3.5.4.4 Data Requirements for Modeling (if applicable)

The objective of a model is to predict if COPCs will reach a receptor of concern above a risk-based criterion. Soil models may be used to demonstrate that residual soil contamination will not impact the quality of groundwater beneath the site above the risk-based concentrations. Groundwater models may be used for many types of demonstrations, including:

- Groundwater flow modeling to illustrate that receptors will not be in the path of the existing groundwater flow or that the remedial technology will intercept the contaminant plume
- Contaminant fate and transport modeling to illustrate that the contaminants of concern will not reach the receptors above the risk-based concentrations
- Natural attenuation modeling to evaluate whether the contaminants of concern will be attenuated by one or more mechanisms before reaching the receptor(s)

Before assessment is performed, the LRS should determine model data requirements, and the planned uses of the output from the anticipated model(s) should be listed and discussed in the SAWP, as applicable. When selecting a fate and transport model, it is critical that site-specific information be reviewed along with model specifications to ensure that the model is capable of simulating site conditions and contaminant properties that may have significant impact on site-specific contaminant transport.

Certain site-specific information that is useful in constructing a more accurate model can be collected during assessment:

- Depth to groundwater
- Permeability
- Aquifer thickness
- Groundwater flow direction and gradient
- Groundwater seepage velocity
- Aquifer bulk density
- Organic carbon fraction (saturated and unsaturated zones)
- Total porosity (saturated and unsaturated zones)
- Effective porosity (or specific yield)
- Cation exchange capacity
- Clay mineral content
- Redox potential

In addition to the physical conditions of the site, the chosen model must be able to handle all contaminant-specific properties that may affect fate and transport. One critical factor will be whether COPCs include organic contaminants or inorganic contaminants. The most important properties affecting organic contaminant transport are compound partition coefficients (such as the Henry's Law constant and the organic-carbon partition coefficient) and the amount of organic carbon in the soil. Transport of inorganic contaminants, however, is heavily influenced by soil properties such as pH, redox potential, and clay content. Properties to consider, based on relevancy to the site, may include:

- Horizontal and vertical extent of contamination
- Volume of release (or initial concentration near source at time of release)
- Solubility
- Acid and base hydrolysis
- Oxidation-reduction potential
- Valence state of the contaminant (e.g., Cr^{+3} or Cr^{+6})
- Vapor pressure
- Henry's Law constant
- K_{oc} or octanol-water partition coefficient (K_{ow})
- Degradation (daughter) products

- Degradation rates of parent and daughter products
- Density (DNAPL vs. LNAPL)

3.6 SAMPLING BY MEDIA

3.6.1 Soil Sampling

Surface soil is defined in the VRP as the top two feet of soil, and subsurface soil is defined as soil below two feet in depth. The LRS may use non-intrusive techniques such as geophysical methods to first identify areas of concern and then follow up with intrusive techniques such as soil borings or test pits to collect quantitative sample data for characterizing the area.

Physical testing of the soil (e.g., grain size analysis, compaction properties) and identification of soil types (e.g., clays, sands, fill) can be performed to obtain properties that may be useful in evaluating various treatment or containment alternatives. The physical properties of the soil can also be used for determining the fate and transport potential for various contaminant types.

Specific information regarding the chemical analysis of soil samples for various categories of contaminants is provided in the following sections. However, contaminant concentrations in all soil samples must be corrected for percent moisture content.

Surface soil chemical data is used primarily to assess human health impacts via direct exposure to soil. Data collected from subsurface soils can be used to assess the horizontal and vertical extent of contamination, to evaluate human health risks due to exposure during excavation activities, or to identify a source of groundwater contamination. The potential for infiltrating precipitation to leach contaminants from soil to groundwater is evaluated using one of the three tiers of Migration to Groundwater screening levels (Section 3.6.2). Subsurface soils should not be used to assess risks due to vapor intrusion. Rather, soil vapor samples are required to directly measure the concentrations of contaminations of concern (COCs) in soil vapor, or the potential for vapor intrusion can be screened in groundwater.

During the planning phase of the investigation, the laboratory should be consulted to determine the type and number of sample containers that will be required, accounting for the additional amount of material needed for spikes and duplicate analyses.

The following references provide general guidance for characterizing soils:

- ASTM. 1987, Standard Guide for Investigating Soil and Rock (D-420-97) (Vol. 4.08).
- ASTM, Site Characterization – Environmental Purposes with Emphasis on Soil/Rock/Vadose Zone/Groundwater (D-5730).
- New Jersey Field Sampling Procedure Manual, Section 6.2, Aug 2005.
- Soil Sampling SOP OER-0120 (available in the WVDEP/DLR/OER QAPP.

- USEPA. 1991. Description and Sampling of Contaminated Soils: A Field Pocket Guide. EPA/625/12-91/002.
- USEPA. 1991. Subsurface Characterization for Subsurface Remediation. EPA/625/4-91/026.
- USEPA. 1992. Preparation of Soil Sampling Protocol: Techniques and Strategies NTIS PB-92220532.
- USEPA Region 4, 2014, *Operating Procedure – Soil Sampling*; SESD PROC-300-R3, USEPA Region 4, Athens, GA, 24 pp.

3.6.1.1 Sampling for VOC Analysis

Soil samples collected for VOC analysis must be collected in a manner that minimizes volatile loss. Volatile loss has been documented to occur when samples are handled and screened using traditional methods. This includes the ambient temperature headspace method (or a variation thereof), where samples are collected from the same container used for PID screening, and the double bagging method, where the potential lab analysis portion is transferred to a second container and iced until field screening is completed. Therefore, VOC samples collected from direct push cores must be handled using one of the two options described below and subsequently collected using EPA Method 5035.

When collecting soil samples for VOC analysis using direct-push technology, the goal is to minimize the loss of volatiles from the sample prior to sampling. The preferred procedure for VOC sample selection involves field screening with a PID to select the interval with the highest probability of containing COCs using one of the following two options:

1. Evaluating every core run by first screening the soil at 12-in. intervals with a PID while the soil remains in the direct-push sleeve, then using plastic wrap to seal the sleeve as airtight as possible and storing at < 6º C until samples are collected. The cores are stored until the boring is completed and samples are subsequently collected from the undisturbed cores based on highest PID reading, staining, soil characteristics, or other factors in accordance with the SAP. See SOP OER 0121 in the WVDEP/DLR/OER QAPP for a detailed explanation of this procedure.

2. Collocated borings, where an initial boring is used only for field screening and logging of subsurface conditions. Once the sample depths for lab analysis have been determined based on screening and logging, a second boring is completed to the desired sample depths at a location immediately adjacent to the first boring and samples are collected from the undisturbed core. See SOP OER 0121 in the WVDEP/DLR/OER QAPP for additional information.

Note that these two options are the only methods recommended for VOC sampling from direct push borings, and OER may not accept data derived using methods other than these. Any deviation from these two options should be detailed in the SAWP and discussed with the OER Project Manager prior to conducting field work.

EPA Method 5035 was adopted by USEPA because of studies showing that sampling using other methods resulted in significant losses of VOCs. Two collection options are typically available for EPA Method 5035: an airtight coring device such as the Encore® sampler or preserved vials (Terra Core™). See SOP OER-0122 in the WVDEP/DLR/OER QAPP for details. The method of collection should be based on holding time, laboratory-processing considerations, soil type (calcareous soils have special considerations when using the preserved vial option), and shipping considerations. Samples for VOC analysis must never be mixed, composited, or homogenized. Refer to SOP OER-0120 for VOC sampling in other situations.

3.6.1.2 Sampling for Non-VOC Analysis (e.g., Metals, SVOCs, PCBs, Pesticides)

Samples collected for non-VOC organic compound analyses is generally not subject to the same handling restrictions as for VOC analysis. However, significant loss of both naphthalene and benzo(a)anthracene can occur at ambient temperatures, and this loss is increased if the sample is homogenized or warmed. Loss due to volatilization is a particularly important consideration because naphthalene concentration often controls risk assessment conclusions.

Because of this issue, samples to be analyzed for naphthalene or benzo(a)anthracene must be handled in a manner to minimize volatilization. Samples to be analyzed for these compounds must be placed into the appropriate sample bottle as soon as possible after sample collection (i.e., prior to homogenization), and the jar should be completely filled to minimize headspace. If field screening is being used to select sample intervals from a boring, cores should be handled as described above for VOCs. Any questions regarding these situations should be discussed with the OER Project Manager during SAWP development.

3.6.1.3 Composite Sampling

Composite sampling is not an acceptable protocol to determine EPCs for risk assessment. However, composite sampling may be used to determine site-specific background concentrations or to evaluate waste disposal options. The LRS should consider the fact that background concentrations estimated by composite sampling will sacrifice the ability to compare site concentrations to several important statistics such as the range of concentrations or calculating an upper tolerance limit on concentrations present in background.

At a minimum, background should be estimated from three to five composite samples, each comprised of four to five similarly collected grab samples. However, a person well versed in statistics should be consulted during SAWP development to determine an appropriate number of composites and discrete samples per composite. Refer to Appendix A – *Determining Background Concentrations* for detailed information regarding determining site-specific background concentrations.

Recommended composite sampling references include:

- A Comparison of Soil Sample Homogenization Techniques EPA 600//X-90/043, Feb 1990.

- Guidance on Choosing a Sampling Design for Environmental Data Collection for Use in Developing a Quality Assurance Project Plan EPA/240/R-02/005, Dec 2002.
- Non-VOC Sample Collection for Soils (Section 6.2.8), NJDEP Field Sampling Procedure Manual.

3.6.1.4 Sampling for Other Analyses

To ensure a sample is representative of the volume of contaminated soil, OER recommends mixing the sample (in a plastic bag or stainless-steel bowl) to obtain a homogeneous blend. The "coning and quartering" sampling technique is recommended to ensure a random sample is obtained. See "A Comparison of Soil Sample Homogenization Techniques" referenced above.

3.6.2 Groundwater Sampling

Groundwater characterization is performed when there is a potential for leaching/percolation of contaminants through site soils into the uppermost water-bearing zone, or if it is known that impacts have occurred. The primary objective of a groundwater investigation is to determine if the concentrations of COPCs exceed regulatory limits as specified under the WV Requirements Governing Groundwater Standards (W. Va. Legislative Rule 47CSR12) or other risk-based standards. A second objective of groundwater investigation is to determine the vertical and horizontal extent and concentration of COPCs in groundwater. A third objective is to evaluate and quantify site hydrogeologic conditions that will govern the fate and transport of COPCs. A fourth objective is to evaluate and document any spatial and temporal variability of COPC concentrations in groundwater. To account for temporal variations, OER requires every VRP project to conduct a minimum of two groundwater sampling events on a quarterly or semiannual schedule. If significant variation is observed, additional samples will be required to evaluate the temporally related pattern.

The need to assess groundwater samples can also be superseded by comparing COPC concentrations in soil to one of the three tiers of Migration to Groundwater screening levels. The simplest approach and most protective tier is the default Migration to Groundwater screening level table provided in Attachment 1 – *Default Migration to Groundwater Screening Levels*. More representative Migration to Groundwater screening levels can be calculated by following the procedures described in the USEPA *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (see Appendix C, Section C.3.7 for more details). Alternatively, the most representative values can be estimated through a measured screening level, developed by analyzing site-specific soil samples for the COPCs using the Synthetic Precipitation Leaching Procedure (SPLP, *SW-846 Test Method 1312*) method. When using this approach, WVDEP requires SPLP analysis to follow the guidance developed by the New Jersey Department of Environmental Protection in *Development of Site-Specific Impact to Ground Water Soil Remediation Standards Using the Synthetic Precipitation Leaching Procedure*, but the applicable health-based groundwater quality criterion will be the WV Groundwater De Minimis Standards. The SPLP method should be used to evaluate leaching from soil unless there is a potential for highly acidic leachate to be present, such as may be associated with a landfill or coal mining operation. In cases where the actual water leaching contaminants from the soil is known or suspected to be highly acidic, the relative acidity

of the leachate water must be evaluated, based on site-specific geochemical conditions. Factors to consider include the presence of municipal waste; coal mine spoil or refuse that produces acidic leachate; acidic soils or bedrock that result in acidic conditions; or other site-specific factors. In these cases, the Toxicity Characteristic Leaching Procedure (TCLP, *SW-846 Test Method 1311*) should be used to develop measured levels for screening migration to groundwater. Both the default and the calculated Migration to Groundwater screening levels are inherently conservative and will frequently be exceeded by concentrations in on-site soils. Thus, WVDEP recommends conducting direct measurements of leaching potential to develop the most accurate screening levels.

Groundwater characterization may not need to be performed during the initial phase of site assessment if it is considered an unlikely media of concern. Example circumstances include if only surface soils are contaminated and the uppermost aquifer is known to be deep (e.g., 50 feet), if subsurface soils consist of clays and silts, and if boring logs are available to document the vertical extent of contamination in soil. However, a groundwater investigation may need to be conducted during later phases of investigation if soil sampling subsequently indicates that the initial conceptual model was in error.

Data may be collected during a single phase or over several phases. At relatively small sites, a single-phase investigation may be the most economical approach. However, at larger sites, a phased investigation may avoid installing unnecessary permanent monitoring wells that do not provide useful data and must later be abandoned. An example phased investigation is as follows:

1. Install borings and temporary groundwater sample points.
2. Collect soil and groundwater samples to determine the extent and concentrations of COPCs.
3. If evidence indicates or infers that groundwater impacts may have occurred, install permanent monitoring wells, or install additional borings and temporary groundwater sample points to further delineate impacts and site permanent wells.
4. When permanent wells have been installed, collect groundwater samples to determine COPC concentrations and collect data for estimating aquifer properties and groundwater flow characteristics.
5. As necessary, install additional wells and collect additional samples to determine the extent of a plume, to better evaluate remedial alternatives, or to calibrate a groundwater model.

In addition to the standard intrusive investigation techniques, non-intrusive techniques such as surface geophysics, borehole geophysics, soil gas surveys, remote sensing, tracers, etc. may be employed.

Factors that would impact the level of effort for completing groundwater characterization may include the following:

- Concentrations of the identified COPCs relative to the risk-based standards
- Presence of non-aqueous phase liquids (NAPLs)

- Complexity of site hydrogeologic conditions (e.g., fractured bedrock, karst geology, fill material)
- Point source vs. non-point source release mechanism for the COPC
- Chemical properties of the COPC (e.g., solubility, K_{OC}, density, vapor pressure)
- Attenuation processes
- Proximity to human and ecological receptors
- On-site and off-site wells, including Wellhead Protection Areas
- Facility structures and utilities (e.g., preferential migration pathways)

3.6.2.1 Well Installation and Groundwater Quality Investigations

Groundwater sampling points can be established using a variety of temporary or permanent wells, such as temporary wells installed via direct push technologies, well points, monitoring wells, and extraction wells. Additionally, springs and seeps may be used as sampling points, since they typically represent zones of preferred groundwater migration. The actual number of sample points necessary to adequately characterize a site is to be based on site-specific characteristics.

Monitoring wells used to collect data for determining exposure point concentrations (i.e., compared to risk-based standards) must be designed and installed in accordance with WV Monitoring Well Regulations (W. Va. Legislative Rule 47CSR59) and Monitoring Well Design Standards (W. Va. Legislative Rule 47CSR60).

The Monitoring Well Design Standards provide information on monitoring well development. According to the standards, sufficient time is needed to allow the seals in the well to properly cure before a well is developed. Specifically, the regulation requires a minimum waiting time of 12 hours after installation is complete prior to development for wells sealed with grout or slurry (annular space seal). Additional seals needing time to cure include the filter pack seal and the ground surface seal. In addition, time is needed for the newly installed well and sand pack to equilibrate with the surrounding formation and for the formation to stabilize after disturbance. It is the responsibility of the LRS and the licensed monitoring well driller to ensure that wells are properly installed, are not damaged during development, and provide groundwater samples representative of aquifer conditions.

An appropriate period of time is also required between well development and sampling, with the understanding that the period of time will vary based on aquifer materials. Monitoring wells installed in low-permeability formations may take longer for the monitoring well environment to stabilize after disturbance.

Selection of appropriate drilling techniques, well installation techniques, well materials, well diameter, and sampling techniques are dependent on a wide variety of site-specific geologic and hydrogeologic factors, as well as the characteristics of the COPCs. Some of those factors include:

- Purpose of the well (e.g., piezometer for determining depth to groundwater, chemical sampling, groundwater extraction, groundwater remediation, geophysical logging, etc.)

- Anticipated depth to groundwater
- Single vs. multiple water bearing zones
- Physical characteristics of the site soils and/or bedrock (e.g., density, tendency to heave, formation permeability, etc.)
- Chemical characteristics of the site soils (e.g., will soils be characterized as hazardous?)
- Chemical characteristics of the site groundwater (e.g., will groundwater be corrosive to well materials?)
- Logistical constraints (e.g., location of property boundaries, steep slopes, overhead power lines, underground utilities, etc.)

Additionally, when selecting the appropriate well installation techniques, consideration must be given to the DQOs. Installation of wells to alternate standards requires prior approval from the OER Project Manager.

Inorganic groundwater COPC concentrations must be based on dissolved phase concentrations derived from field-filtered samples.

Useful resources to assist the LRS in development of the groundwater quality investigation program include:

- Aller, Linda, et al. 1989. Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells. National Water Well Association.
- Driscoll, F.G. 1986. Groundwater and Wells; 2nd Ed.; Johnson Filtration Systems, Inc.; Minnesota.
- USEPA. 1987. Handbook – Groundwater. EPA/625/6-87/016.
- USEPA. 1991. Handbook – Ground Water Volume II – Methodology. EPA/625/6-90/016.
- USEPA. 1993. Subsurface Characterization and Monitoring Techniques – A Desk Reference Guide – Volumes 1 and 2. EPA/625/R-93/003a & b.
- USEPA. 2002. Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers. EPA 542-S-02-001.
- USEPA CLU-IN Field Analytic Technologies – Groundwater Samplers, 2009.

3.6.2.2 Groundwater Flow Characterization

One objective of hydrogeologic characterization is to quantify the ability of the water-bearing unit at the site to transmit water and transport contaminants to a potential receptor. The level of detail required for evaluation of site hydrogeology will vary depending on the data requirements for risk assessment,

remedial design, and/or groundwater modeling. The characterization of groundwater flow should generally proceed from the simplest to more complex methods. Listed below are some of the techniques available to the LRS for quantifying the site-specific hydrologic properties:

- Potentiometric Surface-Mapping
  A potentiometric surface map (e.g., groundwater contour map) is used to evaluate the direction of groundwater flow. Also, gradient calculations can be made from this map using either flow-net, flow-line or three-point calculations. A minimum of three sample points is necessary to project a reliable groundwater flow direction.

- Hydraulic Conductivity and Porosity Evaluation Techniques:
  - Literature Review – The least reliable estimation of hydraulic conductivity is available from standard references (such as Freeze and Cherry, 1979, p29; Driscol, 1986, p75).
  - Grain-Size Distribution – The calculation of hydraulic conductivity from grain-size distribution (such as Freeze and Cherry, 1979, p350-351; Driscol, 1986, p 738) is more reliable than estimation from literature values. Use of these calculations is not typically adequate for making remedial design decisions; however, such estimates can be useful for planning.
  - Laboratory Tests – Tests of hydraulic conductivity conducted in the laboratory on undisturbed samples collected from boings are accurate indicators of vertical permeability. The calculations from these tests are more reliable than those of the grain-size distribution but do not provide reliable values of horizontal hydraulic conductivity.
  - Time Lag Permeability Tests (Slug Tests) –Time lag permeability tests [ASTM Method D-4044, or other applicable guidance references (Hvorslev, 1951; Bouwer and Rice, 1976)] are single-point estimates based on the rate of recovery in response to an instantaneous change in the water level in the well. Tests should be performed at multiple locations if available to evaluate variability across the site.

- Aquifer Tests (Pump Tests)
  Aquifer testing (ASTM Method D-4050 or other applicable guidance) is the most reliable technique for calculating the hydraulic properties of the water bearing zone(s) underlying a site. The results of aquifer tests can be used to define model input parameters and remedial design criteria.

- Tracer Tests
  Tracers introduced into on-site groundwater via monitoring wells can include dyes, salts, or trace elements. The presence of the tracer is monitored at designated points including extraction wells, springs/seeps, and other monitoring points. Tracer data are used to evaluate groundwater flow pathway, flow velocities, and other contaminant transport properties of the water-bearing zone (e.g. dispersion).

- Modeling
  Models must be constructed and run by qualified individuals and are highly dependent on the quality of available data. Selection of the most appropriate model must be carefully considered by a qualified professional to best suit the amount of available data and to achieve the modeling objectives (i.e., future COPC fate and transport patterns or remedial design).

The following list indicates some of the standard sources of information useful in design and characterization of hydrogeologic parameters.

- Driscoll, F.G. 1986. Groundwater and Wells. 2nd Ed. 1986. Johnson Filtration Systems, Inc. Minnesota. Chr.16.
- Freeze, R.A. and Cherry, J.A. 1979. Groundwater. Prentice-Hall.
- Kruseman, G.P. and De Riddler, N.A. 1991. Analysis and Evaluation of Pumping Test Data. 2nd Ed. ILRI Publication 47. The Netherlands.
- Lohman, S.W. 1972. Ground-Water Hydraulics. USGS-Prof. Paper 708. USGPO.
- Fetter, C.W., 1994. Applied Hydrogeology, 3rd Edition.
- Fetter, C.W., 1993. Contaminant Hydrogeology.

3.6.2.3 Collecting Groundwater Samples

Prior to sampling groundwater from newly installed monitoring wells, a sufficient amount of time is required to allow static conditions to return to the groundwater flow system. Monitoring wells installed via rotary, hammer, sonic, or other highly intrusive drilling techniques require additional time for the formation materials to stabilize prior to purging/sampling. Wells installed in low-permeability formations may need several weeks to reach equilibrium with the surrounding formation.

Groundwater sampling should be conducted in accordance with the WVDEP/DLR/OER QAPP. The QAPP includes sampling recommendations specific to OER programs, including parameters measured during low flow sampling and sample preservation requirements. SOPs for groundwater sampling can be found in the QAPP (SOP OER-0110).

To evaluate potential temporal variability of COPC concentrations in groundwater, OER requires every VRP project to conduct a minimum of two groundwater sampling events on a quarterly or semiannual schedule. Sites with more complex hydrogeology, multiple contaminant classes, multiple groundwater exposure pathways, etc. may require several sampling events or long-term groundwater monitoring programs to accurately evaluate contaminant concentrations in groundwater. Any groundwater monitoring program must account for fluctuations of groundwater levels and be sufficient to characterize seasonal variations in concentrations. If groundwater impacts are present above risk-based or regulatory standards and a natural attenuation remedy is proposed, a minimum of eight samples must be collected no

more frequently than quarterly (preferably semiannually) in order to account for both interannual and seasonal variability.

3.6.3 Surface Water and Sediment Sampling

Surface water and sediment sampling may be necessary if there is a possibility that contamination from the site could migrate to a nearby surface water body. The objective is to determine if concentrations exceed applicable regulatory criteria or present an unacceptable risk.

Sample locations should be based on the CSM. Sediment samples (if applicable) should be collected at each surface water sample location. The number of samples must be sufficient to characterize the extent of any potential contamination and to provide sufficient data for risk assessment, if necessary. Samples also should be collected from upstream locations, and unimpacted background locations, if possible.

It is important to identify data use prior to sample collection so that all necessary information can be collected. For example, parameters such as pH, hardness, conductivity, total organic carbon (TOC), grain size, dissolved and/or total metals, Simultaneously Extracted Metals (SEM), Acid Volatile Sulfides (AVS) and pore water concentrations may be necessary to evaluate ecological risks in addition to chemical tests for the COPCs. Because evaluation criteria for ecological receptors may require detection levels lower than those routinely specified, the analytical laboratory should be contacted prior to sampling.

The following reference manuals provide guidance for design of a sampling program, as well as a description of various sampling techniques:

- NJDEP. 1992. Field Sampling Procedure Manual. New Jersey Department of Environmental Protection and Energy.
- USEPA. 1988. Guidance for Performing Remedial Investigations and Feasibility Studies under CERCLA, Interim Final. USEPA, Hazardous Site Evaluation Division, Office of Solid Waste and Emergency Response, EPA/540/G-89/004.
- USEPA. 1991. Compendium of ERT Surface Water and Sediment Sampling Procedures, Surface Water Sampling SOP #2013, EPA/540/P-91-005, OSWER Directive 9360.4-03.
- USEPA. 1992. Guidance for Performing Site Inspections under CERCLA, Interim Final. USEPA, Hazardous Site Evaluation Division, Office of Solid Waste and Emergency Response, EPA/540-R-92-021.
- USEPA. 1992. NPDES Storm Water Sampling Guidance Document. USEPA, Office of Water, EPA/833-B-92-001.

3.6.3.1 Surface Water

When evaluating risk or treatment alternatives with regard to surface water, both contaminant and receiving stream characteristics must be considered. This may include examining maximum contaminant concentrations for evaluating acute impacts or average concentrations for determining exposures. The

receptors, whether human or ecological, will have different exposure times and routes which must be considered. Also, worst case scenarios may need to be included in the analysis. For example, a small stream receiving contaminated groundwater recharge should tend to have higher concentrations during periods of low flow than after precipitation events (which may dilute the water samples). On the other hand, if the contamination is coming from surface water runoff, then the samples collected during periods of heavy rainfall may be representative of worst-case concentrations. Metals must be analyzed for both total and dissolved concentrations in surface water to account for different routes of exposure (e.g., ingestion of drinking water vs. dermal contact during recreational activities).

In addition to chemical data, velocity and flow measurements will be necessary if it is important to estimate the mass of contamination that is entering the water body. Flow can typically be made by measurements of velocity and discharge area. Procedures for measurement of discharge rates can be found in most hydrology textbooks or USGS publications.

Surface water samples can be collected from different depths (e.g. surface, vertical mid-point, near bottom, composites, etc.) as appropriate for anticipated exposure scenarios. For example, surface water should be sampled within one foot of benthic sediments to assess the discharge of contaminants from groundwater or dissolution from sediments. Please refer to the WVDEP/DLR/OER QAPP for details on where to sample surface water within the water body. There are several types of sampling equipment and sampling techniques that can be used to collect surface water samples. The New Jersey Field Sampling Procedure Manual contains a thorough description of sampling techniques/equipment, along with advantages and disadvantages of each.

3.6.3.2 Sediment

Sediment sampling may be appropriate when any of the following conditions apply:

- Contaminant properties suggest they could accumulate to high concentrations in sediments
- Sediments may act as a reservoir and source of contaminants to the water column
- Sediments may accumulate contaminants over time, while contaminant levels in water are more variable
- Sediment contaminant levels could affect benthic organisms or other receptors of concern in aquatic ecosystems

Sediment samples can be collected near the surface or at depth, as appropriate. However, risk evaluations generally are more concerned with the surficial sediments within the biologically active zone (0-6”) than deeper ones. There are several types of sampling equipment and sampling techniques that can be used to collect sediment samples. A few of the more common sampling techniques/equipment are as follows:

- Scoop/Trowel
- Thin Wall Tube Auger or Bucket Auger

- Coring devices
- Dredges (Eckman/Ponar)

In general, sampling equipment which minimizes or eliminates the loss of fine-grained material is preferred over equipment such as scoops/trowels, which tend to result in the loss of fine-grained material and therefore do not provide samples that are representative of conditions to which biota would be exposed. Sampling sediments for VOCs and certain SVOCs must be conducted in a manner that minimizes volatile loss.

The New Jersey Field Sampling Procedure Manual and the SERAS Sediment Sampling SOP# 2016 contain thorough descriptions of sampling techniques/equipment, along with advantages and disadvantages of each and should be consulted for additional information.

3.6.4 Storm Water Runoff

Storm water runoff may be a potential contaminant transport mechanism on some VRP sites and cause an expansion of the contaminated area of concern and/or contribute contaminants to a surface water body. Structures, depressions, or ditches may have been used to convey potentially impacted surface water when the property was in active use. Remnant contamination from historical operations may be present, and therefore, it may be appropriate to sample storm water that passes through potentially contaminated areas.

Many industrial facilities were required to prepare and implement a storm water pollution prevention plan by October 1, 1993. A review of existing information on file at WVDEP under this program could eliminate the need for sampling or could identify potential contaminants of concern with respect to storm water or process water drainage systems.

Sampling protocol for storm water generally requires that:

- Sampling begins at 0.1-inch of rainfall, with 72 hours of dry time having elapsed from the time of the last 0.1-inch storm event;
- A grab sample be taken within 30 minutes of the onset of a storm event; and
- Composite sampling be conducted for 3 hours or the duration of the storm event.

Meeting these protocols may be impossible at abandoned sites where no personnel are available. Therefore, it may be necessary to modify these protocols to match the site data requirements vs. the logistical realities of the investigation.

Composite samples can be either flow-weighted or time-weighted. If flow-weighted composite sampling is conducted, then the storm water discharge flow should be estimated each time a sample aliquot is collected. Common flow measurement techniques include weirs and flumes, velocity methods, volumetric methods, slope and depth methods, and runoff coefficient methods.

Sampling can be conducted either manually or with an automated monitoring system. There are many benefits to using an automated monitoring system including enhanced safety, more accurate documentation of the storm event, enhanced data quality, and reduced field man-hours. However, this approach may not be appropriate for preliminary evaluation of storm water runoff. It may be more appropriate to coordinate the storm water sampling with other site investigation activities.

The following documents are available to assist the LRS with design of a storm water sampling program:

- USEPA. 1992. Storm Water Management for Industrial Activities (EPA 832-R-92-006).
- USEPA. 1992. NPDES Storm Water Sampling Guidance Document (EPA 833-B-92-001).
- USEPA. 2009. Industrial Storm Water Monitoring and Sampling Guide (EPA 833-B-09-003).

3.6.5 Vapor Intrusion

Indoor air quality due to vapor intrusion may be a concern at VRP sites where future use includes the reuse of existing buildings or the construction of new buildings in areas of known or suspected VOC contamination. VOCs may be present inside buildings due to many sources including: (1) those within the building, such as off-gassing from carpets, furniture and construction materials, and stored chemicals; (2) contaminated soils or groundwater surrounding the structure; and (3) outside contaminants introduced through the building ventilation system. When investigating the presence and sources of VOCs within the indoor air of a building, careful examination of these conditions should be conducted.

The current guidance to address vapor intrusion issues provided by the USEPA (*Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface and Vapor Sources to Indoor Air*, and *Technical Guide for Addressing Petroleum Vapor Intrusion at Leaking Underground Storage Tank Sites*) must be followed. Additional recommended ITRC guidance is available in *Petroleum Vapor Intrusion – Fundamentals of Screening, Investigation and Management*. Note that vapor intrusion can no longer be assessed using only soil concentrations, but can be assessed using groundwater concentrations, soil gas or indoor air samples.

3.6.5.1 Vapor Intrusion Assessment Process

The general process for assessing the potential for vapor intrusion is as follows:

1. Concentrations of VOCs and some SVOCs (e.g., benzo(a)anthracene and naphthalene) in groundwater should be screened against the USEPA Vapor Intrusion Screening Levels (VISL) based on residential vs. commercial/industrial uses and the applicable risk thresholds. The USEPA also provides a VISL Calculator that allows for calculating screening levels based on property uses, risk thresholds, and site-specific average groundwater temperatures.
2. Any VOCs and SVOCs that cannot be eliminated from consideration by screening via VISL based on groundwater concentrations should be sampled in soil gas, or a combination of soil gas and indoor air. Alternately, the LRS can proceed to a site-specific risk assessment or implement a

presumptive remedy for vapor intrusion. Note that indoor air should not be sampled without also sampling soil gas to verify that contamination is not caused by indoor sources. Soil gas concentrations should then be screened against the appropriate VISL values based on sub-slab/soil gas vapors to determine if there are any potential exceedances inside the building.

3. If any COCs exceeded the sub-slab/soil gas VISL values, indoor air concentrations would next be screened against the VISL indoor air values. If indoor air sampling is conducted, every precaution must be taken to remove all sources of vapors within the building before sampling occurs. Alternately, the LRS could choose not to conduct indoor air sampling and either implement a presumptive remedy for vapor intrusion or proceed to site-specific risk assessment.
4. Any COCs that exceed the appropriate sub-slab/soil gas VISL values and the indoor air VISL values must be addressed via site-specific risk assessment or remedial actions.

3.6.5.2 Temperature Considerations in Soil Vapor Sampling

Soil vapor evaluations should be conducted using the USEPA guidance previously referenced to conduct soil gas sampling. Note that the PAH compounds benzo(a)anthracene and naphthalene are sufficiently volatile to be of concern in the vapor intrusion pathway. Hayes and others (2005) showed that naphthalene sample recoveries were reduced by up to 47% when the sample train was 10º C cooler than ambient temperature (23º C), whereas there was no effect on recovery of VOCs such as benzene and trichloroethene due to temperature. Differences in seasonal soil temperatures in the upper profile can lead to variations in soil gas concentrations by a factor of two for all VOCs (Luo et al. 2009, USEPA 2010, Hers et al. 2014, Johnson and Deeb 2014). Therefore, WVDEP recommends that soil gas be sampled when the ambient temperature is at least 21°C (70° F). WVDEP may require additional samples be collected at a time when ambient temperature is at least 21°C to verify the data if soil vapor is collected during periods of relatively low soil temperature, especially when concentrations are greater than one-half of benchmark values.

3.7 MODELING

The LRS may use modeling to determine whether contamination at the site will cause an exceedance of the applicable standards at the property boundary, or at an off-site well or surface water body. Note that all fate and transport models must include a sensitivity analysis to assess which input variables have the greatest impact on model results. The sensitivity analysis should discuss the potential changes in model results based on a range of reasonably expected input values for the site.

3.7.1 Model Selection

The first thing that should be considered is whether it is even practical to attempt to model surface water or groundwater flow and/or contaminant transport at the site. Perhaps the most important part of the modeling process is choosing the correct model to use, based on the available data and site conditions.

3.7.1.1 Groundwater Models

In general, most computer models have been designed to simulate transport in porous media like silts, sands, and gravel. These models cannot be effectively used to study a site where contaminants may have moved into fractured bedrock, solution features, or other formations that cannot be considered typical porous media. Sufficient data must be available to run the selected model.

Analytical models evaluate contaminant fate/transport over an isotropic groundwater flow domain with uniform velocity and one-dimensional flow direction. By nature, analytical models require many simplifying assumptions that limit use of results to screening purposes only except at relatively simple, smaller scale sites. As with any modeling effort, irrelevant of model capabilities, results are more reliable for those sites in which hydrogeologic characteristics at the site are well understood. Conservative estimates should be used whenever the knowledge of any input is vague. Results should be evaluated over the range of values expected for the site in question. Confidence is generally enhanced when properly located downgradient wells screened in the appropriate intervals are present to allow more precise calibration of the model.

If adequate site-specific data are not available, justifications will need to be made regarding the use of generic values or another approach must be considered. It may be more cost-effective at some sites to perform leaching tests or install monitoring wells than to do a modeling study.

There are many sources of published guidance to help model users with most aspects of modeling, such as: model selection, correct application, calibration, and verification. ASTM has published several documents regarding these modeling aspects and provides acceptable guidance. See also references such as *Selection Criteria for Mathematical Models Used in Exposure Assessments: Ground-Water Models* (USEPA, 1988) and/or *Modeling of Soil Remediation Goals Based on Migration to Groundwater* (USEPA, 1991) for descriptions of available models. The National Research Council (1990) also provides an excellent discussion of the inherent limitations and uncertainties in using models to assist in the decision-making process. More recent guidance includes *Guidance on the Development, Evaluation and Application of Environmental Models* (USEPA, 2009). Additional guidance may be found on the USEPA's Environmental Modeling webpage.

The proposed models must be:

- Peer-reviewed.
- Model-verified (shown to produce reliable and mathematically accurate results for all functions of the model).
- Consistent with actual physical conditions throughout the modeled area. The assumptions and limitations of the computer code, mathematical solution, technology used, and computer code structure must be consistent with the actual physical conditions throughout the modeled area and the application of the model.

- Used consistent with the model's documentation and all stated assumptions.
- Calibrated to geologic, hydrogeologic, and physical conditions throughout the modeled area.
- Field-validated (if possible) to determine if a consistent comparison exists between the modeled, or predicted, conditions and observed field conditions for the area being modeled.

The following analytical one-dimensional models are acceptable for modeling groundwater in the saturated zone, as long as they are used according to their limitations and intended uses. For example, BIOSCREEN was developed for petroleum plumes and should not be used for chlorinated solvent plumes.

- MULTIMED
- AT123D
- REMChlor
- Models Based upon the Domenico analytical solution are generally acceptable (e.g., BIOSCREEN and BIOCHLOR)

The following numerical models are considered to be acceptable for modeling groundwater in the saturated zone, as long as they are calibrated to site-specific conditions and are used according to their limitations and intended uses.

- FLOWPATH (2D)
- MODFLOW (3D)
- MT3D (in conjunction with MODFLOW)
- RT3D (in conjunction with MODFLOW)

The following models are considered to be acceptable for modeling in the vadose zone, as long as they are calibrated to site-specific conditions and are used according to their limitations and intended uses:

- VLEACH
- SESOIL
- MULTIMED

Other models may be proposed by the LRS in the SAWP.

3.7.1.2 Surface Water Models

Computer modeling can be used to predict the in-stream concentrations of contaminants which are introduced into surface waters via storm water runoff (storm water models) or groundwater infiltration (surface water models). However, in most cases, it is better to simply sample the surface water body directly. Like the previously described groundwater models, appropriate model selection is critical to the prediction of contaminant concentrations. Although detailed hydrologic and hydraulic analysis will not

be necessary for all remediation sites, it may be required under certain circumstances. Hydrologic and hydraulic analyses may be utilized in conjunction with surface water, sediment, and storm water runoff sampling activities. Four types of analysis that may be needed are:

1. Estimating peak discharges
2. Hydraulic analysis
3. Low Flow analysis
4. Fate and transport analysis

Like groundwater models, surface water models must also be:

- Peer-reviewed.
- Model-verified.
- Consistent with actual physical conditions throughout the modeled area.
- Used in a manner consistent with the model's documentation and all stated assumptions.
- Calibrated to hydrologic, geologic, and physical conditions in the area.
- Field-validated (if possible) to determine if there are consistent comparisons between predicted and observed parameters.

3.7.2 Model Approval

The LRS should request WVDEP approval for use of any model that is not already standardly used. The request should include a description of why this model is appropriate for the site. Upon review of the request, WVDEP may ask that the LRS provide sufficiently detailed model documentation that includes relevant technical information about the model, such as:

- Model name, version number, and date
- Names of the author(s) and company
- Intended use of the model as described by the author/company
- Governing mathematical equations and boundary conditions
- Assumptions used in the development of the model
- Comparisons of the proposed model to other established models (if available)
- Example of a field application of the model

3.7.3 Model Application

The purposes of a model could include:

- Predict if soil contamination will leach into the groundwater.
- Predict if contaminants will migrate to the receptors of concern at concentrations above acceptable levels.
- Predict the most effective remedial alternative or design.

Modeling results should be discussed briefly in the "Site Investigation Results" section of the SAR, but a complete model results section should be presented as an attachment/appendix to the SAR that includes:

- Background information (e.g., objective and problem description; geology, hydrology, contaminant distribution)
- Conceptual site model (e.g., hydrogeology, flow direction, source geometry and strength, gradient)
- Model selection, model description, and rationale for selection (i.e., discussion of model capabilities and limitations)
- Model parameters (e.g., range of values employed, rationale for assumptions employed, discussion of uncertainties, and sensitivity analyses of assumed values)
- Discussion of model results and sensitivity analyses
- Conclusion

WVDEP may also ask for complete electronic copies of all input and output files used in the site-specific study.

3.8 BACKGROUND CONCENTRATIONS

Where the De Minimis Standard is below natural background and where the Uniform and Site-Specific Standards are below anthropogenic background, natural background may be used in place of the De Minimis Standard, and natural or anthropogenic background may be used in place of the Uniform and Site-Specific Standards.

3.8.1 Definition of Background

Natural background refers to the concentrations of elements and compounds that occur naturally in the earth, without any human interference. Anthropogenic background refers to concentrations of elements and compounds that occur over a widespread area as a result of human activities.

Methods to ascertain background levels are described in Appendix A – *Determining Background Concentrations*. Alternatives to the methods for determining background levels described in this guidance should be presented in the SAWP and approved by the OER Project Manager prior to implementation. No single method is appropriate for all contaminants, media, or sites, so a case-by-case evaluation and expert judgment is required to design an appropriate strategy to determine background

levels, particularly where anthropogenic sources are involved. A weight-of-evidence approach, where several independent lines of evidence are used to determine anthropogenic background, is preferred. For some sites, this may involve demonstrating that a release is confined to a "hot spot" or other aggregated area of contamination and has not become widely dispersed beyond a site, but that other human activities or natural deposition unrelated to site activities have resulted in low levels of the contaminant being widely dispersed across the site and the area beyond. Unfortunately, it is extremely difficult to prove that a contaminant released at a site did not move to those other locations and is present due solely to activities unrelated to operations at the site.

Examples of methods to support a determination of anthropogenic background include the following:

- Documentation of another area-wide source (outside the site) for the contaminant in soils, groundwater, or surface water. This approach is particularly useful for groundwater contamination where the flow rate and direction of the aquifer is well defined. Where groundwater monitoring wells upgradient of the site indicate the presence of anthropogenic contaminants, these levels provide an indication of anthropogenic background. Caution should be used for aquifers that are not well defined, or contaminants that may move in an unexpected fashion (e.g., DNAPLs).
- Statistical methods to compare upgradient and downgradient samples should account for spatial and temporal correlations among samples.
- Use of geostatistics or other spatial statistical approaches to demonstrate the extent of spread of a contaminant from the on-site source, relative to anthropogenic background.
- Vertical and/or horizontal stratification of contaminant concentrations throughout a region, showing that anthropogenic sources contribute to elevated levels of the contaminant.
- Chemical fingerprinting of releases, particularly where multiple contaminants or suitable tracer contaminants are involved, to demonstrate which contaminants are associated with a release vs. off-site sources. Levels of contaminants in samples may provide evidence of an anthropogenic background level when patterns of chemical constituents associated with site-related releases are distinct from those found with releases associated with anthropogenic background. The presence of release-specific ratios of constituents, or specific tracer compounds in samples are examples of this approach. To be useful, the tracer compound(s) should have similar transport and fate characteristics as the contaminant of concern so that its distribution provides a reliable estimate of the distribution and concentration of the contaminant of concern.
- Historical records of past releases documenting the source(s) of anthropogenic contaminants. Baseline data pre-dating on-site releases are particularly useful in this regard. Records of past releases provide supporting information.

- Sampling of carefully selected areas outside the site to demonstrate that contaminants are widespread. Sample area selection criteria should be approved with the work plan in advance and should assure that site-related activities did not contribute to sample area contaminant levels.

3.8.2 Establishing Background for the De Minimis Standard

Published values of background concentrations for soil, sediment, groundwater, and surface water are to be used for the De Minimis Standard. Natural background levels of many elements in soil are described in published literature and can be used for comparing natural background levels with the De Minimis Standard. Mean, standard deviation, and 90th percentile values for WV soils are provided in Table 3-3.

Table 3-3: Background Concentrations of Elements in WV Soils (mg/kg)

Element	Mean	Standard Deviation	90th Percentile
Aluminum	52921	18518	77120
Antimony	0.61	0.25	0.89
Arsenic	8.3	5.2	13.1
Barium	380	143	565
Beryllium	1.9	0.8	2.8
Bismuth	0.23	0.09	0.35
Cadmium	0.3	0.2	0.5
Calcium	1568	1412	3300
Carbon	18386	19263	37490
Cerium	70.4	26.0	94.5
Cesium	7	2	9
Chromium	40.5	15.6	57.4
Cobalt	14.0	7.3	23.8
Copper	17.5	8.3	27.5
Gallium	14.2	5.6	21.5
Indium	0.05	0.02	0.07
Iron	26256	10964	39380
Lanthanum	35.9	28.1	44.3
Lead	24.8	10.1	38.0
Lithium	37	18	54
Magnesium	3414	1820	5640
Manganese	907	761	1998
Mercury	0.06	0.03	0.09
Molybdenum	1.08	0.59	1.99
Nickel	20.4	10.1	34.4
Niobium	10.1	4.0	15.3
Phosphorus	520	264	902
Potassium	13650	6444	19880
Rubidium	79	32	126
Scandium	8.6	3.6	13.4

Selenium	0.5	0.3	0.8
Silver	<1	<1	<1
Sodium	1991	1384	3600
Strontium	63	33	91
Sulfur	287	140	500
Tellurium	0.1	0.0	0.1
Thallium	0.5	0.2	0.8
Thorium	9.7	3.0	13.7
Tin	2.11	0.71	3.05
Titanium	3226	1114	4500
Tungsten	0.9	0.4	1.6
Uranium	2.7	0.9	3.8
Vanadium	63.0	26.2	98.8
Yttrium	16.5	20.3	21.8
Zinc	67	28	103

Until information for background levels in groundwater for WV is compiled for use with the De Minimis Standard, refer to the guidance on establishing background for the Uniform and Site-Specific Standards below.

3.8.3 Establishing Background for the Uniform and Site-Specific Standards

Because background levels are greatly influenced by soil type and geologic strata, site-specific sampling is a more accurate method of determining an appropriate background value. The Uniform and Site-Specific Standards permit the use of anthropogenic background levels as the standard where anthropogenic background levels exceed the risk-based level. Methods to identify sample location and numbers of samples to collect for determining background in soils, groundwater, and surface water are discussed in Appendix A – *Determining Background Concentrations*. Sediments may not be evaluated under the Uniform Standard.

3.8.4 Natural vs. Anthropogenic Background

Natural *vs.* anthropogenic background levels cannot always be easily established. This occurs because some contributors to anthropogenic background are decades or centuries old, such as the use of arsenical pesticides in the early 1900s and the effects of mining. As a result, it may not always be useful to try to determine whether background levels are natural or include some component of anthropogenic activity. However, it is appropriate to use any site-specific determination of background, whether it includes an anthropogenic component or not, for comparison to the Uniform and Site-Specific Standards.

3.8.5 Comparison of Site Contaminant Concentrations to Background

The methods for comparing site contaminant concentrations to background concentrations from various media are outlined in Appendix A – *Determining Background Concentrations*. Note that the most common statistical methods of comparison require samples to be collected randomly in order to be valid.

Therefore, the LRS must be careful to select the correct procedure when comparing groundwater or air concentrations to background values because groundwater and air samples are not typically taken randomly. In these cases of non-random samples, the average concentration may not be the appropriate parameter to test for statistical differences.

Statistical comparisons of downgradient vs. upgradient well samples include multiple comparison procedures (ANOVA or Kruskal-Wallis), upper tolerance limits (UTLs), or other approved methods as described in 33CSR1.4.11. Additional guidance for statistical comparison of groundwater data may be found in USEPA (1989, 1996a), and supplementary guidance for statistical comparisons of soil data may be found in USEPA (1996b,c). Wells developed for determining upgradient groundwater concentrations also need to be located within the same aquifer as downgradient wells.

3.9 SELECTION OF CONTAMINANTS OF CONCERN

Chemicals detected in at least one sample—including at levels below Practical Quantitation Limits (PQLs)—in a given medium at the site should be considered COPCs and should be carried through the screening assessment or risk assessment unless there is specific, justifiable rationale for excluding the contaminant. The following subsections outline acceptable reasons for eliminating contaminants. The final list of COPCs remaining after conducting the selection process described below is termed the contaminants of concern (COCs). The site assessment or risk assessment portion of the project should document the process of identifying COCs and list the chemicals that are identified for both the human health and ecological risk assessment. The specific basis for eliminating a chemical detected at the site from the list of COPCs should also be clearly documented. Contaminants may be eliminated for other reasons upon approval by the OER. The decision process for screening COPCs to COCs should be presented in both text and in a table explaining why each chemical is to be retained or eliminated as a COC.

3.9.1 Field or Laboratory Contaminants

Contamination may be introduced into a sample during sample collection, transport, or laboratory handling and analysis. A variety of QC samples such as trip, equipment, laboratory calibration, and method blanks should be collected and analyzed to determine whether contaminants are being introduced by field or laboratory practices. A careful review of QA/QC data should be conducted as part of an investigation to avoid including chemicals attributable to sampling or laboratory activities, while ensuring that chemicals which are site-related are not eliminated from further evaluation. When assessing the potential for sample contamination, USEPA (1989, 1992) recommends the following rule of thumb for common laboratory contaminants (e.g., acetone, 2-butanone, methylene chloride, toluene, and the common phthalate esters): consider sample results positive only if the concentration in the sample is more than ten times the maximum detected in any blank; otherwise, treat the sample as non-detect. If the contaminant in the blank is not one of these common laboratory contaminants, consider sample results positive only if the concentration in the sample is more than five times the maximum detected in any blank; otherwise, treat the sample as non-detect. An exception to this rule may be if these contaminants are otherwise associated with the site based on their history of prior use at the site.

3.9.2 Low Concentrations and Low Frequency of Detection

Substances detected at low concentrations and low frequency may be omitted. The purpose of this criterion is to eliminate from risk assessment any substance that is not present consistently enough or at high enough concentrations to contribute significantly to exposure.

3.9.2.1 Low Concentrations

For a chemical to be identified as a COPC, it must be present in a concentration above the detection limit of an appropriate method. Some compounds, e.g., those which biomagnify in the food chain or for which synergistic interactions have been reported, may cause health risks at levels below the detection limit of some standard methods, so care must be taken not to rule out COPCs prematurely. The method detection limit (MDL) is the smallest concentration of a chemical which can be accurately measured considering the instrumentation and background noise. As the chemical concentration approaches the MDL, the level of confidence in quantitation decreases. For use in risk characterization, the *Guidance for Data Usability in Risk Assessment (Part A) Final* (USEPA, 1992) recommends the use of the sample quantitation limit (SQL), which is the MDL adjusted to reflect sample specific variables such as volume, dilution, or percent moisture, or the MDL itself. Instrument detection limits should never be considered appropriate for use in the risk assessment. The SQL, or the MDL multiplied by a factor of two to five, may be appropriate to derive a practical quantitation limit (PQL), unless the PQL is unusually high. Site-specific conditions should be considered in determining which quantitation limit is used. When the SQL is greater than the screening value for the COPC, there is still a possibility that the chemical may be present at the site in concentrations that pose an unacceptable risk. In such cases, there are several statistical options to account for the unknown concentrations in *ProUCL*, such as the Gehan test, the Kaplan-Meier test, and Regression on Order (ROS) methods. A simple and common method that does not require statistical analysis is to assume that the concentrations are one-half of the SQL.

Data may be qualified due to concerns regarding chemical identification, chemical concentration, or both. One of the most commonly encountered types of data qualifiers are “J” values, which indicate that the identification of the contaminant is uncertain or approximate or that the concentration of the contaminant in the sample is estimated. USEPA (1989) recommends the use of J-qualified data but cautions that care should be exercised if the risk is being driven by qualified data results.

3.9.2.2 Low Frequency of Detection

The frequency of detection should be evaluated at each site based upon the total number of samples collected, the sampling design, and the total area sampled. In order to establish that the frequency of detection is low, the total number of samples collected must be adequate to characterize the extent of contamination at the site. The number for what constitutes low frequency of detection will be a function of total sample size and, as such, it would not be appropriate to consider contaminants detected in one to two samples as low frequency when the total sample size was less than ten samples.

The samples included in the total sample size should be collected in the same medium with similar characteristics. For example, in soil samples, the samples used to develop frequency of detects should be

collected at similar depths in areas where the soil has similar characteristics (e.g., soil collected in a flood plain would differ from that collected from a valley wall).

When determining whether the frequency of detection of a particular contaminant is low, it is also important to consider the spatial relationship of that sample relative to other samples at the site. For example, a contaminant may only be detected in two out of 20 samples, but those two samples may be adjacent and represent a source area or "hot spot" which may need to be remediated to prevent degradation of other media (e.g., groundwater).

3.9.3 Unusually High Sample Quantitation Limits

Sample quantitation limits for a particular chemical reported as not-detected (ND) in some samples may be unusually high due to one or more sample-specific problems (e.g., matrix interferences). Sometimes these values greatly exceed the positive results reported for the same chemical in other samples from the data set. The SQLs may be reduced by reanalyzing the sample, or the reported ND samples with a high SQL may be excluded from the risk assessment if they cause the calculated exposure concentration to exceed the maximum detected concentration for a particular sample set (USEPA, 1989). If there are numerous problems with a data set such that quantitation limits for the majority of the samples are elevated, a modification of the analytical methodology, reanalysis, and possibly resampling is indicated.

3.9.4 Comparison to Background

COPCs associated with a site should be evaluated in relation to background conditions, either natural or anthropogenic, as appropriate. When chemicals are present at levels which are consistent with background, those chemicals need not be carried through the risk assessment process.

3.9.5 Evaluation of Essential Nutrients

Chemicals that are essential nutrients present at low concentrations, and toxic only at very high doses, should not be considered further in the risk assessment. Examples of such chemicals are iron, magnesium, calcium, potassium, and sodium (USEPA, 1989).

3.9.6 Screening Against De Minimis or Benchmark Levels to Identify COCs

In an effort to streamline the investigation and cleanup of properties, WVDEP has provided De Minimis human health screening levels for soil and groundwater media. The screening levels are provided for residential and commercial/industrial land use for soils. The screening levels are derived from the USEPA Regional Screening Levels and procedures documented in the *User Guide (June 2017).* For WV De Minimis levels, the industrial risk-based concentrations have been modified to reflect a 1×10^{-5} carcinogenic risk, and WV Groundwater Standards have been inserted when available.

All COPCs must be screened against the Human Health De Minimis Standards to determine the list of COCs for the site. Additionally, the ecological portion of the *Checklist to Determine Applicable Remediation Standards* must be completed to determine if the COPCs must also be screened against ecological risk benchmarks. COPCs in soil must be screened against the Human Health De Minimis Standards for Residential Soil, and COPCs in groundwater must be screened against the Human Health

De Minimis Standards for Groundwater and the USEPA VISL groundwater value appropriate for residential use. After the list of COCs is determined for the site, these are carried through the risk assessment.

If the *Checklist to Determine Applicable Remediation Standards* shows that ecological receptors may be exposed to potential harm from the site, the COPCs should be screened first against the USEPA Region 3 Biological Technical Assistance Group (BTAG) values for the appropriate media (e.g., surface water or sediment samples). Chemicals that do not have benchmark BTAG values or whose toxicity has been updated since the BTAG values were developed should be screened against the USEPA Region 4 Ecological Risk Assessment Supplemental Guidance benchmarks, or the National Oceanic and Atmospheric Administration (NOAA) Screening Quick Reference Tables (SQuiRTs), which includes surface water, sediment, and soil benchmarks for ecological receptors.

3.9.7 Additional Issues for Consideration

3.9.7.1 Chemical Species

It may be important to consider specific states of the chemicals when identifying COCs. Depending on the specific state of the chemical that is present at the site, there may be different health or environmental effects associated with the chemical. For example, differences in oxidation states of metals can result in changes in absorption or toxicity (e.g., hexavalent chromium is more toxic than trivalent chromium). In circumstances where the site has historic uses which include metal-plating, coal ash (any heated ore), mafic/serpentine geology, wood preservation, fungicides, or paints/dyes, hexavalent chromium should be assumed to be present unless laboratory analysis indicates otherwise. In addition, some products may degrade over time and products of degradation may have different toxicity parameters (e.g., vinyl chloride vs. trichloroethene). These factors of long-term fate should be considered when identifying COCs.

3.9.7.2 Groups of Compounds

Some of the data collected for a site may be presented as groups of compounds (e.g., TPH). Data on groups of chemicals is not generally useful in the risk assessment process. Toxicity information used to estimate risk is compound specific; therefore, the estimation of risk associated with exposure to compounds that are identified as a group can be highly inaccurate or impossible, and as a result is not generally recommended. The individual contaminants are the COCs, but to simplify discussion within the risk assessment, may be described as groups of compounds.

3.9.7.3 Tentatively Identified Compounds

When gas chromatography-mass spectrometry (GC-MS) is used to analyze for the presence of organic compounds, the instrument is calibrated for authentic chemical standards. When compounds are identified in the sample, but the GC-MS instrument was not specifically calibrated for those compounds, they are designated as tentatively identified compounds (TICs). The mass spectrum of the sample is compared to a computerized library of mass spectra, but since no standard was calibrated for the TIC, the identification is less certain than for target compounds. The *Guidance for Data Usability in Risk*

Assessment (Part A) Final (USEPA, 1992) identifies several techniques which can be used to increase the confidence in identification and quantification of TICs.

It is also advisable to evaluate whether the TIC is likely to be associated with other compounds detected at the site. The result may support the tentative identification or may aid in making a decision regarding the need to resample.

The TIC may also be classified as belonging to a particular class of compounds, such as PAHs, and may be discussed qualitatively in the risk assessment. When dealing with TICs qualitatively, the impacts on cumulative site risk and overall uncertainty should be discussed. The data should be reviewed by an experienced analyst to obtain an "order of magnitude" estimate of the concentration, prior to any discussions of qualitative risk posed by TICs. The concentrations of TICs vs. concentrations of identified compounds should be discussed in terms of the overall risk associated with the site.

3.10 SITE ASSESSMENT REPORT

The following information should be included in all SARs submitted for review and approval. The amount of information and the level of detail presented in each section will vary, depending on the complexity of the site; however, all SARs should include each of the sections listed below.

1. Title Page
   The title page should include the site name and VRP number, name of the report (note that the name of the report should coincide with the title specified in the VRA or VRA Modification), the party that prepared the report, the party for whom the report was prepared, and date of report completion.

2. Table of Contents
   The table of contents should include sections (and subsections) and the pages on which they begin, as well as a list of figures, tables, attachments, and appendices.

3. List of Acronyms
   A list of acronyms used in the report is required for each submittal.

4. Executive Summary
   The executive summary should be a one or two-page summary of the findings, conclusions, and recommendations of the report. This summary should be written in a manner that is easily understood by the general public.

5. Introduction
   The introduction of the report should include a statement of the purpose of the report with respect to implementation of the site-specific SAWP. The introduction should also include site

background information, such as site location, site description, history, and previous environmental investigations or remediation.

6. Physical Characteristics of the Site
   This section must be of sufficient detail to adequately describe the overall physical characteristics of the site to the reader. Generally, the text should also refer to photographs and site plans that portray the site graphically. Site physical characteristics should include man-made and natural surface and subsurface features, including buildings and other structures, underground and above-ground utilities, topography and surface water drainage patterns, vegetation patterns, Source Water Zones of Critical Concern, Wellhead Protection Areas, and local and regional geology and hydrogeology.

7. Site History and Contaminants of Potential Concern
   This section should include a discussion of current and past land use; chemicals used, stored, or produced at the site; and any breakdown/daughter products. The report should reference any previous site assessment (e.g., Phase I or Phase II ESA) or other due diligence activity conducted to develop site history, land use, and contaminants of potential concern.

8. Site Investigation Objectives
   This discussion should restate the objectives provided in the site-specific SAWP which may be included as an appendix to the report or incorporated by reference. Any deviations from the site-specific SAWP should also be explained.

9. Site Investigation Activities
   This section should include a discussion of the actions completed to implement the SAWP and reference standard operating procedures included in the SAWP. Rationale for the selection of sample locations, media, and analytical parameters should be discussed and related to the CSM. Additionally, this section should include a discussion of the management of investigation-derived waste (IDW) and QA/QC procedures, with respect to the site-specific QAPP.

10. Site Investigation Results
    This section should include a detailed description of soil, fill materials, and bedrock types encountered. References should be made to figures, tables and appendices as necessary. Contaminant source locations, water table levels, and soil/bedrock contacts should be discussed, as well as results of any geophysical testing.

    A detailed description of hydrogeology should also be included. This should include discussion of any influences of groundwater level fluctuations on contaminant concentrations at monitoring wells; discrete areas of groundwater recharge or discharge and their proximity to contaminant sources and monitoring points; and influence of subsurface utilities, conduits, or fill areas on groundwater flow and occurrence. If multiple groundwater flow zones are present (i.e., soil

versus bedrock, karst zones, cohesive versus granular soil zones, etc.) these should be clearly delineated and discussed. References should be made to figures, tables and appendices as necessary. Results of any aquifer testing should also be discussed.

Finally, the results of laboratory analytical testing should be summarized and discussed by medium. If analytical data are available from previous assessment activities, those results should be included and compared with results of the current assessment. Results of screening contaminant concentrations against De Minimis Standards should also be discussed and presented in tabular format. Any new contaminant source areas should be highlighted, as well as unexpected results, data outliers, etc. The results of any fate and transport models should also be presented in this section.

11. Conclusions and Recommendations

This section should specifically address the goals set forth in the SAWP and whether the objectives were met. The QAPP should also be addressed and whether data DQOs were met. Discussions of the delineation of the horizontal and vertical extent of contamination in each media should be included, including off-site impacts, if applicable. Reference should be made to related figures and tables, as appropriate, to provide a concise and clear depiction of site-related impacts. For human receptors, actual and potential contaminant migration routes should be discussed, as well as exposure points and potential or actual exposure routes, based on the results of the site investigation. Potential or actual ecological impacts should also be discussed. Additionally, the Baseline CSM should be upgraded to the Characterization CSM based on the site investigation results.

Recommendations may include the need for additional site investigation to better define contaminant impact in certain media. Recommendations for interim remedial actions may also be included. If the site investigation is deemed complete, a recommendation to proceed with risk assessment may be included.

12. Figures and Tables

All figures should include a legend, scale bar, north arrow, figure number, name and address of site, and revision number. All figures should be placed in a single section. The actual types and number of figures, as well as the level of detail, is dependent on site conditions; guidance is provided in Attachment 4 – *Figures and Tables Formatting Guidance*. In general, each SAR should include the following figures:

- Site Location Map
- Site Plan
- Sample Location Map (by media if appropriate)
- Contaminants of Potential Concern Concentration Map
- Groundwater Potentiometric Surface Map
- Geologic Cross Sections (if appropriate)

- Conceptual Site Model

In general, each SAR should include the following tables:

- Analytical laboratory results for each medium (e.g., soil, groundwater, etc.) and pathway (e.g., vapor)
- Groundwater gauging information, including NAPL thickness
- Geophysical and aquifer test results when appropriate

A separate table should be provided for each environmental medium and pathway (e.g., surface and subsurface soil, sediment, groundwater, surface water, indoor air, soil vapor, etc.) for which sampling data are available. Throughout the text and tables, present the data in a consistent manner (e.g., µg/L for groundwater and mg/kg for soils). Arrange the data chronologically, if appropriate (e.g., groundwater), and discuss in the text any apparent time trends in the data. Present frequency of detection, range of sample quantitation limits, minimum and maximum concentrations, arithmetic mean (for lead only) and 95% Upper Confidence Limit (UCL) on the most appropriate distribution as identified by *ProUCL* (as applicable). If hot spots are identified, they may be presented in separate tables or excluded from statistical analysis.

13. Appendices
    Appendices that support the findings of the assessment should be provided. These generally include:
    - Boring logs
    - Well construction diagrams
    - Monitoring well development and purging logs
    - Laboratory analytical reports and chain(s) of custody
    - QA/QC sample results
    - IDW manifests
    - Field notes
    - Photographs
    - Data validation report

3.11 DATA VALIDATION REPORT

A summary of the data validation quality assurance review can be incorporated into the SAR or provided as a separate deliverable. The report must be prepared in easy-to-understand, "user-friendly" language. The report must list the samples and methods that were validated; address method compliance issues; provide comments about the performance of field, matrix, and laboratory QC samples as compared to DQOs; and present data usability issues (qualified data and the reason they are qualified). The report should also address reporting and/or calculation errors by the laboratory, if discovered. The report must include data summary tables/qualified result summaries using standard Contract Laboratory Program

(CLP) qualifiers, unless dictated otherwise in the QAPP. The data summary tables/qualified result summaries should include all reported results and the associated data qualifiers.

In addition, the report will include a cover letter or executive summary that summarizes all data usability issues, any relevant reporting issues, a statement defining the level of data validation being performed, and a statement from the chemist that reads, "The analytical data associated with the (insert site name and location), were determined to meet (or, not meet) the data quality objectives of the project." If the DQOs were not met, the OER Project Manager must be notified prior to use of the data for any decision-making purposes.

See Attachment 8 – *Data Validation Report Checklist*. The recommended format is as follows:

1. Introduction
   This section presents the number of samples analyzed, the laboratory(ies) that analyzed the samples, the date(s) of sample collection, the parameter(s) for which the samples were analyzed, and the analytical method(s) used.

2. Laboratory Compliance
   This section presents correctable and/or non-correctable deficiencies relative to the requirements and deliverables specified in the methods performed. Deficiencies may or may not affect data usability. Appropriate citations are provided for each deficiency identified. Comments regarding the data or deliverables are also presented.

3. Data Qualifiers
   This section presents data qualifiers that should be considered in order for the data to be best utilized. Each qualification is followed by a justification for the qualification. The qualifiers/findings are presented as bulleted items in order of importance relative to their impact on the data set. This can be an analytical method specific section(s) including an overview/summary, major and minor issues/problems associated with the analysis, and a discussion of QC measures related to the specific analysis.

4. Supplemental Documentation
   This section may include a list of data validation qualifiers with explanation, copies of the chain of custody record, copies of relevant correspondence with the laboratory and/or the user of the data, and analytical data sheets used by the chemist to qualify the data.

3.12 DECONTAMINATION

Decontamination is the process of removing or neutralizing contaminants which may have accumulated on field equipment. This process provides for protection of personnel and reduces or minimizes cross-contamination between sampling locations or from contaminated zones to non-contaminated zones. The LRS is responsible for ensuring that the proper decontamination procedures are identified in the SAWP.

The field team leader is responsible for ensuring that the field decontamination procedures are implemented properly in the field. SOPs for decontamination are presented in the WVDEP/DLR/OER QAPP, SOP OER-100 (General Decontamination Procedures).

The following references include information about decontamination alternatives.

- ASTM D5088-15a, Standard Practice for Decontamination of Field Equipment Used at Waste Sites, ASTM International, West Conshohocken, PA, 2015, www.astm.org.
- USEPA. 1985. Guide to Decontaminating Buildings, Structures, and Equipment at Superfund Sites. EPA/600/2-85/028.
- USEPA. 1992. RCRA Groundwater Monitoring Technical Enforcement Guidance Document (TEGD). Office of Waste Program Enforcement. OSWER Directive 9950.1.
- USEPA. 2015. Field Equipment Cleaning and Decontamination. SESDPROC-205-R3. Science and Ecosystem Support Division. Athens, Georgia.

3.12.1 Heavy Equipment

All heavy equipment such as drill rigs, backhoes, augers, and down hole tools should be decontaminated prior to drilling, excavation, or sampling activities. "Dirty" equipment may result in false positive sampling results simply due to contamination from another site. Therefore, prior to performing any field activities, or prior to leaving the "hot zone" at the site, heavy equipment should be decontaminated. For augers and other down hole tools, decontamination should be performed between each sampling location.

3.12.2 Sampling and Field Equipment

Sampling equipment should be properly decontaminated prior to the field effort, during the sampling program (i.e., between sample locations or sample intervals), and at the conclusion of the field program. Preferably, dedicated sampling equipment (e.g., bailers) or disposable sampling equipment should be employed. Decontamination methods should be designed based on the suspected contaminants of concern.

3.12.3 Field Analytical Equipment Decontamination

Field analytical equipment that may contact the sample media should be decontaminated prior to use, between sampling locations, and after the conclusion of the field program. Decontamination of this equipment should follow manufacturers recommended procedures and should prevent cross contamination.

3.13 INVESTIGATION DERIVED WASTE

The LRS should consider all of the following when developing a plan to manage IDW:

- The potential degree of contamination that may be exhibited by the IDW.

- The potential exposure to human health or the environment to concentrations of contaminants exceeding the De Minimis or other appropriate standards.
- Safety and aesthetic factors associated with the disposition of the wastes (if the management option is to leave the IDW on-site).
- State or federal regulatory requirements for proper handling and treatment /disposal.

More information on RCRA wastes, including Land Disposal Restrictions (LDRs), and TSCA wastes can be found in the following references:

- 40 CFR Part 260 (Hazardous Waste Management System: General).
- 40 CFR Part 261 (Identification and Listing of Hazardous Wastes).
- 40 CFR Part 761 (PCBs).
- USEPA. 1989. OSWER Directive 9347.3-05FS.
- USEPA. 1990. PCB Guidance Manual, EPA/540/G-90/007.

In addition to ensuring that the IDW management is protective of public health and the environment and conducted in accordance with applicable regulations, site managers need to consider two general objectives: (1) minimize the amount of IDW when possible; and (2) manage the IDW as part of the final remedial action for the site.

Potential ways to reduce the amount of IDW include the following:

- Select field techniques which do not result in excessive IDW (e.g., soil gas surveys, Geoprobe[R] sampling, direct push sampling techniques, etc.).
- Segregate wastes from “hot areas” and from other areas which may not be contaminated.
- Do not containerize IDW from background locations, which are known or suspected to be non-contaminated.

Managing the IDW as part of the final remedial action should consider the following:

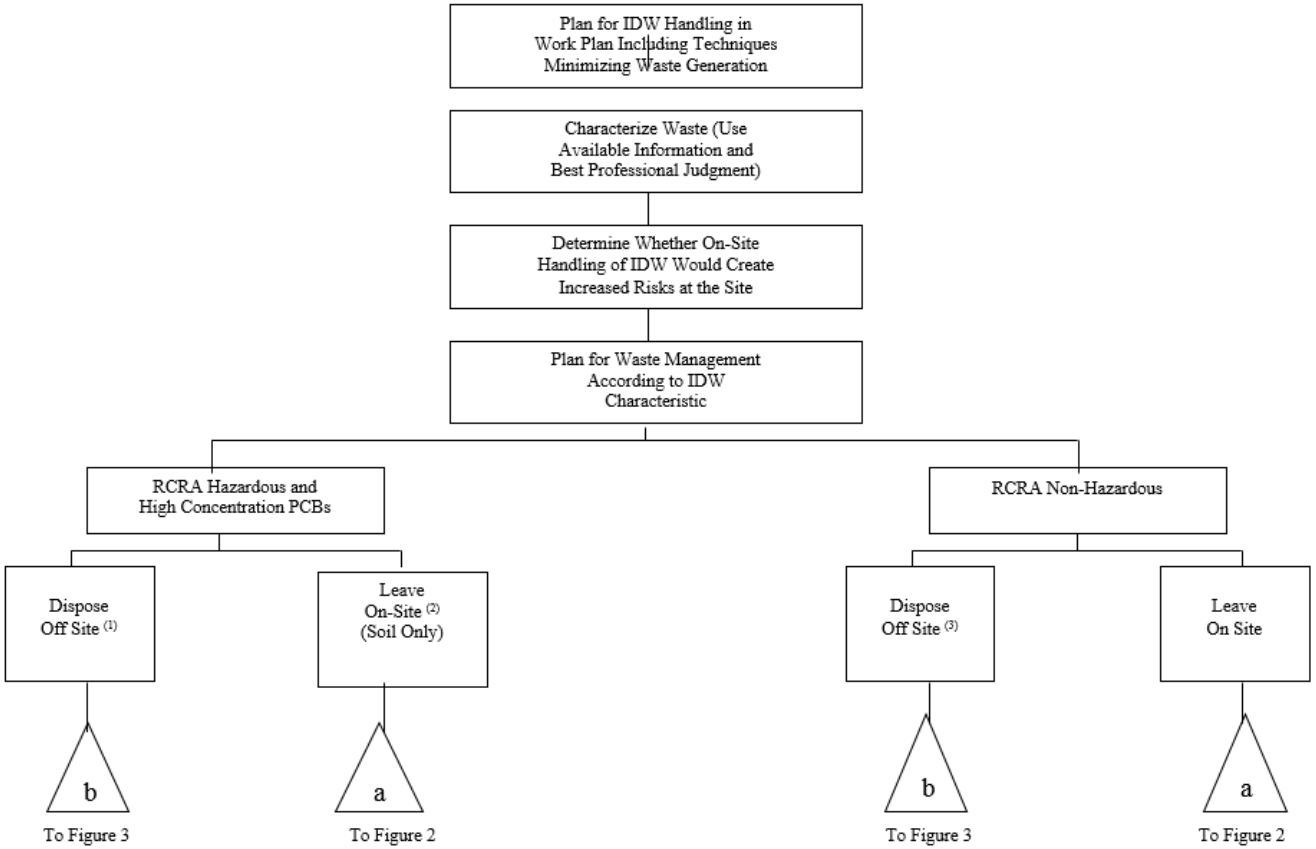
- Backfill test pits and soil borings in areas where remediation is likely to occur (based on background information, field observations, or previous investigative data).
- If the IDW is containerized, manage the treatment/disposal as part of the remedial actions for the various site media.

3.13.1 Investigation Derived Waste Characterization

Management of IDW should be consistent with guidance provided in *Management of Investigation-Derived Wastes During Site Inspections* (USEPA, 1991). Figures 3-4, 3-5, and 3-6 provide IDW Management Decision Trees that can be used by the LRS to evaluate IDW disposal options.

All waste containers are required to be properly labeled pending analysis and final disposition. Labeling includes stating whether the contents are hazardous or nonhazardous; waste generator; waste source; and the date the waste was generated. To assess whether the IDW possesses a health or environmental risk, WV De Minimis Standards can be used as a guide. In cases where the LRS is unable to use generator knowledge or previous sample analyses to demonstrate the nature of any generated wastes, it will be necessary to analyze for RCRA hazardous waste constituents (ignitability, reactivity, corrosivity, and/or leachability/toxic compound leaching procedure) prior to shipment to an off-site treatment/disposal facility.

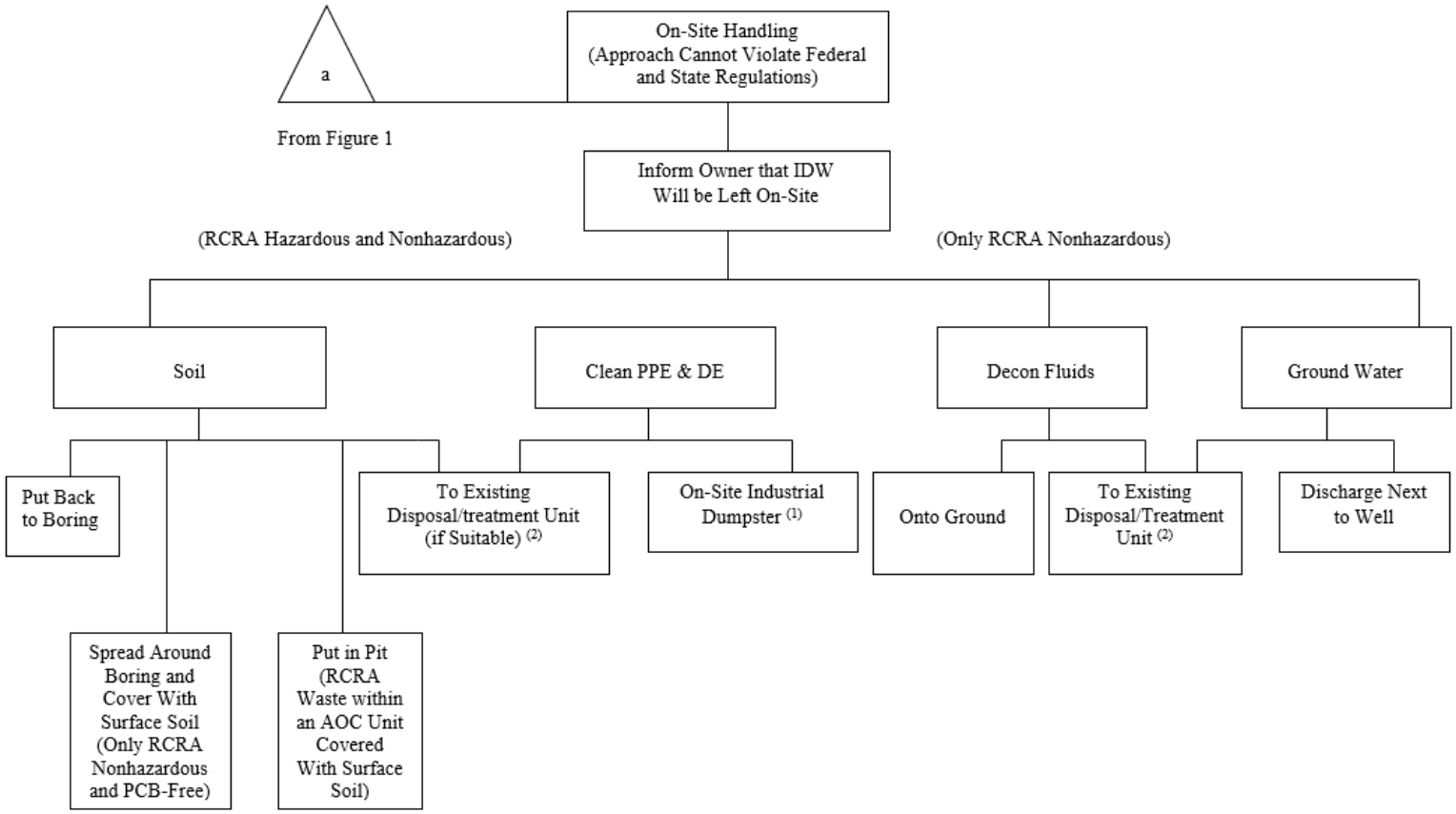
Figure 3-4: IDW Management Decision Tree – Part 1



(1) Soil cuttings, ground water, and decontamination fluids creating increased hazards at the site should be disposed off-site. Before and after the site investigation, determine anticipated waste quantity and applicable regulations for waste generators.
(2) If not prohibited by other legally enforceable requirements such as state ARARs.
(3) Justified only in rare circumstances when a RCRA nonhazardous waste is a state hazardous waste and state legally enforceable requirements call for waste removal, or if leaving the waste on-site would significantly affect human health and the environment.

Source: USEPA 540G-91-009 – Management of Investigation Derived Wastes During Site Inspections – May 1991

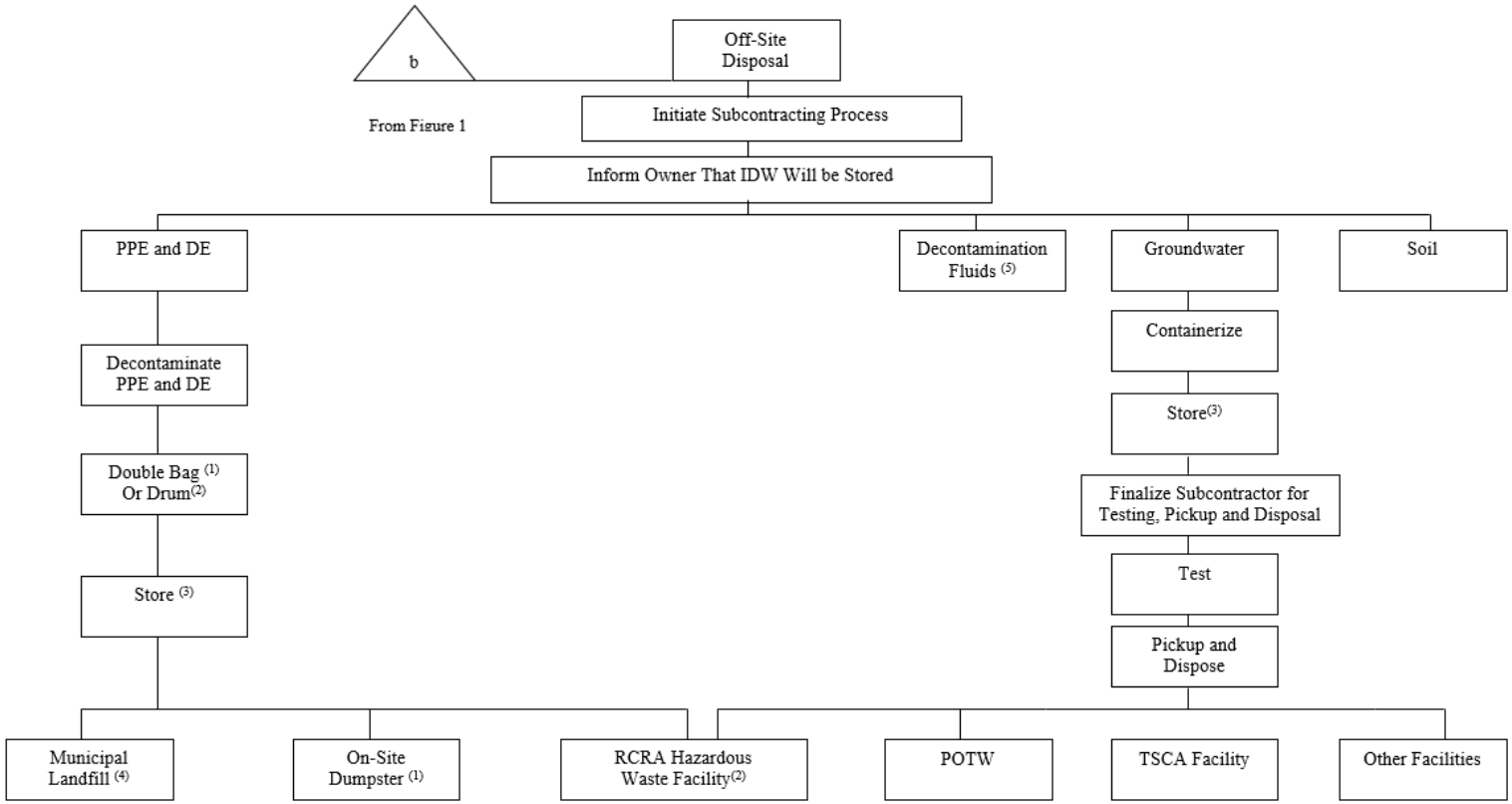
Figure 3-5: IDW Management Decision Tree – Part 2



(1) Clean PPE and DE may also go to the nearest landfill or to a dumpster.
(2) If the receiving unit meets the off-site policy acceptability criteria.

Source: USEPA 540G-91-009 – Management of Investigation Derived Wastes During Site Inspections – May 1991

Figure 3-6: IDW Management Decision Tree – Part 3



(1) Only RCRA nonhazardous waste.
(2) Only RCRA hazardous waste generated in quantities greater than 100 kg/month when sent off-site.
(3) In accordance with accumulation requirements for RCRA hazardous wastes.
(4) Only if the conditionally exempt small quantity generator exception applies.
(5) If the conditionally exempt small quantity generator exception applies, off-site disposal of decon fluids may not require subcontracting.

Source: USEPA 540G-91-009 – Management of Investigation Derived Wastes During Site Inspections – May 1991

3.13.2 IDW Disposal Options

The disposal option selected should be based on best professional judgment, with consideration of the following:

- Volumes and types of wastes requiring disposal
- Risks posed by disposing the IDW at the site without any containerization or characterization
- Compliance with state and federal regulations
- Whether the IDW can be managed as part of a future remedial action at the site
- Public perception and safety
- Compliance with transporter and disposal facility requirements

3.14 REFERENCES

3.14.1 Preliminary Characterization

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4.0 Risk Assessment

The risk-based standards provide for the protection of human health and the environment relative to current and reasonably anticipated future land and water uses of the site. Risk-based standards are used to determine whether a remedial response action is necessary, to identify target cleanup levels if a remedial action is required, and to document that a site meets required levels of protectiveness for human health and the environment.

4.1 EXPOSURE ASSESSMENT

Risk assessment begins with exposure assessment by first determining all of the receptors that may be exposed to contaminants via any pathway. An exposure pathway must have the following four elements to be considered complete:

1. A source and mechanism of chemical release to the environment
2. An environmental receiving or transport medium (i.e., soil or groundwater) or pathway (i.e., air vapor and/or particulates, surface water, and sediment) for the released chemical
3. A point of potential contact with the environmental medium/pathway of concern
4. An exposure route (i.e., ingestion, dermal contact, inhalation) at the receptor contact point

Ingestion, dermal, and inhalation exposure routes that are currently or may reasonably be complete in the future need to be determined from the conceptual site model (CSM), indicating the importance of a well-developed CSM. The exposure assessment should establish the setting, the potential transport mechanisms, the potential receptors, the exposure pathways, and intake estimation methods and determine the exposure point concentrations (EPCs). The primary media of concern are surface soils, subsurface soils, and groundwater, but secondary exposure pathways may include sediment, surface water, and vapor. Each of the media and pathways need to be assessed for potential exposures through the routes of ingestion, dermal contact, and inhalation of vapors/particulates. All exposure routes need to be accounted for in the exposure assessment and CSM via each of the media and pathways. Many of the exposure routes will obviously not be potentially complete (e.g., ingestion of vapors) and may not need to be assessed.

The list of potential receptors for an exposure assessment includes both on-site and off-site, current and future:

- Residents
- Trespassers
- Recreators
- Indoor commercial/industrial workers
- Outdoor commercial/industrial workers

- Construction workers (down to ten feet below ground surface)
- Utility workers (down to four feet below ground surface)
- Terrestrial ecological receptors
- Aquatic ecological receptors

Knowledge of the site and presumptive remedies that sever potential exposures and make the need for relevant site-specific risk calculations unnecessary (e.g., LUCs) may be used to exclude some of the potential receptors from further assessment. Presumptive remedies will need to be approved by WVDEP and must be fully implemented to receive a Certificate of Completion for the site. Examples of presumptive remedies that can be applied in an exposure assessment include, but are not necessarily limited to:

- Residential use restrictions
- Groundwater use restrictions
- Vapor mitigation systems
- Soil management plans (with HASPs)
- Caps and covers

Once the potentially complete exposure routes have been established in the exposure assessment, the EPCs will need to be calculated based on the lowest of the maximum concentration or the 95% Upper Confidence Limit (UCL) of the COPCs in each applicable media/pathway. Once the exposure assessment is complete, the EPCs should first be screened against the relevant benchmarks (e.g., De Minimis Standards) to determine if any potential exposure may be unacceptable by completing a De Minimis Risk Assessment.

- If no EPCs exceed their relevant benchmark, then no further remedial actions are required.
- If any EPCs exceed their relevant benchmark, then either a Uniform or Site-Specific Risk Assessment will need to be completed or the EPC reduced through remediation.

4.2 DUPLICATE AND SPLIT SAMPLES IN EXPOSURE POINT CONCENTRATIONS

Duplicate and soil samples may be used in the calculations of EPCs, but only with care. Soils are notoriously heterogeneous, and homogenizing soils in the field is impractical since it requires drying, grinding, and sifting the soils, which is impossible for VOC samples. Therefore, soil samples may be treated as separate (discrete) samples in the analysis, or the maximum of the duplicate/split samples can be used to conservatively represent the general location and depth. Duplicate and split soil samples should be grouped into either the surface soil (0-2 ft. bgs) or subsurface soil (>2 ft. bgs) category as appropriate.

Whenever duplicate or split samples are taken from groundwater, the maximum validated analytical result will be used to represent the place and time of sampling. Using the maximum concentration recognizes

that water is easier to homogenize in the field than soils; should have consistent results between the duplicates and splits; and is the most conservative estimate to protect potential receptors. In cases of large differences between duplicate or split samples (>25% of the lowest value), the LRS should investigate the possible sources of such unexpected differences. If lab procedures are found to be the probable source of differences and an unbiased sample is identified, the LRS can use the unbiased result for the Risk Assessment. However, if lab procedures are found to be the probable source of difference and no unbiased sample can be identified, the LRS can either use the maximum concentration result or resample the water. If lab procedures cannot be identified as the probable source of the differences, then the sample collection methods are implicated as the source of error and the LRS will have to discard the samples and likely resample the water.

4.3 HUMAN HEALTH STANDARDS

In conjunction with the ecological standards, a variety of human health standards may be applied to different contaminants at a site or to different portions of a site. The goal is to provide flexible standards so that Applicants may select the standard(s) most appropriate for their site. The purpose of these standards is to develop risk-based surface soil, subsurface soil, sediment, surface water, soil vapor, and groundwater remedial objectives for site-remediation, as applicable.

Three options are available for developing risk-based human health standards at a site:

1. <u>De Minimis Standards</u>
   These standards are calculated for several chemicals using established risk equations from the USEPA Regional Screening Levels (RSLs) and default exposure assumptions. They are calculated by the agency and promulgated under the Rule, attached as Table 60-3B. In instances where risk-based concentrations exceed residual soil saturation concentrations (C_{SAT}), the values provided in the table are C_{SAT} values and are indicated by "Csat" value basis entries (see industrial soil standard for acetone). Similarly, in some instances the mathematical algorithms for deriving risk-based standards result in concentrations exceeding the theoretical maximum concentration of $1x10^6$ mg/kg. In these cases, the standards are listed as 1.0E+6 and indicated by "max" value basis entries (see industrial soil standard for aluminum).

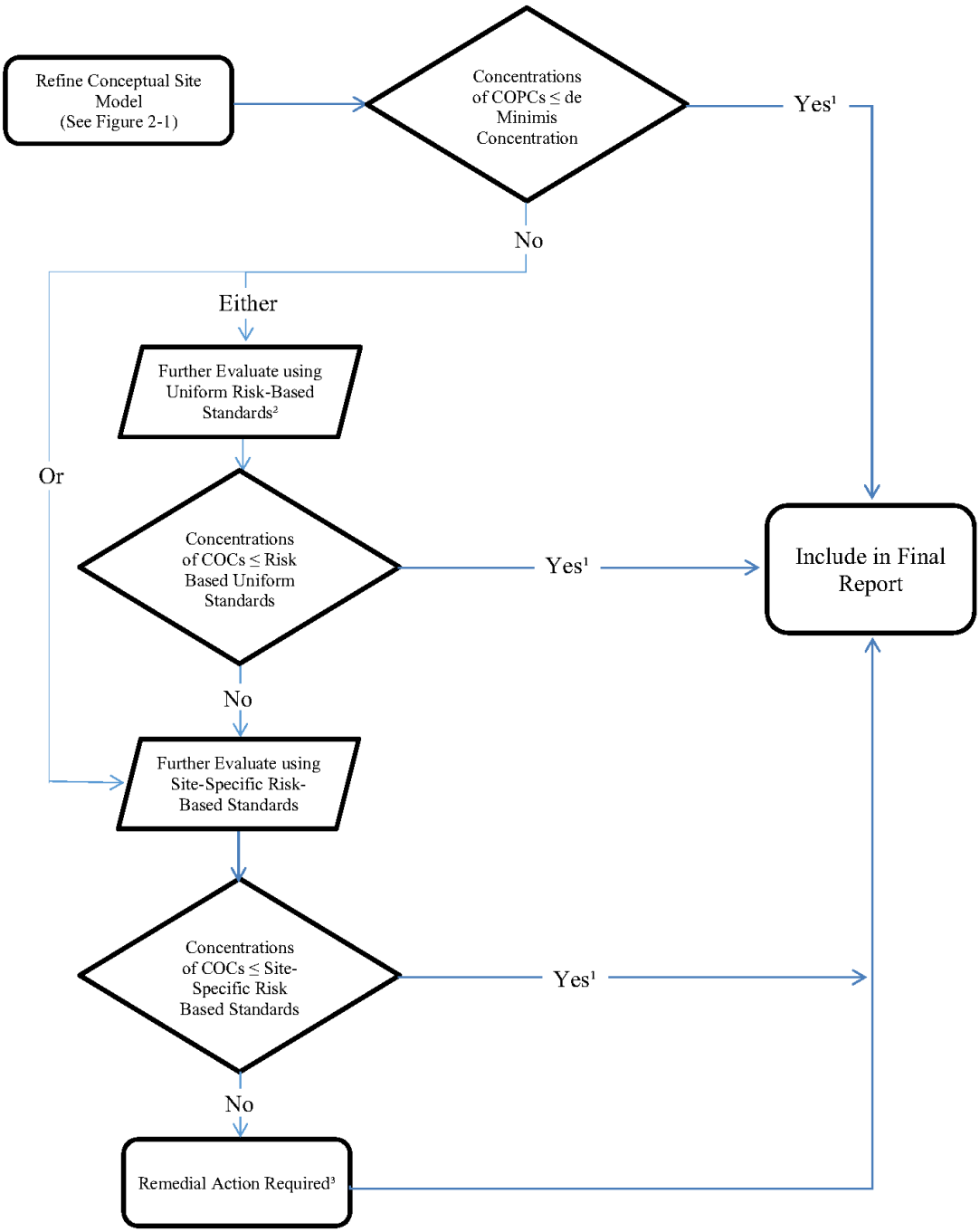
   Note that natural background concentrations can be used as alternative De Minimis Standards when they exceed risk-based values (e.g., arsenic). The USEPA Vapor Intrusion Screening Levels (VISLs) also serve as the De Minimis Standards for potential vapor intrusion scenarios.

2. <u>Uniform Standards</u>
   These standards are determined by the LRS using the same equations described above to establish site-specific remediation goals. They differ from De Minimis Standards in that some assumptions incorporating site-specific information may be substituted for generic exposure assumptions, where applicable. In addition, Uniform Standards are also calculated for constituents not included in the De Minimis Table.

3. Site-Specific Standards
   These standards are determined using baseline and/or residual risk assessments to establish protective cleanup standards based on site-specific conditions and reasonably anticipated future land and water uses, and they can incorporate properly implemented engineering and institutional controls. They may be expressed as specific potential risk values (Excess Lifetime Cancer Risk) and non-cancer hazard quotients/indices that meet the prescribed levels, or as risk-based concentrations meeting the same levels.

Figure 4-1 illustrates the decision-making process for selecting a method of deriving human health standards for a site. This diagram should be used together with Attachment 2 – *Checklist to Determine Applicable Remediation Standards*. This decision-making process should begin only after a Characterization CSM has been developed and COCs have been identified and sufficiently characterized in terms of concentrations in media of concern.

Figure 4-1: Human Health Remediation Standard Selection Process



[1] Ecological receptors are not a factor or ecological standards are ≥ Human Health Standards

[2] Applicant may proceed to a Site-Specific Risk-Based Standard or proceed with remediation rather than evaluate using a Uniform Risk-Based Standard

[3] Prior to clean up the applicant must evaluate the remedial alternatives, submit a Remedial Action Plan, and obtain WVDEP approval of the plan.

For many simple sites with few contaminants, the De Minimis Standards may be sufficient to determine the need for remediation. For more complex sites (e.g., sites with both human and ecological receptors), or sites where De Minimis exposure assumptions may not be applicable (e.g. recreational sites where Residential De Minimis Standards are exceeded), Uniform or Site-Specific Standards should be applied to all—or portions of—the site.

Where site contamination is impacting surface waters, the following must be addressed:

- A De Minimis Standard may not be appropriate in instances where impacted soil or groundwater may result in exceedances of surface water standards.
- The Uniform and Site-Specific Standards for surface water are the applicable water quality standards found within W. Va. Legislative Rule 47CSR2 (Requirements Governing Water Quality Standards).
- Except as provided under conditions of a permitted point-source discharge, compliance with surface water quality standards may be demonstrated using the approach described in Appendix B – *Assessing Non-Point Source Stream Impacts*.
- For any contaminant for which there is no water quality standard in W. Va. Legislative Rule 47CSR2 (Requirements Governing Water Quality Standards), a remediation standard may be developed using the methodology for determining a Site-Specific Standard.

4.4 HUMAN HEALTH DE MINIMIS STANDARDS

The De Minimis Standards are intended to be the quickest and easiest method for deriving remediation standards that are protective of human health and meet applicable programmatic risk goals. De Minimis Standards apply to chemicals in soil and/or groundwater for which the primary exposure routes include ingestion, inhalation, and dermal pathways. For this reason, development of an accurate CSM, is a critical step in determining eligibility of a site, or portions of a site, for assessment using De Minimis Standards. The CSM in the De Minimis Risk Assessment may account for presumptive remedies that the Applicant intends to apply to their site, such as land use covenants.

For direct contact soil exposures, the De Minimis Standard for each constituent is the higher of its risk-based concentration (RBC) value listed in the De Minimis Table or its natural background concentration. Risk-based standards are provided in the De Minimis Table for both residential and industrial land use scenarios. For direct contact groundwater exposures, De Minimis concentrations listed in the table are either groundwater standards promulgated under W. Va. Legislative Rule 47CSR12 (Requirements Governing Groundwater Standards), if available (indicated by “gws” value, respectively), or carcinogenic or non-carcinogenic risk-based values (indicated by a “c” or “nc” value basis). While groundwater standards promulgated under W. Va. Legislative Rule 47CSR12 (Requirements Governing Groundwater Standards) are enforced under the VRP, background concentrations may be considered as De Minimis values if greater than risk-based values.

Note that human health-based De Minimis Standards are not available for surface water or sediments. Site eligibility for using the De Minimis Standards is determined by responses to Attachment 2 – *Checklist to Determine Applicable Remediation Standards* of this guidance manual.

4.4.1 De Minimis Standards for Soil

The De Minimis Standards for both surface (0 – 2 feet depth) and subsurface (>2 feet depth) soils are the higher of the following values:

- De Minimis values listed in Table 60-3B of the Rule
- Natural background levels

The De Minimis Standard may be selected for all or a portion of the contaminants and for all or a portion of the site, as appropriate. However, sites with numerous (>10) COPCs will need to consult with WVDEP to account for potential cumulative impacts. An LUC restricting residential land use is required for portions of a site where the Industrial De Minimis Standards are used, but the chemicals of concern that exceed Residential De Minimis Standards must be listed to justify the need to restrict residential use, which requires screening the concentrations against both Residential and Industrial De Minimis Standards.

Background concentrations of naturally occurring constituents vary greatly, depending upon the source of the soil matrix or the depositional environment. When natural background is used as the De Minimis Standard, attainment may be demonstrated in several ways. A simple approach is to document that sample concentrations for a particular contaminant at a site are less than the upper tolerance limit (UTL) for that same analyte in natural background samples. A comparison of the UTLs for analytes in natural background soils to the De Minimis Standards indicates that natural background concentrations of several constituents may be greater than the Residential De Minimis Standards for those analytes. (Methods for calculating the UTL are provided in Appendix A – *Determining Background Concentrations*.)

4.4.2 De Minimis Standards for Groundwater

For constituents with standards promulgated under W. Va. Legislative Rule 47CSR12 (Requirements Governing Groundwater Standards), the De Minimis Standards for groundwater are the promulgated values. They are listed in the De Minimis Table and identified by a value basis of "gws." Under the Rule, industrial and residential uses of groundwater are not distinguished.

For constituents having no value promulgated under W. Va. Legislative Rule 47CSR12 (Requirements Governing Groundwater Standards), the De Minimis standards are the higher of:

- De Minimis values listed in Table 60-3B of the Rule, indicated by a value basis of "c" or "nc"
- Natural background values for inorganic constituents

Since the De Minimis Standards do not account for potential vapor intrusion, WVDEP uses USEPA's VISLs for groundwater, soil gas, and/or indoor air to screen for vapor intrusion issues. Therefore, the

COPCs should also be screened against the appropriate VISL values for groundwater based on their concentrations and planned use for the site (commercial/industrial vs. residential).

4.4.3 Implementing De Minimis Standards

Once the soil concentrations of contaminants of potential concern (COPCs) are determined for both surface and subsurface soils as separate media, EPCs are compared to the De Minimis Standard for residential and industrial land uses. The EPC is defined as the lower of the 95% UCL of the concentration as calculated using the most appropriate frequency distribution in *ProUCL* (see Appendix A – *Determining Background Concentrations*) or the maximum value of each COC. If the EPC is below the De Minimis value and there is no apparent risk to ecological receptors as verified by an ecological risk assessment, no further site assessment or remediation needs to occur. If the EPCs exceed De Minimis concentrations, contaminant concentrations must be reduced below the De Minimis levels, remedies that eliminate any potential exposure must be applied, or alternative remediation standards must be derived using the Uniform or Site-Specific Standards. Samples that appear to be derived from locations that are distinct from the majority of those obtained from the assessment area (e.g. hotspots) should be evaluated separately. (Appendix A – *Determining Background Concentrations* has statistical methods for determining outliers via *ProUCL*).

For groundwater, if the EPCs of COPCs in each monitoring well are below their De Minimis Standards and VISL values, no further assessment is necessary. As with soils, if EPCs exceed De Minimis or VISL values, options include remediating to the De Minimis or VISL standards, applying remedies that eliminate any potential exposure, or further evaluating the site using either Uniform or Site-Specific Standards. Groundwater exceeding the relevant VISL values may also be further assessed by screening soil gas or indoor air concentrations against the relevant VISL values to determine if further remediation or assessment is necessary.

Once the soils, groundwater, and vapor have been screened against the De Minimis Standards, a De Minimis Risk Assessment that includes all of the potentially complete pathways and the presumptive remedies may be submitted. The calculation of site-specific risk standards or values is not necessary in a De Minimis Risk Assessment, which can save considerable time and money, as long as the site-related EPCs and presumptive remedies indicate acceptable exposures for all potential receptors. To expedite the VRP process, the De Minimis Risk Assessment may also be combined with the Remedial Action Work Plan (RAWP), which should describe the planned implementation of the presumptive remedies but combining these documents may require a Modification of the Voluntary Remediation Agreement (VRA).

The De Minimis Standard may not be applied to any contaminant at a site where the contaminant is impacting surface water. An expedited De Minimis Risk Assessment process is also available for qualifying Rail Trail sites (see Appendix G – *Rail Trail Guidance*).

4.5 HUMAN HEALTH UNIFORM STANDARD

The Uniform Standard relies on uniform, approved methodologies, exposure factors, and other input variables to calculate remediation standards. Site-specific variables may replace default variables with adequate technical justification. The remediation standards will be protective of human health based on current or reasonably anticipated future land and water use. Applicants who select the Uniform Standard need not meet the De Minimis Standard.

USEPA (1991a, 1996b,c) has developed standard default risk equations for typical exposure pathways, available through the USEPA RSLs webpage; it is those exposure pathways and equations that are considered and used in the Uniform Standard. The equations used in the Uniform Standard and USEPA RSLs consider the following residential exposure pathways, where applicable:

- Ingestion of groundwater or surface water
- Dermal contact with groundwater or surface water
- Inhalation of volatiles from groundwater or surface water
- Ingestion of soil
- Inhalation of volatiles and particulates from soil
- Dermal contact with soil
- Soil concentrations protective of groundwater

The equations used in the Uniform Standard and USEPA RSLs consider the following industrial exposure pathways:

- Ingestion of surface water
- Dermal contact with groundwater or surface water
- Inhalation of volatiles from groundwater or surface water
- Ingestion of soil
- Inhalation of volatiles and particulates from soil
- Dermal contact with soil
- Soil concentrations protective of groundwater

The Uniform Standard and USEPA RSLs also consider pathways specific for outdoor workers, indoor workers, construction workers, recreators, vinyl chloride, trichloroethylene, and fish ingestion. The equations for each of these pathways are available from the USEPA on the RSLs webpage. Default exposure and other factors, including a default fish consumption rate for WV adults, can be found in Appendix C – *Exposure and Chemical Parameters*.

For any land use, soil concentrations that are protective of groundwater must also be determined. Any major exposure pathways not included in the USEPA RSL equations may need to be evaluated under the Site-Specific Standard.

The default assumptions for the Uniform Standard can be found in Appendix C – *Exposure and Chemical Parameters* of this guidance manual. The equations are available via the USEPA RSLs webpage, but USEPA also provides an online RSLs Calculator that may be used without having to code the equations into a spreadsheet. Site-specific information may be substituted for any of the default values listed provided that the justification for the site-specific value is adequately documented. Where significant non-cancer hazards or potential risks occur from more than one pathway, cleanup levels determined from the Uniform equations should be adjusted to consider cumulative effects, such as multiplying by a factor of ten for every ten chemicals of concern or some other method approved by the OER Environmental Toxicologist.

It should be noted that the Uniform Standard and USEPA RSL equations are not appropriate for lead. Lead in drinking water must meet the WV Groundwater Standard. Lead in soils must meet either the De Minimis Standards or the method for deriving lead standards established by the USEPA for use at Superfund sites, which includes the Integrated Exposure Uptake Biokinetic (IEUBK) model for lead in children and the Adult Lead Methodology (ALM) for adults.

As with the De Minimis Standard, not all sites may be appropriate for evaluation using the Uniform Standard approach. For example, Uniform Standard methods for assessment of contaminated sediments are not provided. An accurate conceptual site model is crucial in determining whether the Uniform Standards will be sufficient to guide remediation decisions at a site.

4.5.1 Uniform Standards for Groundwater

In instances where De Minimis or VISL groundwater standards are exceeded by the EPC, Uniform Standards may be considered. Unlike the De Minimis values, particularly those based on drinking water standards (i.e., maximum contaminant levels or MCLs), Uniform Standards may consider the current or likely future land use, groundwater quality as it pertains to potential use as a potable water source (e.g., background total dissolved solids > 2500 mg/ml), and potential off-site migration.

Calculation of a Uniform Standard for groundwater includes consideration of inhalation of constituents from, dermal contact with, and ingestion of groundwater. The standard applied at such sites would be the higher of the MCL, the Uniform Standard, or the natural or anthropogenic background concentration for each COC.

For sites where contaminants are present in groundwater, the methods and equations provided by the USEPA RSLs should be used to derive a Uniform Standard. For sites where potability or groundwater use may be an issue, the Uniform Standard for groundwater must be derived based on current or reasonably anticipated future land and water uses, the potential for migration of contaminants, and the usefulness of the aquifer as a source of drinking water. Groundwater that has a background total dissolved solids content greater than 2500 milligrams per liter (mg/L) is probably not useful as a source of drinking water. If it is suitably demonstrated that the groundwater is not and cannot serve as a source of drinking water using the criteria above and that the aquifer is not hydrogeologically connected to an

aquifer being used for drinking water, the groundwater may be deemed not suitable as a source of drinking water.

4.5.2 Uniform Standards for Soil

The Uniform Standards for soil are based on USEPA's soil screening guidance (USEPA, 1996b and c) and the USEPA RSLs. RSLs provide for three exposure routes: ingestion, dermal, and inhalation. For volatile chemicals, inhalation of vapors is considered; for nonvolatile chemicals, inhalation of particulates is included. The methods and equations provided by the USEPA RSLs should be used to derive a Uniform Standard, and the RSLs Calculator may be used, rather than developing a spreadsheet. Site-specific adjustments may include consideration of site data regarding the relative oral bioavailability of chemicals in soil (see Appendix D – *Relative Absorption Factors and Bioavailability*), site data pertaining to the flux rates of volatile chemicals from soil, or site or regional data modifying assumptions about particulate releases to air.

The soil screening guidance also includes screening levels that provide varying degrees of protection for migration of chemicals from soil to groundwater. Two sets of values are provided based on dilution and attenuation factors (DAFs) of 20 and 1. Site-specific DAFs may be developed with appropriate documentation. The standards for soil concentrations that are protective of groundwater were derived by USEPA using a complex model to predict contaminant migration from soil to groundwater in a two-stage process: (1) release of contaminant in soil leachate, and (2) transport of the contaminant through the underlying soil and aquifer to a receptor well. The USEPA methodology is described in detail in the *Soil Screening Guidance: Technical Background Document* (USEPA, 1996b). The USEPA document also provides guidance for making site-specific adjustments to the default standards.

In cases where risk-based soil or groundwater protection Uniform Standards are exceeded by anthropogenic background concentrations, the background value may be used to determine the need for remediation.

4.5.3 Establishing the Uniform Standards

For known or suspected carcinogens, acceptable cleanup levels may be calculated using Uniform Standards established at levels that represent an excess upper bound lifetime risk of between one in ten thousand (1×10^{-4}) to one in one million (1×10^{-6}). Special notification must be given for those sites where remediation levels will exceed the one in 100,000 (1×10^{-5}) level of risk for industrial sites and the one in 1,000,000 (1×10^{-6}) risk for residential sites. Note that WVDEP considers residential uses to include, but not be limited to, daycares, schools, nursing homes, other residential-style facilities, and recreational activities. Risks should be characterized by the quantification of cumulative risks posed by multiple contaminants. Cumulative site risks shall not exceed one in 10,000 (1×10^{-4}).

For individual systemic toxicants, the Uniform Standards shall represent levels to which the human population could be exposed without appreciable risk of deleterious effect. For the Uniform Standard, the hazard quotient (HQ) shall not exceed one (1.0) for any individual or group of toxicants that act on the same target organ. Where multiple systemic toxicants affect the same target organ or act by the same

method of toxicity, the hazard index (sum of the hazard quotients) shall not exceed one (1.0). Where multiple systemic toxicants do not affect the same organ, the hazard index shall not exceed ten (10.0). If the hazard index exceeds one (1.0), further evaluations and/or remediation may be necessary. Consult the Integrated Risk Information System (IRIS) or Health Effects Assessment Summary Tables (HEAST) databases for the most recent information on target organs/systems affected by various chemicals.

If a contaminant exhibits both carcinogenic and noncarcinogenic effects, then the more conservative risk-based standard (i.e., the lower of the two values) shall be used as the remediation standard.

Either natural or anthropogenic background concentrations may be used as the Uniform Standard. Background concentrations of anthropogenic constituents vary greatly depending upon regional sources and local conditions. The most critical consideration in developing an anthropogenic background will be to demonstrate that the anthropogenic levels found are from area-wide sources not related to site activities. Methods for determining background are provided in Appendix A – *Determining Background Concentrations* of this guidance manual.

4.5.4 Uncertainty Analysis

It is important to specify the uncertainties associated with the assumptions made in developing the Uniform Standard to put the standard in proper perspective. Highly quantitative statistical uncertainty analysis is usually not practical or necessary. As in all environmental risk assessments, it is already known that uncertainty about the numerical results are generally large (i.e., on the range of an order of magnitude or greater). Consequently, it is more important to identify the key site-related variables and assumptions that contribute most to the uncertainty than precisely quantify the degree of uncertainty in the risk assessment (USEPA, 1989). USEPA (1989) suggests a format for qualitatively identifying uncertainty associated with risk calculations, which should be adequate for evaluating uncertainties associated with development of the Uniform Standard.

4.5.5 Attaining Compliance with the Uniform Standard

4.5.5.1 Soils

For soils, compliance with the Uniform Standards, or with the background level that has been equated to any of the standards, is achieved when the EPC, a conservative estimate of the average contaminant concentration on the site or in the exposure unit, is equal to or less than the standard for the surface and subsurface soil media. Because average concentrations are uncertain, the EPC should use either the maximum value or the 95% UCL of the concentration calculated for all surface soil and subsurface soil samples within the site or exposure unit using the latest version of *ProUCL* following the procedure given in USEPA (2016) for either normal, log-normal, or gamma distributions. The EPC is defined as the lower of the maximum concentration or the 95% UCL. If the EPC is less than the standard, then remediation is complete. Sample locations that are clearly part of a different population (e.g., hotspots) should be evaluated separately (see guidance such as USEPA, 1996a). This is especially true for volatiles when evaluating the vapor intrusion pathway where a localized zone(s) of contamination can significantly influence the soil gas to indoor air exposure assessment.

4.5.5.2 Groundwater

Because of the site-specific factors related to groundwater, there are several methods that can be used to demonstrate compliance with the Uniform Standard. These methods include comparison of the highest concentration level in any well to the standard, statistical comparison of results from select wells to the standard, or other reasonable methods as approved by WVDEP. When an acceptable demonstration is made that site levels meet the Uniform Standard, the site has attained compliance and no additional remediation will be required.

The following is a list of factors to consider when deciding upon the method to be used to demonstrate compliance:

- In most situations, it is recommended that a statistical evaluation of the groundwater be conducted. An approved and acceptable method to derive an EPC is to calculate a one-sided 95% upper confidence level on the mean on selected wells in *ProUCL*.
- Selection of wells to be used is supported by the site characterization and the conceptual site model. The wells must be part of the same population obtained during the same round of groundwater sampling (e.g., wells within a plume of contamination). Wells that are upgradient or cross-gradient and clearly outside the contaminant plume should not be included in the statistical evaluation.
- If there is an insufficient number of wells (or samples) to do statistical evaluation, the results from each well may need to be compared to the standard. In this case, all results would need to be below the standard to demonstrate compliance. It should be noted that the additional wells may be installed or more samples may be collected from existing wells to be able to do a statistical evaluation.
- Groundwater data requires at least two rounds of samples to account for temporal variability, but, in cases where samples have been collected for several years, the most recent two years of data should be used to calculate any statistics, such as an EPC.
- If areas of contamination (i.e., plume) exist that are at least an order of magnitude higher than surrounding concentrations, those may need to be evaluated separately.
- Other statistical methods or evaluated techniques may be used, provided they are shown to be appropriate, adequate, and approved by WVDEP.

4.6 HUMAN HEALTH SITE-SPECIFIC STANDARD

The Site-Specific Standard relies on a baseline/residual risk assessment or site-specific risk-based concentrations. All sites or portions of sites qualify for the Site-Specific Standard, but some sites may be more easily or economically remediated using De Minimis or Uniform Standard methods. Site-specific Standards must take into account current and reasonably anticipated future land and water use expectations and the use of institutional or engineering controls, if applicable.

Critical review of the CSM is the first step in determining whether a baseline risk assessment is warranted. The CSM describes potential receptors and potentially complete exposure pathways. The complexity of the conceptual model (i.e., the kinds of affected media, number of complete exposure pathways, and exposure scenarios) will determine the need for a baseline risk assessment. At the characterization stage of the CSM, a list of complete exposure pathways and list of COCs should be reviewed to determine if any revisions are needed based on currently available information.

Prior to undertaking a baseline risk assessment, the adequacy of available data to support a risk assessment should be determined. Guidance on developing data quality objectives (DQOs) for risk assessment purposes may be found in *Guidance for Data Usability in Risk Assessment (Part A) Final* (USEPA, 1992b). Particular attention should focus on whether DQOs have been met. DQOs from the site assessment should be reviewed and refined for the risk assessment process.

The following subsections provide guidance for conducting the baseline risk assessment, followed by guidance for implementing the Site-Specific Standard. For point estimates, more detailed guidance is provided in the USEPA Risk Assessment Guide for Superfund (RAGS) documents. Probabilistic risk assessments are specifically discussed in RAGS Volume III, Part A.

4.6.1 Baseline Risk Assessment

The guidance provided in this subsection may be applied to both baseline risk assessments and residual risk assessments. The primary source of guidance for baseline risk assessments is found in the Risk Assessment Guidance for Superfund: Volume I – Human Health Evaluation Manual (Part A) (USEPA, 1989). When evaluating risks of exposure to lead, USEPA Superfund guidance and WVDEP recommend that the IEUBK childhood lead exposure model should be used for residential land uses or other land uses where young children may be exposed frequently. For commercial/industrial land uses, USEPA and WVDEP recommend the ALM lead exposure model should be used. Alternative models with appropriate documentation may be used for evaluating lead exposures to adults with the approval from WVDEP. The methods described in the following subsections do not apply to evaluating contamination by radionuclides. Until specific guidance is issued by WVDEP, evaluation of radionuclide contamination should be conducted in accordance with current USEPA guidance.

4.6.1.1 Exposure Assessment

Exposures can be assessed following the procedures outlined in the RAGS documents and this guidance manual. Exposure factors can be found in USEPA's Exposure Factors Handbook. The 2011 Edition of the USEPA Exposure Factors Handbook should be the first option to find the default exposure factors, but several updated exposure factors may be found in USEPA's Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors (2014). Common default exposure factors, such as those for recreational activities, can also be found in Appendix C – *Exposure and Chemical Parameters*.

Assuming that an exposure assessment has been completed and at least one of the EPCs exceeded the relevant benchmark, an exposure intake (e.g., dose) should be calculated using the standard equations

provided in USEPA's RAGS documents. The exposure intake values will be used along with the toxicity data to calculate the cancer risks and noncancer hazards associated with the exposures.

4.6.1.2 Toxicity Assessment

The purpose of a toxicity assessment is to evaluate the potential for substances of potential concern to cause adverse health effects in exposed persons and to define, as thoroughly as possible, the relationship between the extent of exposure to a hazardous substance and the likelihood and severity of any adverse health effects. Standard procedures for a toxicity assessment include identifying toxicity values for carcinogenic and noncarcinogenic effects and summarizing other relevant toxicity information. WVDEP relies on toxicity values, developed and verified by USEPA, to describe the dose-response relationship. If verified toxicity values for a COC are not available from USEPA, WVDEP should be consulted prior to relying on other sources of toxicity values. Complete copies of all references used to support alternate toxicity values must be provided to WVDEP upon request.

USEPA-derived toxicity values used in risk assessments are termed carcinogenic slope factors (CSFs), inhalation unit risk factors (IURFs), non-cancer reference doses (RfDs), and non-cancer reference concentrations (RfCs). Oral slope factors (OSF) are used to estimate the incremental lifetime risk of developing cancer corresponding to ingested doses calculated in the exposure assessment. Some chemicals also have IURFs that are used to estimate the incremental lifetime risk of developing cancer corresponding to inhaled concentrations. The potential for noncarcinogenic health effects of ingested chemicals is typically evaluated by comparing estimated daily intakes with RfDs (which represent daily intakes at which no adverse effects are expected to occur) or RfCs (which represent exposure concentrations in air) over a lifetime of exposure. CSFs, IURFs, RfCs, and RfDs are specific to the route of exposure.

Currently, there are no CSFs or RfDs for dermal exposure; therefore, route-to-route extrapolation is necessary to assess dermal exposure as described in Appendix C – *Exposure and Chemical Parameters*. No toxicity values are available for lead. Instead, USEPA relies on benchmark values for blood lead levels that are health protective. Exposures are assessed by comparing the blood lead benchmark values with blood lead levels predicted by pharmacokinetic models that estimate blood lead levels resulting from specified doses of lead. The standards established by USEPA for lead at Superfund sites and approved by WVDEP were created using the IEUBK model for lead in children and the ALM for adults.

The primary source for USEPA-derived toxicity values is USEPA's IRIS database. USEPA's Superfund Health Risk Technical Support Center (SHRTSC) develops Provisional Peer-Reviewed Toxicity Value (PPRTV) assessments to support USEPA programs and regional offices in the area of human health risk assessment, and this is used as the secondary source of toxicity information. The third-tier sources of toxicity values include USEPA's Health Effects Assessment Summary Tables (USEPA, 1997), which provide USEPA-derived toxicity values that may or may not be verified at the time of publication, state agency-derived toxicity values (e.g., CalEPA), and peer-reviewed literature.

Because toxicity information may change rapidly and quickly become outdated, care should be taken to find the most recent information available. IRIS is updated monthly, provides verified toxicity values, and supersedes all other sources. Additionally, many polycyclic aromatic hydrocarbons (PAHs) do not have toxicity data in IRIS, but USEPA uses Toxic Equivalency Factors (TEF) based on the toxicity of benzo(a)pyrene, and the TEF values should be used. Only if values are unavailable in IRIS for the contaminant of concern should other information sources be consulted. Toxicity values which have been withdrawn from IRIS may be used in the risk assessment provided a discussion is included on the uncertainty associated with using these values. Consultation with the OER Environmental Toxicologist prior to use of non-IRIS values is strongly suggested.

Toxicity Information Needed

For each COC included in the risk assessment, a toxicity profile or a tabular representation of the information should be provided. The following elements should be included:

- Carcinogenicity of the chemical (e.g., OSF and/or IURF verified by USEPA), critical study(ies) upon which the values are based (including the exposure/dosing medium), weight of evidence and carcinogenicity classification, and type of cancer observed for all Class A carcinogens
- Systemic non-cancer toxicity of the chemical, [e.g., chronic and subchronic RfDs and RfCs, the critical effect associated with each RfD and RfC (e.g., kidney damage), critical study(ies) upon which the RfD and/or RfC is based (including the exposure/dosing medium), uncertainty factors and modifying factors used in deriving each RfD/RfC, and "degree" of confidence in each RfD (i.e., high, medium, or low)]
- Pharmacokinetic data that may affect the extrapolation from animals to humans for both the RfD/RfC and the slope factor/IURF
- Degree of absorption from various media
- Uncertainties in any route-to-route extrapolations
- A determination of the mutagenic abilities of the COPCs

Table 4-1: Example Toxicity Table (Toxicity Values for COCs at Former XYZ Inc.)

COC	Target Organ/ Critical Effects	Mutagen	Oral Ref. Dose (RfD_o) (mg/kg-day)	Oral Cancer Slope Factor (CSF_o) $(mg/kg\text{-}day)^{-1}$	Fractional Absorption Factor (ABS)	Dermal Ref. Dose[1] (RfD) (mg/kg-day)	Dermal Cancer Slope Factor.[2] (CSF_d) $(mg/kg\text{-}day)^{-1}$	Inhal. Ref. Conc. (RfC) (mg/m^3)	Inhal. Unit Risk Factor (IURF) $(\mu g/m^3)^{-1}$
Volatile Organics									
Benzene	Blood, immune system	N	4.0E-03 I	5.5E-02 I	1	4.0E-03	5.5E-02	3.0E-02 I	7.8E-06 I
Hexachlorobutadiene	Kidney, liver	N	1.0E-03 P	7.8E-02 I	1	1.0E-03	7.8E-02	3.5E-03 R	2.2E-05 I
Semi-Volatile Organics									
Naphthalene	Whole body, kidney, thymus, respiratory	N	2.0E-02	I	1	2.0E-02	NA	3.0E-03 I	3.4E-05 C
Total Inorganics									
Arsenic	Skin, vascular GI Tract	N	3.0E-04 I	1.5E+00 I	0.6	1.8E-04	2.5E+00	1.5E-05 C	4.3E-03 I

Notes
[1]Dermal RfDd are calculated by multiplying the oral RfDs by the fractional absorption value, in accordance with USEPA (2004b).
[2]Dermal CFS_d are calculated by dividing the oral CSF_o by the fractional absorption value, in accordance with USEPA (2004_b).
NA - USEPA-derived toxicity values are not available for this particular exposure route or endpoint.
(I) – Integrated Risk Information System (IRIS; USEPA, 2016a).
(C) – California (EPA) toxicity values, as presented in USEPA (2016b).
(P) – USEPA Provisional Peer Reviewed Toxicity Values (PPRTV), as presented in USEPA (2016b).
(R) – Based on route-to-route extrapolation from the oral value (as per WVDEP).

For a more detailed evaluation of the toxicity of a compound, toxicity profiles, such as those from IRIS or ATSDR, may be reviewed. However, note that the appropriate sources of toxicity information for human health risk assessments, in order of preference, are (1) USEPA Integrated Risk Information System (IRIS); (2) USEPA Superfund Health Risk Technical Support Center (SHRTSC) provisional peer reviewed toxicity criteria (PPRTV); and (3) other scientifically valid documents or information developed from governmental or non-governmental sources and approved by WVDEP (i.e., HEAST, CalEPA, etc.).

Noncarcinogenic Assessment

Currently, USEPA derives RfDs/RfCs by applying uncertainty factors to a no observed adverse effect level (NOAEL) or from a lowest observed adverse effect level (LOAEL) for each chemical. Another method of deriving RfDs/RfCs is called the benchmark dose (BMD) approach (USEPA, 1995). The BMD is a dose or concentration of a chemical that is predicted to result in a specified amount of increased response compared to unexposed controls. In the BMD approach, a dose-response model is applied to toxicity data. Toxicity information used in IRIS to derive BMDs should be obtained from the IRIS

database, if available. A statistical lower bound on the BMD (termed the BMDL) may be used as a substitute for the traditional NOAEL or LOAEL method of deriving RfDs/RfCs.

Carcinogenicity Assessment

The carcinogenic assessment includes three aspects for the substance in question: (1) the weight-of-evidence judgment of the likelihood that the substance is a human carcinogen; (2) quantitative estimates of risk from oral exposure; and (3) quantitative estimates of risk from inhalation exposure. The quantitative risk estimates are presented in three ways. The slope factor is the result of application of a low-dose extrapolation procedure and is presented as risk per mg/kg-day. The unit risk is the quantitative estimate in terms of either risk per micrograms per liter (μg/L) drinking water or risk per micrograms per cubic meter ($\mu g/m^3$) air breathed. The third form in which risk is presented is a drinking water or air concentration providing cancer risks of 1 in 10,000, 1 in 100,000, or 1 in 1,000,000. The rationale and methods used by USEPA to develop the carcinogenicity information in IRIS are described in The Risk Assessment Guidelines of 1986 (EPA/600/8-87/045) and in the IRIS Background Document. IRIS summaries developed since the publication of USEPA's Guidelines for Carcinogen Risk Assessment also utilize those guidelines where indicated (EPA/630/P-03/001F, March 2005).

Uncertainties Related to Toxicity Assessment

Sources of uncertainty in the toxicity assessment should be identified. Typical sources of uncertainty include:

- Using dose-response information from effects observed at high doses to predict the adverse health effects that may occur following exposure to the low levels expected from human contact with the agent in the environment.
- Using dose-response information from short-term exposure studies to predict the effects of long-term exposures, and vice-versa.
- Using dose-response information from animal studies to predict effects in humans.
- Using dose-response information from homogeneous animal populations or healthy human populations to predict the effects likely to be observed in the general population consisting of individuals with a wide range of sensitivities.
- The potential for synergistic and antagonistic interactions among contaminants associated with a site.

The likelihood and relative magnitude of each source of uncertainty should be discussed. For example, USEPA states that the range of possible values around RfDs is “perhaps an order of magnitude” (USEPA, 1995).

4.6.1.3 Risk Characterization

Risk characterization is the final step of the baseline human health risk assessment process. Cancer and noncancer health risks are estimated, assuming long-term exposure to chemicals detected at the site. The risk characterization methods described in USEPA guidance (USEPA, 1989) are used to calculate upper-bound excess lifetime cancer risks for potential carcinogens and hazard indices for chemicals with non-cancer health effects. Following USEPA guidance, numerical estimates of risk should be rounded to one significant figure to reflect the level of certainty associated with calculated risks. Risks associated with exposures to lead may be assessed following the methods established by the USEPA for use at Superfund sites, which includes the IEUBK model for lead in children and the ALM for adults. The major assumptions, scientific judgments, and the uncertainties embodied in the risk assessment should also be presented.

The risk characterization will generally be completed by calculating the product of the intake and toxicity.

$$\textit{Risk} = \textit{Exposure Intake} \text{ X } \textit{Toxicity}$$

Cancer ingestion risks are:

$$\textit{Excess Lifetime Cancer Risk} = \textit{Exposure Intake}\ (\text{mg/(kg•day)}) \text{ X } \textit{OSF}\ (\text{mg/(kg•day)})^{-1}$$

Dermal cancer risks are typically estimated by the OSF but may be adjusted for dermal absorption intake vs. ingestion intake following procedures outlined in RAGS Part E.

Inhalation cancer risks are:

$$\textit{Excess Lifetime Cancer Risk} = \textit{Exposure Intake}\ (\mu\text{g/m}^3) \text{ X } \textit{IUR}\ (\mu\text{g/m}^3)^{-1}$$

For each route the cumulative cancer risks must be accounted for by adding the Excess Lifetime Cancer Risk of each COC in the route. The cumulative cancer risks for each route are then summed for each pathway and media to determine the cumulative Excess Lifetime Cancer Risk for each receptor.

Noncancer ingestion hazards are:

$$\textit{Hazard Quotient}\ (\text{HQ}) = \textit{Exposure Intake}\ (\text{mg/(kg•day)}) \ / \ \textit{RfD}\ (\text{mg/(kg•day)})$$

Dermal noncancer hazards are typically estimated by the RfD but may be adjusted for dermal absorption intake vs. ingestion intake following procedures outlined in RAGS Part E.

Noncancer inhalation hazards are:

$$\textit{Hazard Quotient}\ (\text{HQ}) = \textit{Exposure Intake}\ (\text{mg/m}^3) \ / \ \textit{RfC}\ (\text{mg/m}^3)$$

The cumulative noncancer hazards must be accounted for by adding the hazard quotient of each COC in a route to determine the hazard index for that route. The hazard indices for each route are then summed for each pathway and media to determine the cumulative hazard index for each receptor. However, hazard indices may also account for systemic toxicants that impact target organs (see Subsection 4.6.2).

4.6.1.4 Uncertainty Analysis

A description of the minimum requirements for the uncertainty analysis is provided for the Uniform Standard. For the Site-Specific Standard, the uncertainties need to be much more explicitly analyzed. Risk managers, decision makers, and the public need to be aware of the uncertainties in the analysis in order to avoid becoming overly dependent upon quantitative representations of results and to assure that nonquantifiable values are also considered properly.

Uncertainty commonly surrounds the likelihood, magnitude, distribution, and implications of risks. As a critical dimension in the characterization of risk, uncertainties must be considered in terms of magnitude, sources, and character. There are three sources of uncertainty in risk assessments:

1. *Inherent randomness* (stochasticity)
   This type of uncertainty can be estimated (e.g., standard deviation) but not reduced because it is a characteristic of the system being assessed.
2. *Imperfect or incomplete knowledge of things that could be known* (ignorance)
   This is the "easiest" type of uncertainty to reduce or eliminate as it becomes less as the general knowledge bases about contaminants expand.
3. *Error* (mistakes in execution of assessment activities)
   This type of uncertainty can only be estimated.

Some additional reasons why uncertainties are desirable to have identified and addressed:

- Uncertain information from different sources of different quality must be combined for the assessment.
- Decisions need to be made about whether or how to expend resources to acquire additional information.
- Biases may result in so-called "best estimates" that are not very accurate.
- Important factors and potential sources of disagreement in a problem can be identified.
- Addressing uncertainties increases the likelihood that the results of an assessment will be used in an appropriate manner.

Table 4-2 illustrates common types of uncertainty that surround exposure assessments. A table such as this should be used to summarize the main sources of risk.

Table 4-2: Three Types of Uncertainty and Associated Sources and Examples for Exposure Assessment

Type of Uncertainty	Sources	Examples
Scenario Uncertainty	Aggregation errors	Spatial or temporal approximations
	Descriptive errors	Incorrect or insufficient information
	Incomplete analysis	Overlooking an important pathway
	Judgement errors	Selection of an incorrect model
Parameter Uncertainty	Measurement errors	Imprecise or biased measurements
	Sampling errors	Small or unrepresentative samples
	Surrogate data	Structurally-related chemicals
	Variability	In time, space, or activities
Model Uncertainty	Modeling errors	Excluding relevant variables
Source: USEPA. 2011 Edition. Exposure Factors Handbook, Chapter 2 Variability and Uncertainty.		

Part of the uncertainty analysis is to address the limitations of uncertainty analysis in risk assessments. These include, but are not limited to:

- Truly unexpected risks
- Unknown frequencies of risk to real events
- Cognitive biases that affect judgments about uncertainty, as well as risk
- The pressures caused by social, cultural, and institutional forces upon analysis and interpretation of uncertainty, and risk in general

Additional information on uncertainty analysis may be found in the *Exposure Factors Handbook, Chapter 2 Variability and Uncertainty, 2011 Edition*, USEPA/600/R-09/052F.

4.6.2 Implementing Site-Specific Standards

For individual known or suspected carcinogens, the remediation standard must be set to represent an excess upper-bound lifetime cancer risk of between one in 10,000 ($1x10^{-4}$) to one in 1,000,000 ($1x10^{-6}$). Public notification is required if calculated residual cancer risks exceed the one in 1,000,000 level ($1x10^{-6}$) for residential land use or the one in 100,000 ($1x10^{-5}$) level for industrial land use. Note that WVDEP considers residential uses to include, but not be limited to, daycares, schools, nursing homes, other residential-style facilities and recreational activities.

For individual systemic toxicants, remedial standards shall represent levels to which the human population could be exposed without appreciable risk of deleterious effect. For individual systemic toxicants, remedial standards shall represent levels where the hazard quotient shall not exceed one (1.0) (one significant digit of accuracy).

Where multiple systemic toxicants affect the same target organ or act by the same method of toxicity, the hazard index (sum of the hazard quotients) shall not exceed one (1.0). Where multiple systemic toxicants do not affect the same organ the hazard index shall not exceed ten (10.0). If the hazard index exceeds one (1.0), further evaluations or remediation may be necessary.

4.6.2.1 Site-Specific Standards for Groundwater

Site-Specific Risk-Based remedial standards for groundwater shall be established using at least the following considerations:

- Potential receptors based on the current and reasonably anticipated future use of groundwater
- The potential for groundwater to serve as a drinking water source, based on:
  - The total dissolved solids content is greater than 2500 milligrams per liter (mg/L), or
  - It can be demonstrated that the aquifer is not being used and cannot be used for drinking water, and
  - The aquifer is not hydrologically connected to an aquifer being used for drinking water.
- The site-specific sources of contaminants
- Natural environmental conditions affecting the fate and transport of contaminants (e.g., natural attenuation)
- Institutional and engineering controls

4.6.2.2 Site-Specific Standards for Soils, Surface Water, and Sediments

Remediation standards for soils, surface water, and sediments should be established using at least the following considerations:

- Potential receptors based on the current and reasonably anticipated future use of the site
- The site-specific sources of contaminants
- Natural environmental conditions affecting the fate and transport of contaminants (e.g., natural attenuation)
- Institutional and engineering controls

Site-Specific Standards for surface water and sediments are likely to be based on recreational exposures. Default recreational exposure factors can be found in Appendix C – *Exposure and Chemical Parameters*.

4.7 ECOLOGICAL STANDARDS

Remediation standards must also adequately protect the environment through the ecological assessment protocol. Applicants undertaking an ecological assessment are directed to consult the references listed in Table 4-3 for general guidance and background information. Additional references may be found on the USEPA Ecological Risk Assessment website or at the USEPA's Ecological Risk Assessment Support

Center (ERASC). However, it should be noted that requirements and stipulations outlined in this guidance and the Rule must take precedence in order to ensure compliance with the VRP.

Table 4-3: Recommended Guidance Sources for the Execution of Ecological Risk Assessments

Recommended Guidance Sources for the Execution of Ecological Risk Assessments
USEPA. 1992. Framework for Ecological Risk Assessment. EPA/630/R-92/001.
USEPA. 1997. Ecological Risk Assessment Guidance for Superfund: Process for designing and Conducting Ecological Risk Assessments. Interim Final. June 5.
USEPA. 1998. Guidelines for Ecological Risk Assessments 63 CFR 26846-26922 (1998).
USEPA, Region 3. 1991. EPA Region III Guidance on Handling Chemical Concentration Data Near the Detection Limit in Risk Assessments. Interim Final.
USEPA, Region 3. 1994. Use of Monte Carlo Simulations in Risk Assessment. EPA/903/F-94/001.

Like the procedures for human health risk assessment, an ecological risk assessment begins with an exposure assessment. Unlike the procedures for human health risk assessment, all site must have a De Minimis Ecological Screening Evaluation at the minimum. If the results of the De Minimis analysis indicate the presence of potential receptors of concern and complete pathways of exposure, either a Uniform Ecological Evaluation may be undertaken, or Site-Specific Ecological Standards may be developed. The CSM provides the basis for the design of the ecological risk evaluation/assessment.

The three types of evaluation that constitute the ecological assessment protocols are developed in greater detail below:

1. De Minimis Ecological Screening Evaluation — This first step in the ecological assessment process is intended to determine whether ecological receptors of concern are exposed to site-related stressors. The De Minimis Ecological Screening Evaluation differs from the human health De Minimis Standard in that few quantitative standards are involved other than a comparison to water quality standards for aquatic life. It is intended to simply evaluate whether any potential ecological pathways of exposure to site contaminants exist. If exposure pathways exist and ecological receptors of concern are present, further evaluation is required to determine whether assessment is needed under the Uniform or Site-Specific Standards (see Figure 4-2). A De Minimis Ecological Screening Evaluation must be performed for every site.
2. Uniform Ecological Evaluation — If the De Minimis Ecological Screening Evaluation indicates that further assessment of ecological risk is needed, a site may proceed to a Uniform Ecological Evaluation. In this analysis, contaminant concentrations in soil and sediments are compared to WVDEP-approved generic benchmarks (e.g., BTAG or USEPA Region 4 Ecological Risk Assessment Supplemental Guidance) and reflect no significant ecological risk to specific receptors of concern. Contaminant concentrations in surface water are compared to WVDEP surface water quality standards for the protection of aquatic life. If no surface water quality

standard for the protection of aquatic life exists for a particular contaminant, the procedure outlined in W. Va. Legislative Rule 47CSR2 (Requirements Governing Water Quality Standards) may be used to develop benchmark values as comparison criteria, or WVDEP accepted surface water benchmarks (e.g., BTAG) may be used. As in the Human Health Uniform Standard, if the benchmark values for media other than surface water are less than natural or anthropogenic background, the background concentrations are used as the comparison criteria. If a contaminant's concentration exceeds the comparison criterion, the environmental media may be remediated using the criterion concentration as a remediation standard or a site-specific ecological risk-based value may be developed.

3. Ecological Site-Specific Standards — If a valid exposure pathway exists and ecological receptors of concern are present, Site-Specific Standards may be developed. This may be performed as a baseline ecological risk assessment where the specific attributes and parameters of the site and the receptor(s) of concern are used to determine their ecological risk from the contaminants. If the risk associated with the contaminant(s) exceeds the acceptable risk, it may be necessary to remediate the site using site-specific values as remediation standards. As in the Human Health Site-Specific Standard, if the calculated values are less than natural or anthropogenic background, the background concentrations are used as the remediation standards. In addition, surface water quality standards for aquatic life must be met.

Local conditions may be considered to decide whether a site is degrading an aquatic habitat. In cases where a site does not present an ecological risk over and above "local conditions" and further release of contaminants into the aquatic environment has been stopped, there will be no need for further evaluation beyond completion of Attachment 2 – *Checklist to Determine Applicable Remediation Standards*.

If no complete exposure pathway exists and the site does not meet any of the other criteria outlined above, then no further ecological analysis or remediation, based on ecological risk, is required. If, however, the site meets any of the listed criteria in § 60-3-9.5.b of the Rule, and exposure pathways can be demonstrated to exist between the site contamination and any ecological receptors of concern, a Uniform Ecological Evaluation may be undertaken or the Site-Specific Ecological Standards may be developed. A flow chart illustrating this decision process is provided in Figures 4-2 and 4-3.

Figure 4-2: De Minimis Ecological Screening Evaluation

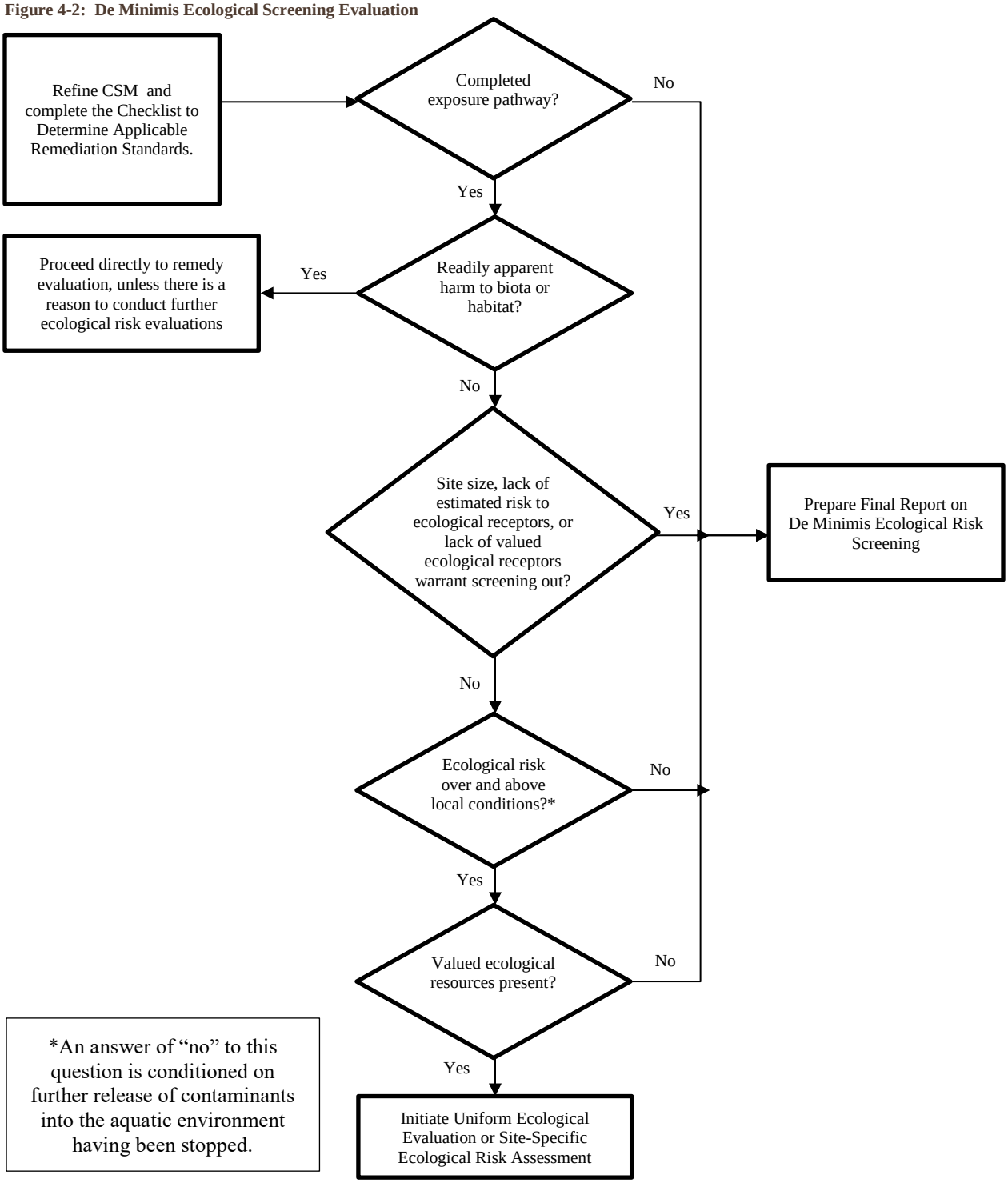
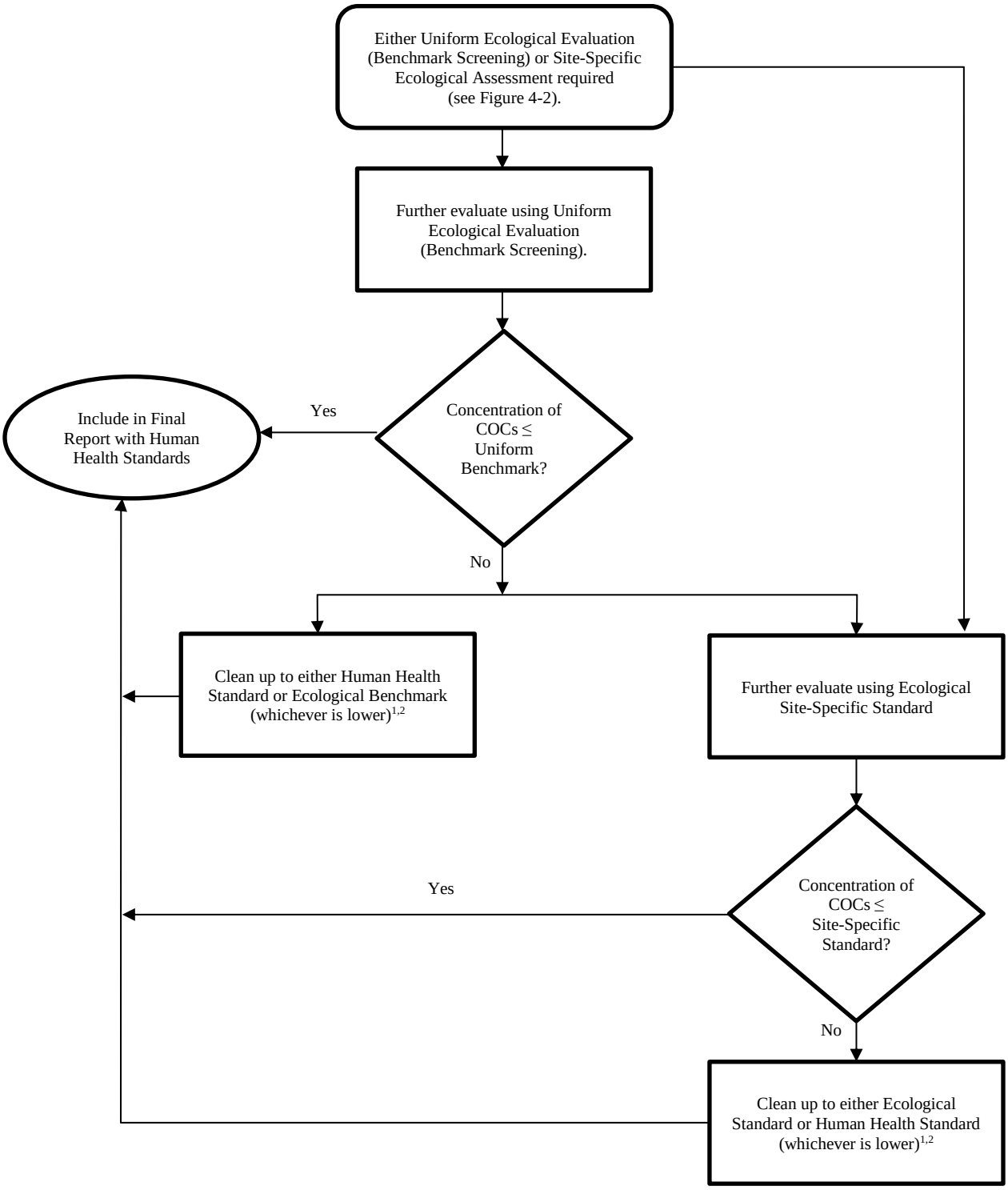


Figure 4-3: Ecological Risk Assessment



[1] Prior to cleanup, the applicant must evaluate the remedial alternatives, submit a Remedial Action Plan, and obtain WVDEP approval of the plan
[2] Assumes background has been determined (see Section 2.5)

4.8 DE MINIMIS ECOLOGICAL SCREENING EVALUATION

A De Minimis Ecological Screening Evaluation includes an assessment of the physical and ecological characteristics of the site and the nature and extent of contamination to determine if there are complete exposure pathways to ecological receptors of concern. If there are no complete exposure pathways between contaminants of concern in environmental media and ecological receptors of concern, it can be concluded that contaminants at the site pose no unacceptable ecological risk. Decisions associated with the De Minimis Ecological Screening Evaluation are illustrated in Figure 4-2.

At the screening stage of the ecological assessment process, the goal is to confirm the presence of a contaminant release, an ecological receptor of concern, and an exposure pathway. Actual site concentrations will not be a consideration at this screening stage unless a valid exposure pathway can be demonstrated. Site contamination can be identified concurrently with the requirements for site characterization and the human health risk assessments.[1] Receptor and pathway identification specific to the ecological evaluation must be performed to fulfill the mandated screening requirements.

If the site does not pass the De Minimis Ecological Screening Evaluation, then additional ecological risk evaluations are necessary at the site. Failure to pass the De Minimis Ecological Screening Evaluation is not equivalent to a finding that there is an unacceptable ecological risk at a particular site; only that additional evaluation is required.

This section focuses on the use of the ecological standards section of Attachment 2 – *Checklist to Determine Applicable Remediation Standards*. The checklist process and logic are illustrated in Figure 4-2. The checklist is divided into five steps, as follows:

STEP 1: Determine whether a De Minimis Ecological Screening Evaluation is appropriate for the site.

STEP 2: Identify any readily apparent harm or exceedances of water quality standards.

STEP 3: Identify contamination associated with ecological habitats.

STEP 4: Characterize the potential ecological habitat.

STEP 5: Identify any potential ecological receptors of concern.

[1] It is important to note that although contaminant analysis for ecological assessments may be conducted concurrently with the human health assessment, special considerations must be taken into account. For example, ecological benchmarks are sometimes lower than the corresponding human health-based standards. Therefore, it would be prudent to ensure that the sample detection limit for a given contaminant is appropriate. Furthermore, the distribution of the contamination should be evaluated not only with regard to human exposures, but also exposures to potential ecological receptors of concern.

This section of the guidance manual addresses Steps 1, 2, and 3 in the following three subsections. Steps 4 and 5 are addressed together in a fourth succeeding subsection. The last subsection discusses the reporting requirements for this screening process and checklist.

4.8.1 Determination of a Potential Complete Exposure Pathway

An exposure pathway is a direct or indirect physical association between a contaminant originating from the site and an ecological receptor of concern. An exposure pathway should be considered complete if an ecological receptor of concern is reasonably expected to contact a contaminant from the site via exposure to any environmental medium, including biota. Therefore, like the exposure assessment for human health, the presence of a complete ecological exposure pathway will require a source and mechanism of contaminant release to the environment, an environmental transport medium, a point of potential contact between an ecological receptor of concern and the environmental medium, and a feasible exposure route at the contact point. Assumptions regarding contaminant transport or fate should be conservative and should ensure that all relevant exposure pathways are evaluated.

Contaminated media for consideration in the De Minimis Ecological Screening Evaluation includes soil, sediments, surface water, and biota. Groundwater may also be an important medium of exposure through uptake of shallow groundwater by deep-rooted plants and in the transport of contaminants into a surface water body. Table 4-4 outlines the type of exposure routes that must be considered in identifying potential complete exposure pathways.

Table 4-4: Expected Routes of Exposure Based on the Medium of Contamination

Media	Direct Receptor Exposure	Indirect Media Exposure
Soil	Dermal contact Ingestion Gas/particulate inhalation Plant uptake	Leaching to groundwater Runoff to surface water and sediments Food chain contamination
Sediments	Direct contact Ingestion Plant uptake	Transport to surface water Bulk transport downstream Food chain contamination
Groundwater	Plant uptake (shallow groundwater)	Discharge to surface water
Surface Water	Direct contact Ingestion Inhalation of gases Plant uptake	Bulk transport downstream Saturation and capillary transport to soil Absorption in sediments Food chain contamination
Biota	Ingestion	

If there has not been a release to the environment at or from the site, the De Minimis Ecological Screening Evaluation can be concluded based on the lack of contaminated media, and, therefore, an exposure point. If no habitat exists that could be affected by site-related contamination, the De Minimis Ecological Screening Evaluation can also be concluded based on the lack of any potential ecological receptors of concern.

To fulfill the requirements of the De Minimis Ecological Screening Evaluation, a demonstration must be made for the presence or lack of pathways of exposure between the contamination and the ecological receptor(s) of concern. A Certificate of Completion will only be granted if none of the following conditions are found to apply:

- A contaminant stressor has migrated off-site and has become widely distributed in the environment.
- Wildlife or ecological resources (receptors) of concern are exposed or have the potential for exposure to stressors (contaminants), either on or off-site.
- Remediation of contamination at the site has the potential to expose ecological receptors of concern to adverse impacts.
- There is a potential for indirect or cumulative impacts to ecosystems of concern.
- Rare or sensitive species of concern are potentially at risk.
- Adverse ecological effects have been observed in otherwise high-quality habitats.
- Projected land use involves the presence of sensitive ecosystems.

4.8.2 Identifying Readily Apparent Harm

Sites which have been the cause of readily apparent ecological harm, or sites where there is a significant risk of harm to biota or habitats, do not pass the De Minimis Ecological Screening Evaluation. If any one of the following criteria are observed at the site, then readily apparent harm is found:

- Visual evidence of stressed biota attributable to the release at the site, including, but not limited to, fish kills or abiotic conditions
- Visible presence of oil, tar, or other non-aqueous phase contaminants in soil over an area greater than two acres, or over an area equal to or greater than 1,000 square feet in sediment

Potential ecological risk would exist if it were reasonable to forecast any of these conditions as occurring in the future due to site-related constituents of concern.

For sites with readily apparent harm or the risk of such harm, further ecological evaluation may be redundant and unproductive. It may be more appropriate to postpone further ecological evaluations until some remediation has been implemented and the readily apparent harm has been controlled or, at least, mitigated. In most cases of readily apparent ecological harm, prompt remedial action to control the source and to address the impacted media to the maximum and quickest extent is best. At a minimum, the site should proceed promptly to remedy selection and implementation.

4.8.3 Identifying Contamination Associated with Ecological Habitats

Although a release to the environment may have occurred or natural habitat is located on or near the site, the De Minimis Ecological Screening Evaluation can be concluded at this stage if the following two conditions are met:

1. Environmental media associated with the on-site and adjacent habitat have been sampled and analyzed, and the site-related constituents have not been detected above background concentrations.
2. Site-related constituents are not currently migrating to aquatic habitats, including wetlands.

If both conditions are not met, or if site contamination and/or background concentrations have not been investigated, the site must proceed with identification of potential ecological habitats and receptors of concern.

4.8.4 Identifying Potential Ecological Habitats and Receptors of Concern

Ecological receptors of concern are defined as specific ecological communities, populations, or individual organisms protected by federal, state, or local laws and regulations or those local populations which provide important natural or economic resources, functions, and values.

If no habitat exists that could be affected by contamination related to the site, the De Minimis screening can be concluded based on the lack of any potential receptors of concern. However, if natural habitats exist, progress toward identifying receptors of concern should begin with a description of each habitat. Descriptions of all potential habitats should address the following:

- General type of habitat on-site and downgradient
- Location of the habitat relative to the rest of the site (considering potential transport pathways)
- Area and topography of the defined habitats
- Predominant physical and geographical features
- Dominant plant and animal species known to occur at the site
- Soil and sediment types
- Human encroachment and interactions, including historical disturbances
- Evidence of natural disturbance

Once it has been established that natural habitats exist and they have been described and characterized, it is necessary to identify potential assessment endpoints. The criteria for selecting assessment endpoints, upon which receptor selection will depend, are based on the management goals developed for the site. The management goals for the De Minimis Ecological Screening Evaluation should address the protection of ecological receptors of concern.

The presence of ecological receptors of concern will depend on the habitat on and near the site. Those receptors residing or otherwise utilizing valued environments shall be identified as ecological receptors of

concern. If such habitat is identified within or near the site, a complete exposure pathway may exist, and it will be necessary to proceed with further ecological risk assessment. Either a Uniform Ecological Evaluation may be undertaken, or development of Ecological Site-Specific Standards may be pursued. Note that there may be additional requirements that apply under federal law in the case of threatened or endangered species, which are not preempted by the VRP.

State and regional wildlife agencies, local governments, interest groups, and universities are available to provide technical assistance in the identification of potential receptors. The WVDNR and the regional offices of the U.S. Fish and Wildlife Service maintain wildlife databases, including information on threatened and endangered species. Any site that is found to have natural habitats associated with the site must contact WVDNR and the U.S. Fish and Wildlife Service via a Project Review Request to ask for any documentation or evidence of the presence of sensitive ecological receptors in the vicinity of the site. Other sources that may be helpful in these determinations are listed in Table 4-5.

An on-site investigation should follow the initial habitat analysis. The purpose of the on-site investigation is to verify that the previously identified habitat can support potential ecological receptors of concern and to ensure that other potential receptors were not overlooked. The results of this investigation should be documented for inclusion in the work plan. The final selection of receptors, along with criteria and rationale, must be included in the Final Report.

Table 4-5: Reference Sources for Species Distribution Information

Reference Sources for Species Distribution Information
Allen, T. 1997. The Butterflies of West Virginia and Their Caterpillars. University of Pittsburgh Press. Pittsburgh, PA. 388 p.
Bucklew, A. R., Jr., and G. A. Hall. 1994. The West Virginia Breeding Bird Atlas. University of Pittsburgh Press. Pittsburgh, PA. 215 p.
Endangered Species Program, U.S. Fish and Wildlife Service Endangered Species Program: http://www.fws.gov/endangered/
WVDNR (game species).
Green, N. B., and T. K. Pauley. 1987. Reptiles and Amphibians in West Virginia. University of Pittsburgh Press. Pittsburgh, PA. 241 p.
Hall, G. 1983. West Virginia Birds: Distribution and Ecology. Carnegie Museum of Natural History. Pittsburgh, PA. 180 p.
Mussels of West Virginia (in preparation, contact WVDNR).
National Wetlands Inventory: https://www.fws.gov/wetlands/.
Natureserve.org
Stauffer, J. R. Jr., J. M. Boltz and L. R. White. 1995. The Fishes of West Virginia. Academy of Natural Sciences of Philadelphia. Philadelphia, PA. 389 p.
Strausbaugh, P. D., and E. L. Core. 1973. Flora of West Virginia. Seneca Books, Inc. Grantsville, WV. 1079 p.

U.S. Fish and Wildlife Service: Information, Planning and Conservation System (IPaC)
WVDNR Natural Heritage Database (Rare, Threatened, and Endangered Species): http://www.wvdnr.gov/wildlife/endangered.shtm.
WVU Herbarium (county-by-county database in preparation).

4.8.5 Reporting Requirements

A report on the execution of the De Minimis Ecological Screening Evaluation must be included in the Final Report. If the assessment is completed prior to the submission of the work plan, it should be included in support of proposed assessments and remediation activities, such as a Human Health and Ecological Risk Assessment Report. The report should be structured to address the questions presented in the ecological standards section of the *Checklist to Determine Applicable Remediation Standards* (Attachment 2). It should also include any validated sampling data, a description of the habitat characterization and identification of any assessment endpoints, measurement endpoints and receptors of concern, and any responses or documentation from WVDNR or the U.S. Fish and Wildlife Service. The report should also describe the presence or absence of exposure pathways.

4.9 UNIFORM ECOLOGICAL EVALUATION

A Uniform Ecological Evaluation is a generic evaluation of the potential effect a site's contamination may have on identified ecological receptors of concern. It is a screening analysis that compares the site-specific EPC of a contaminant with WVDEP-approved standards or criteria in order to determine whether it represents a potential threat to ecological communities associated with the site.

4.9.1 Benchmarks and Generic Exposure Models for Uniform Ecological Evaluation

The Uniform Ecological Evaluation involves comparing the concentrations of stressors in environmental media with generic standards or benchmarks. These standards are intended to protect the most sensitive ecological receptor(s) of concern as defined in the management goals. Selection of suitable reference concentrations is discussed below.

Sources of appropriate ecological benchmarks are listed in Table 4-6. The priority ranking for ecological benchmarks is as follows:

- WV Water Quality Standards (W. Va. Legislative Rule 47CSR2)
- USEPA Region 3 Biological Technical Assistance Group (BTAG) values for all COPCs in sediment and for any COPC that does not have a WV Water Quality Standard
- USEPA Region 4 Ecological Risk Assessment Supplemental Guidance (ERASG) for any chemical not in BTAG or for chemicals whose toxicity has been updated since the BTAG values were developed
- Other sources of ecological benchmarks, such as NOAA SQuiRTs, ECOTOX, etc.

The receptors of concern used in this analysis should be those identified in the De Minimis Ecological Screening Evaluation.

Table 4-6: Approved Sources and Methods for the Derivation of Medium-Specific Ecological Benchmarks

Benchmark/Toxicity Data Sources	Surface Soil[a] and Sediment	Groundwater[b]	Surface Water
Applicant-Derived Values		✓[c]	✓[d]
Applicant-Derived Values for Direct Contact	✓		✓
Natural Background Levels	✓	✓	✓
Anthropogenic Background Levels	✓	✓	✓
Direct Contact Benchmarks: USEPA ECOTOX database USEPA IRIS database USEPA HEAST database USEPA BTAG Screening Levels USEPA Region 4 ERASG USFWS technical reports Oak Ridge Tox Benchmarks ATSDR Toxicological Profiles NOAA SQuiRTS Other peer-reviewed publications	✓		✓
State Water Quality Criteria		✓	✓

[a] Surface soil constitutes the layer no greater than 4 feet below the surface.
[b] Groundwater should only be considered if it is expected to affect a surface water body of concern.
[c] This category is limited to benchmark values available from sources outlined in Table 4-5.
[d] This method is only to be used if no state criteria exist.

4.9.2 Applicant Derived Benchmarks for Uniform Ecological Evaluation

The BTAG ecological benchmarks should be the first screening for chemicals that do not have a WV Water Quality Standard, followed by ERASG benchmarks for those chemicals not in BTAG or whose toxicity has been updated since BTAG was developed. However, the Ecological Screening Value (ESV) versus Refinement Screening Value (RSV) modification methods that are outlined in ERASG can be used to develop and apply site-specific benchmarks. ERASG defines ESVs as "screening values based on chemical concentrations associated with a low probability of unacceptable risks to ecological receptors," whereas RSVs "are screening values from other sources or are modifications to screening values to reflect site-specific conditions." However, whenever a BTAG value is available for a chemical of potential concern, the BTAG value must be used as the ESV and the refined value will have to be developed based on the BTAG value as a starting point. Any site-specific information used to develop RSVs must also be adequately documented and approved by the OER Environmental Toxicologist. RSV benchmarks should address background concentrations, nutrients and dietary considerations, mode of toxicity and potential

for bioaccumulation, multiple contaminant effects, exposure considerations, and frequency, magnitude and pattern of detected chemicals using more than one line of evidence.

If no criterion or appropriate benchmark exists for a given stressor, it is the responsibility of the Applicant to derive an appropriate benchmark, referred to as the toxicity reference value (TRV). The TRV must be based on either the bounded no observed adverse effects level (NOAEL) or 10% of the lowest observed adverse effects level (LOAEL) derived from peer-reviewed sources for the contaminant stressor specific to the contaminated medium and the receptor of concern. A NOAEL-based TRV represents the concentration or exposure dose at which no unacceptable ecological risk is expected. A particular TRV is specific both to the receptor and stressor. It is empirical in that it is based on a specific dose-response relationship derived from experimental observations. TRVs for typical representative ecological receptors are available. In this absence of toxicity information derived for the receptor of concern, a similar species/receptor may be used as a proxy, but the proxy should be as taxonomically close to the original receptor as possible.

Approved sources for TRVs are listed in Table 4-7. For receptors that must be protected on an individual basis (e.g., special status species), the TRV is the bounded NOAEL for the respective receptor and stressor. If the receptor is to be protected at the population level, the TRV is the dose that is likely to induce a population-level response. Criteria for the evaluation of an appropriate TRV are listed in Table 4-8. Benchmark values may be developed using the formulas provided in Equations 4-1 through 4-4.

With appropriate documentation, site-specific input parameters for the equations are preferred over default values. If there are numerous receptors of concern, then the screening criteria should be established based on the receptor whose exposure and toxicological sensitivity results in the lowest benchmark screening value. For surface water, the benchmark criterion is usually the TRV (in mg/l) that is protective of all aquatic receptors. If the most sensitive receptor exposed to surface water is terrestrial, the model in Equation 4-1 should be used. For other environmental media, models and inputs are provided in Equations 4-2, 4-3, and 4-4.

Table 4-7: Acceptable References for the Derivation of Benchmark Values

Acceptable References for the Derivation of Benchmark Values
ATSDR Toxicological Profiles (http://www.atsdr.cdc.gov/toxprofiles/index.asp)
Data developed in accordance with a peer-reviewed scientific testing protocol and approved by WVDEP
Oak Ridge National Laboratory Toxicological Benchmark Technical Reports
Other peer-reviewed publications
USEPA AQUIRE Database[a]
USEPA ASTER Database (https://archive.epa.gov/med/med_archive_03/web/html/aster.html)
USEPA Ecological Soil Screening Documents (https://www.epa.gov/chemical-research/guidance-developing-ecological-soil-screening-levels)
USEPA HEAST Database (https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=2877)
USEPA IRIS Database (http://www.epa.gov/iris/)
USEPA PHYTOTOX Database[a]
USEPA Terrestrial Toxicity Database (TERRATOX)[a]
USFWS Technical Reports
[a] Access available through ECOTOX (http://cfpub.epa.gov/ecotox/).

Table 4-8: Criteria for the Evaluation of TRVs

Criteria for the Evaluation of TRVs
Does the nature of the response have a direct impact on the measurement endpoint?
Is the response the most sensitive effect to be expected?
Is the mode of exposure consistent with the conceptual site model?
Is the TRV specific to the stressor as it occurs in the medium onsite?
Is the expected response associated with the TRV consistent with the routes of exposure?
Is the TRV relevant to the receptor and its habitat conditions on-site?
Were appropriate allowances made for interspecies comparisons? • Application of uncertainty factors • Use of secondary interspecies application models • Comparable considerations of bioavailability relative to the exposure model

4.9.3 Risk Characterization Based on the Uniform Ecological Evaluation

Risk characterization in the Uniform Ecological Evaluation involves comparing the contaminant EPC developed in the exposure assessment (either the 95% UCL of the mean or the maximum value) to the appropriate benchmark values specific to the receptors of concern. If a contaminant's EPC in an environmental medium is less than the benchmark, it may be assumed that it represents no unacceptable ecological risk and no further action is needed. If the contaminant's concentration in the medium exceeds the benchmark, there is a potential for unacceptable ecological risk. While field survey data are valuable for understanding current environmental conditions, they are not used under the Uniform Standard to

determine adverse effects to ecological receptors of concern. The use of field survey data is appropriate under the Site-Specific Standard.

When more than one chemical is present, the potential for additive, synergistic, or antagonistic effects should be discussed. This discussion will usually be qualitative, except for cases where quantitative estimates of relative toxicity are available (e.g., dioxins, PCBs, or organophosphates). Interactions among chemicals are considered most likely when chemicals are known to affect the same toxic endpoint (e.g., reproductive effects). If multiple chemicals are present which have the same toxicity endpoint and toxicity data are available, the concentrations should be summed and compared to a single benchmark that has been approved by WVDEP. If a substantial number of chemicals with similar toxic endpoints are present and toxicity data are not available, the potential for interactions should be discussed even if no benchmarks are exceeded.

If field survey data show readily apparent harm where several chemicals are involved, selected benchmarks should consider interactive or synergistic effects.

If a stressor exceeds a benchmark concentration, then there are two alternatives available: (1) the benchmark is accepted as the remediation standard for that stressor, or (2) a Site-Specific Ecological Evaluation may be performed to determine a remediation standard unique to the particular site.

Where the TRV is derived from water exposures which assumed 100% bioavailability, the following equations are to be used.

Equation 4-1: Derivation of Benchmarks for Surface Water Specific to Terrestrial Receptors

$$SWSTL = \frac{TRV}{IR}$$

where:

SWSTL	=	Mean surface water screening threshold limit (mg/l)
TRV	=	Toxicity reference value (mg/kg bw day)
IR	=	Intake rate (l/kg bw day)

Equation 4-2: Derivation of Benchmarks for Soil

Where the TRV is derived from soil exposures:

$$SSTL = TRV / IR$$

Organic Contaminants:

$$SSTL = \frac{TRV \times \left(k_{oc} \times f_{oc} + \left[\frac{(\theta_w + \theta_a \times H')}{(1-n) \times \rho_s} \right] \right)}{IR}$$

Inorganic Contaminants:

$$SSTL = \frac{TRV \times 10^{7-pH-pKa}}{IR}$$

where[1]:

SSTL	=	Mean soil screening threshold limit (mg/kg soil dw)
TRV[2]	=	Toxicity reference value (mg/kg bw day)
k_{oc}[3]	=	Water-organic carbon partition coefficient (l/kg soil dw)
f_{oc}	=	Fraction of organic carbon (kg/kg; default0.0165[6])
θ_w	=	Water filled pore space (l/l; default 0.3)
θ_a	=	Air filled pore space (l/l; default 0.13)
H'	=	Henry's law constant (unitless)
n	=	Soil porosity (l/l; default 0.43)
ρ_s	=	Particle density (kg/l; default 2.65)
pH[4]	=	Soil pH (default 4.7[6])
pKa	=	Log equilibrium constant for hydroxide formation
IR	=	Intake rate (kg dw/kg bw day)

Intake Rates:

For plants: IR = 1

For passerines: $IR = \frac{0.398 \times W^{0.85}}{W}$

For herbivorous mammals: $IR = \frac{0.577 \times W^{0.727}}{W}$

For predatory mammals: $IR = \frac{0.235 \times W^{0.822} \times BAF}{W}$

For predatory birds: $$IR = \frac{0.648 \times W^{0.651} \times BAF}{W}$$

where:

W	=	body mass (g)
BAF	=	Biomagnification Factor[5]

Notes:

[1] Unless otherwise stated, all default values were taken from the USEPA's Soil Screening Guidance (1994).

[2] The TRV used should be the lowest for all terrestrial receptors of concern associated with the site.

[3] The k_{oc} may be estimated from the contaminant's octanol-water partition coefficient (k_{ow}) using the following equation:

$$Log(k_{oc}) = 2.8x10^{-4} + 0.983 \times Log(k_{ow})$$

[4] Median values for 181 West Virginia Soils (Jenks, 1969).

[5] BMFs are chemical and receptor-specific parameters.

Equation 4-3: Derivation of Benchmarks for Sediment

Organic Contaminant:

$$SdSTL = ATV \times f_{oc} \times k_{oc}$$

Inorganic Contaminant:

$$SdSTL = ATV \times 10^{7-pH-pKa}$$

where[1]:

SdSTL	=	Mean sediment screening threshold limit (mg/kg sediment dw)
ATV[2]	=	Aquatic Toxicity Value (mg/l)
k_{oc}[3]	=	Water-organic carbon partition coefficient (l/kg)
f_{oc}	=	Fraction of organic carbon (default 0.20)
pH	=	Sediment pH (default ?)
pKa	=	Log equilibrium constant for hydroxide formation

Notes:

[1] Unless otherwise stated, all default values were taken from the USEPA's Sediment Quality Criteria (1993).

[2] If available, use the appropriate ecological ambient water quality criteria. Otherwise, use the lowest TRV (mg/l) for all aquatic receptors of concern associated with the site.

[3] Refer to Equation 4-2, note 3 for the derivation of the K_{oc} from the contaminant's K_{ow}.

Equation 4-4: Derivation of Benchmarks for Groundwater

$$GwSTL = \frac{Qs}{Qgw} \times ATV$$

where:

GwSTL	=	Mean groundwater screening threshold limit (mg/L)
Qs[1,2]	=	Surface water turnover rate (L/day)
Qgw	=	Groundwater discharge rate (L/day)
ATV[3]	=	Aquatic Toxicity Value (mg/L)

Notes:

[1] If the surface water body is a stream, determine the Qs term in the above equation as directed in Appendix B.

[2] If the surface water body is a lake or pond, then the volume of a mixing zone shall not affect in excess of 10% of the volume of that portion of the receiving waters above the projected area of discharge. The volume of discharge shall be calculated as cubic feet per month.

[3] If available, use the appropriate ecological ambient water quality criteria. Otherwise, use the lowest TRV for all aquatic receptors of concern associated with the site.

4.9.4 Reporting Requirement for the Uniform Ecological Evaluation

The results of the Uniform Ecological Evaluation are to be included in the Final Report. If the assessment is completed prior to the submission of the work plan, it should be included in support of proposed assessment and remediation activities, such as a Human Health and Ecological Risk Assessment Report. The report should identify ecological receptors of concern and media upon which exposure pathways are based. It should also list appropriate benchmarks and discuss their sources and derivations. Comparisons of contaminant concentrations to their benchmarks should be presented in tabular form for each medium. Any documentation of sensitive habitats or species from WVDNR or the U.S. Fish and Wildlife Services should also be provided. The report on the Uniform Ecological Evaluation should also include a clear discussion of the screening results and an analysis of the uncertainty associated with any of the quantified values in a manner similar to uncertainty analysis conducted for human health.

4.10 SITE-SPECIFIC ECOLOGICAL STANDARDS

The development of Site-Specific Ecological Standards is analogous to developing a baseline ecological risk assessment. Applicants may choose to develop remediation standards through this process instead of relying on the benchmark standards derived in the Uniform Ecological Evaluation. The process for ecological risk assessment generally follows the guidance sources listed in Table 4-3 and involves problem formulation, exposure analysis, ecological effects, and risk characterization.

4.10.1 Problem Formulation

The problem formulation component addresses the management goals through the definition of the assessment and measurement endpoints, identification of the receptor(s) of concern, and the development of the CSM and the analysis plan. The following is an example of the development of management goals and assessment and measurement endpoints.

Management goal: Maintenance of fish communities

Assessment endpoint: Maintenance of a benthic community that can serve as a prey base for local fish populations

Measurement endpoints:

- Concentrations of contaminants in the sediment and water column relative to levels reported in scientific literature to be potentially harmful
- Toxicity observed in a whole sediment bioassay at levels considered significant according to test protocol
- Benthic invertebrate community structure / productivity relative to reference areas

Measurement endpoints should be weighted, giving the most weight to the measurement endpoint that best represents the assessment endpoint, allowing it to have the greater influence on the conclusions of the risk assessment. Attributes to be considered which help to define how well a measurement endpoint represents the assessment endpoint include: (1) strength of association between assessment and measurement endpoints; (2) data quality; and (3) study design and execution. This process is described in Menzie et al., 1996.

4.10.1.1 Quantifying Measurement Endpoints

In the De Minimis and Uniform Evaluations, measurement endpoints were considered qualitatively to identify the ecological receptors of potential concern. In the development of Site-Specific standards, it will be necessary to establish quantitative limits on the measurement endpoints to characterize the relationship between the contaminants of concern and the receptor population effects. The methods employed will be specific to the particular situation being considered. A review of the scientific literature and guidance documents listed in Table 4-3 will provide examples that may be applicable.

4.10.1.2 Refinement of the Conceptual Site Model

The CSM is a series of working hypotheses regarding how the contaminant(s) interact with the ecological receptor(s) of concern. Refinement of the CSM will help in quantifying the measurement endpoints. Examples of criteria that the conceptual site model should address include the following:

- Is the model sufficiently quantitative to associate the stressor to the measurement endpoint via the receptor?
- Does the model directly reflect the habitat of consideration?
- Does the model account for all media and all potential routes of exposure?
- Does the model adequately reflect the concerns inherent in the management goals?

Based on the results of the CSM, an assessment plan should be formulated. The assessment plan is the practical description of the methods and strategies that will be used to meet data requirements of the CSM. It should include the types of media and biota to be sampled, the contaminants to be analyzed, as well as the potential ecological habitats and their characterization requirements. The assessment plan will ensure that there is adequate site-specific information to perform the risk analysis as well as providing a useful tool in the identification of data gaps for the subsequent uncertainty analysis.

Although the establishment of the measurement endpoints, the CSM, and the assessment plan should be done early in the assessment process, they must be considered amendable and open to modifications during the course of the site investigations as new information develops. Flexibility is essential in problem formulation to ensure completion of a precise and cost-effective site-specific ecological assessment.

4.10.2 Quantitative Exposure Analysis

The quantification of receptor exposure to a stressor requires the numerical description of both the nature of the contaminant and the effect it has on the receptor as it interacts with that environment. The former is defined by contaminant fate and transport models and the latter by the risk characterization.

In selecting pathways for evaluation, the assessment may consider the availability of toxicity information in the scientific literature. There is a paucity or complete absence of scientific information on several pathways (e.g., inhalation and dermal contact) for a large number of contaminants and a majority of potential receptors of concern (see Table 4-4). Such pathways need not be evaluated if a lack of quantitative information in the scientific literature can be documented; however, a qualitative assessment should be discussed in the risk characterization and uncertainty subsections. Field surveys may be used to help determine whether COPCs are having an adverse effect on receptors.

Sometimes both exposure and effects are assessed directly using media toxicity testing or biological field surveys. The application of these direct toxicity analyses is most commonly used for assessments of lower and middle trophic organisms. For higher trophic receptors, it is usually neither practical nor economical to determine the actual toxicity. Therefore, it becomes necessary to model the potential impact based on the exposure the receptor is likely to incur and the toxicity threshold above which an adverse effect may be sustained. Considerations for this type of assessment are discussed below.

4.10.2.1 Biological Field Surveys

Field surveys are a method used to determine whether evidence of an adverse impact can be identified and correlated with contaminant concentrations within the environment. The scope of the survey is based on the measurement endpoints established in the problem formulation phase. The performance of a biological field survey involves the cataloging of wildlife present within the habitat under evaluation. Within this context, the field survey should be performed with sufficient detail and statistical precision to permit a quantitative comparison with a reference site that is similar to the site under investigation in all respects possible with the exception of the contaminant(s) under investigation. The detail required should be sufficient not only to determine if there has been any adverse impact, but also to reasonably attribute

such impacts to the appropriate cause. For aquatic settings, a macroinvertebrate survey may be appropriate for this type of assessment. For terrestrial settings, a plant survey of each of the vegetative strata (herbaceous, shrub, sub-canopy and canopy layers) or a survey of the invertebrate community may be appropriate.

4.10.2.2 Direct Toxicity Determinations

The determination of potential risk may also be made through the application of direct toxicity testing. This is most common in the assessment of surface waters and sediments, although it may be applied to other environmental media. In direct toxicity testing, an indigenous or sentinel species is exposed to samples of the site media, usually under laboratory conditions, and the toxicity of the medium is determined based upon its effect on a measurement endpoint (e.g., lethality, reproduction, malformations, etc.). Examples of this type of direct toxicity analysis would include the Daphnia survival/reproduction assay for surface water or the 10-day Hyalella or Chironomus toxicity test for benthic macroinvertebrates in sediment (SETAC, 1993). Care must be taken to ensure that the results of direct toxicity testing are applicable to the overall risk characterization of the site. Verifying applicability is best accomplished by comparing the results to a reference site that is similar to the site under investigation in all respects possible with the exception of the contaminant(s) of potential concern.

4.10.2.3 Receptor Exposure Models

Receptor exposure models are mathematical constructs used to estimate the amount of a contaminant to which a specific receptor or population of receptors is likely to be exposed. The two major considerations in receptor exposure models are direct contact with contaminated media and indirect contact through contaminated foodstuffs. Parameters used as variables in the fate, transport and exposure models should ideally be derived from site-specific observations. Where this is not practical, default assumptions, approved by WVDEP, may be used.

> Direct Exposure to Contaminated Media — A receptor of concern will be exposed to a contaminant if it is found in direct contact with a contaminated medium. The receptor exposure model determines the actual dose of the stressor that the receptor is expected to receive. For animals, direct exposure usually occurs through a combination of dermal contact, respiration, and ingestion[2]. For plants, exposure occurs through deposition, stomatal infusion, and/or evapotranspirative uptake.
>
> The specific exposure is the product of the amount of environmental medium contacted, the contaminant's concentration in the environment and the proportion of the contaminant that is likely to be absorbed by the receptor. Attenuation factors may also be used if the affected habitat only accounts for a portion of the receptor's total range, or if absorption of the chemical stressor is expected to be less than complete. When evaluating absorbance efficiencies, it is important to consider this parameter relative to the bases of the comparative TRV and not just that of the absolute absorbance. The total direct exposure to a stressor is the sum of all specific exposures

[2] Exposure to a contaminant through drinking water will be considered a direct exposure for the purpose of this analysis.

by all pathways. Model formulas for the determination of direct exposure are listed in Equations 4-5, 4-6, and 4-7.

Equation 4-5: Direct Ingestion Exposure

Soil and Sediments:

$$D_{is} = [C_s] \times IR_s \times Ba_s \times 10^{-6}$$

Water[1]:

$$D_{iw} = [C_w] \times IR_w \times Ba_w$$

where:

D_{is}	=	Exposure dose from ingestion of soil or sediment (mg/kg day)
D_{iw}	=	Exposure dose from ingestion of water (mg/kg day)
$[C_s]$	=	Concentration of contaminant in soil/sediment (mg/kg)
$[C_w]$	=	Concentration of contaminant in water (mg/l)
IR_s	=	Soil/sediment ingestion rate (mg/kg day)
IR_w	=	Water ingestion rate (l/kg day)
Ba_s	=	Proportional Bioavailability from soil/sediment
Ba_w	=	Proportional Bioavailability from water

Notes:

[1] This model is to be applied to terrestrial receptors only. For aquatic receptors, water ingestion is considered a component of direct contact.

Equation 4-6: Exposure of Receptors through the Ingestion of Biota

$$D_f = \sum_{k=1}^{m} \left([C_k] \times Ba_k \times IR_k \times 1000 \right)$$

where:

D_f	=	Average daily dose (mg/kg day)
m	=	Number of contaminated food types
$[C_k]$	=	Average contaminant concentration in food *k* (mg/kg)
Ba_k	=	Proportion absorbed from foodstuff *k*
IR_k	=	Daily intake rate of item *k* (g/kg day)

In some situations, it may not be possible to directly determine the concentration of a contaminant within a receptor's food item(s). In these cases, it will be necessary to estimate the concentration based on the foodstuff/prey's exposure and a biomagnification factor. Biomagnification factors are empirical estimates that possess a high degree of uncertainty particularly when applied in situations different than those in which they were derived or over multiple trophic levels. Biomagnification factors tend to be very conservative and should only be considered when site-specific data cannot be obtained. Sources for bioaccumulation factors, biomagnification factors, and food chain multipliers are limited but available from various USEPA guidance and scientific literature.

Equation 4-7: Estimation of Absorption of Contaminants by Biota Based on Constituent Concentration in the Affected Medium

$$[C_k] = [C_m] \times BMF$$

Where:

$[C_k]$	=	Contaminant concentration in foodstuff/prey item (mg/kg)
$[C_m]$	=	Contaminant concentration in environmental media (mg/kg)
BMF	=	Biomagnification factor

Determination of BMF:

$$BMF = BAF \times FCM$$

where:

BAF	=	Bioaccumulation factor: $BAF = \frac{[C_{T1}]}{[C_m]}$
$[C_{T1}]$	=	Contaminant concentration in first trophic level
FCM	=	Food chain multiplier (contaminant-specific)

Total Exposure Profiles — The total exposure is the sum of total direct and total indirect exposures. It is the value (or distribution) that will be used in the risk characterization analysis. Estimates of total exposure are to be reported in terms of central tendency (mean or median) as well as plausible upper-bound estimates (e.g., 90th percentile).

4.10.3 Ecological Response Analysis

The ecological response analysis is the phase where comparative toxicity values are generated in order to evaluate the risk from exposure. Its primary function is to provide a standard against which the contaminant exposure under investigation may be measured. The standard should represent a level of exposure that is considered allowable or acceptable. Evaluation on the suitability of the standard is based on the values inherent in the management goals and should be detailed within the analysis plan.

If the risk analysis is to be based upon either a biological field survey or direct toxicity analyses, then an acceptable habitat standard must be established to which the results are to be compared. In most cases, the results are compared to a reference area that represents an ecologically acceptable condition and is similar in all respects possible with the exception of the contaminant(s) of potential concern. Alternately, the site may be compared to a hypothetical construct of what would be expected under acceptable circumstances, although this method tends to be highly uncertain.

If the risk characterization is to be based on exposure modeling, then the effects analysis must provide a threshold dosage that the specific receptor of concern may be exposed to without unacceptable ecological risk. This is usually referred to as the TRV. Approved sources for TRVs are listed in Table 4-6. For receptors that must be protected on an individual basis (e.g., special status species), the TRV is the bounded NOAEL for the respective receptor and stressor. If the receptor is to be protected at the population level, the TRV is the dose that is likely to induce a population-level response. Criteria for the evaluation of the applicability of a TRV are listed in Table 4-8.

If probabilistic methodologies are to be employed in the response analysis, then the estimations developed as part of a probabilistic method must fall within the bounds of the dose-response curve. Determinations based on unbounded estimates of toxicity should be avoided.

4.10.4 Risk Characterization

Risk characterization is the phase of the risk assessment where a value is placed on the potential impact that a stressor has on the ecological environment. This value is an expression of the risk based on the evaluation of the measurement endpoints. In most cases, the risk is expressed in a Boolean fashion; that being whether an acceptable risk exists or not. The definition of acceptability is evaluated on the assessment endpoints based on the parameters established in the management goals. If the risk characterization demonstrates that conditions for a site exceed the bounds of acceptable ecological risk, remediation may be necessary prior to issuing a Certificate of Completion. Decisions on the appropriate remediation measures required for the site to conform to the management goals should be determined on a weight-of-evidence basis. If an adverse effect can be demonstrated to have occurred and that effect can be attributed to the contaminant, then it may be necessary to consider remediation at the site.

4.10.4.1 Risk Characterization Based on Biological Field Surveys

When characterizing ecological risk based on biological field surveys, the biological condition of the site is compared to the reference established in the ecological effects analysis. This comparison must meet two specific considerations in order for an unacceptable ecological risk to be attributed to a specific contaminant. The first is whether any differences observed between the site under investigation and the reference represents an adverse impact. This may require a level of professional judgment since no two habitats are ever identical. The determination of an adverse effect is best based on quantifiable differences in the character of the habitats such as significant differences in biodiversity or productivity. The second consideration is whether any detectable adverse effect can be directly attributable to the contaminant in question. This must be determined through a process of elimination where all other potential factors that could affect the habitat are ruled out until a characteristic adverse effect can be reasonably attributed to the presence of the contaminant.

4.10.4.2 Risk Characterization Based on Direct Toxicity Testing

Risk characterization based on direct toxicity testing is similar to that of characterization by the biological field survey in that it is based on comparison to a reference situation either real or hypothetical that is within the definition of acceptable as defined by the management goals. Here, the effects analysis defines a rate of toxic response that is the threshold for acceptable ecological risk. If the medium toxicity from the site under investigation statistically exceeds that level, then the risk of an adverse effect is deemed unacceptable. Similarly, as with the biological field survey method, it is necessary to ascribe the causative stressor through a process of elimination. However, unlike field surveys, it is much easier to ascribe a threshold concentration based on the results of the toxicity tests and concurrent medium contamination analysis. This threshold concentration can then be used as a site-specific benchmark to evaluate other portions of the site that have not been directly tested for toxicity.

4.10.4.3 Risk Characterization Based on Exposure Models

Risk characterization using exposure models entails comparing the site-specific exposure results against the TRV derived in the effects analysis to determine whether there is unacceptable ecological risk. This comparison is to be made regardless of whether single-point or probabilistic methods are employed. For point-estimate analyses, this process is accomplished by calculating a hazard quotient for each stressor and receptor. The format for the calculation of single point estimates is detailed in Equation 4-8. For probabilistic determinations, the receptor response threshold (or distribution) is compared to the approximated response corresponding to the 90th percentile of the exposure distribution.

Equation 4-8: Determination of Hazard Indices

$$HI_n = \frac{(D_{ds} + D_{dw} + D_{is} + D_{iw} + D_f + D_o)_n}{TRV_n}$$

where:

HI_n	=	Hazard index for contaminant *n*
D_{ds}	=	Exposure resulting from direct contact with soil/sediment (mg/kg day)
D_{dw}	=	Exposure resulting from direct exposure to water (mg/kg day)
D_{is}	=	Exposure resulting from ingestion of soil/sediment (mg/kg day)
D_{iw}	=	Exposure resulting from ingestion of water (mg/kg day)
D_f	=	Exposure resulting from ingestion of foodstuffs (mg/kg day)
D_o	=	Exposure resulting from any other significant route (mg/kg day)
TRV_n	=	Toxicity reference value for contaminant *n* (mg/kg day)

If the ratio of the exposure concentration to the TRV (or the approximate receptor response to the threshold response) is less than one (1.0) for the receptor, it can be concluded that no unacceptable ecological risk exists for that receptor. If, however, the hazard quotient is greater than one (1.0), an unacceptable risk is deemed to exist, and remediation may be necessary.

4.10.5 Remediation Standards Based on Ecological Risk

If it is found that a particular receptor/stressor interaction represents an unacceptable ecological risk, it will be necessary to establish Site-Specific Standards. This is accomplished by calculating a concentration for the stressor in an environmental medium that corresponds to an exposure level for the receptors of concern that does not exceed the lowest TRV. For surface water, the remediation benchmark is equivalent to the TRV for the identified receptors of concern with the highest HI. This value may be compared to a daily average concentration for the entire water body and should not necessarily be applied as a “not-to-exceed” value.

4.10.6 Uncertainty Analysis

The uncertainty analysis identifies the uncertainty associated with the various steps of the risk assessment process. This information is vital for interpreting the results of the risk assessment in the remedial decision-making process. Descriptions of uncertainty should be as complete and detailed as possible and should cover both quantitative and qualitative aspects of the assessment process. A partial list of potential sources of uncertainty that may be included in this analysis is provided in Table 4-9. Table 4-10 identifies

specific considerations to be included in the uncertainty analysis for the ecological risk assessment final report. Additional guidance on uncertainty analysis may be found in USEPA guidance sources listed in Table 4-3.

If probabilistic methodologies were employed in the risk assessment, the uncertainty associated with the selection of the data distribution, compensation for potential correlations, and the bounded limits of the inputs should be addressed in the uncertainty analysis. Furthermore, the results of all sensitivity analyses should be included and discussed with regard to the uncertainty inferred from the distribution of the results. Further information on the reporting of uncertainly associated with probabilistic models may be found in RAGS Volume III, Part A.

Table 4-9: Potential Sources of Uncertainty

Source	Considerations
Habitat Characterization	Theoretical or empirical basis for the inclusion or exclusion of regions as habitats and appropriateness of reference sites.
	Identification of species present in identified habitats
	Evaluation of the significance of the habitat to potential receptors
	Characterization of physical attributes to habitat
	Characterization of ecological attributes of habitat
Stressor Distribution	Selection of stressors of concern
	Sensitivity and errors associated with media sampling
	Data gaps in sampling (spatial, temporal, media types)
	Identification of pathways for stressor transport
Endpoint and Receptor Selection	Assumption and uncertainty in statistical models of stressor distribution
	Presence or absence of threatened or endangered species
	Basis for the selection of measurement endpoints
Exposure Models (including fate and transport modeling)	Significance of the measurement endpoint to the quality of habitat
	Causal association of the receptor to the endpoint
	Ecological significance of receptor(s)
	All qualifications of the ecological models employed
	Applicability of selected models to site-specific conditions
	Quantification limits of selected exposure models
	Basis for the selection of default assumptions in the quantitative models
	Error associated with site-specific parameters and input variables
Response Models	Basis and applicability of response models to specific receptors of concern
	Basis for the selection of default assumptions in the quantitative models
	Applicability of quantified toxicity values and other input variables
	Extrapolation of toxicological response to population and measurement endpoints
	Confidence in the accuracy of the dose-response relationship

Table 4-10: Critical Items on the Site-Specific Ecological Risk Assessment for the Final Report

Critical Items to be Included in the Final Report on the Site-Specific Ecological Risk Assessment
Results and basis for the problem formulation
Description of and rationale for the management goals, assessment and measurement endpoints, and receptor selection
Presentation of the conceptual model and the assessment endpoints
Discussion of the major data sources and analytical procedures used
Review of the exposure and response analyses
Description of the risks to receptors, including quantitative risk estimates
Review and summary of major areas of uncertainty and the approaches used to address the uncertainty: • Discussion of generally accepted scientific positions on issues of inherent uncertainty (e.g., inter-species extrapolation of toxicity information). • Identification of major data gaps and, where appropriate, indicate of whether gathering additional data would significantly reduce uncertainty. • Discussion of science policy judgements or default assumptions used to bridge information gaps, and the basis for these assumptions.

4.10.7 Reporting Requirements

At the completion of the Site-Specific Risk Assessment, it should be possible to communicate a reasonable estimate of ecological risks, indicate the overall degree of confidence in the risk estimates, cite lines of evidence supporting the risk estimates, and interpret the ecological adversity. This information is to be outlined in the Final Report. It is important that the risk assessment results be presented in a manner that is clear, transparent, reasonable, and consistent to facilitate its use in making risk management decisions. Specific aspects particular to the ecological risk assessment process are listed in Table 4-10.

4.11 RESIDUAL RISK ASSESSMENT

A residual risk assessment may be conducted considering conditions that will be present at the site following implementation of a proposed remedy. The residual risk assessment should consider and evaluate both human health and ecological risk and must include an assessment of the risks under current and reasonably anticipated future land and water use scenarios under the following conditions:

- The exposure conditions that will be present following remediation and the concentrations of untreated waste constituents or treatment residuals remaining at the conclusion of any excavation, treatment, or off-site disposal; and/or
- The exposure conditions that will result following implementation of any institutional or engineering controls necessary to manage risks from treatment residuals or untreated hazardous constituents.

The residual risk assessment must follow the same basic procedures outlined in Sections 3 and 4 of this guidance manual, except that the conditions used to define the site must reflect post-remediation conditions, including site-specific numeric remediation standards and site-specific exposure conditions that incorporate any engineering and institutional controls proposed as part of the remedial action. It is not necessary to develop residual risk assessments for sites where any one of the three standards indicates no further action is necessary.

At some sites, the residual risk assessment may be the only risk assessment performed to obtain a Certificate of Completion. Examples may include, but are not limited to:

- Sites where a remedial action has already been implemented (e.g., a removal action, engineered cap installation, groundwater treatment, etc. has taken place and the risk assessment can now be performed using concentrations of contaminants remaining after the remedial action)
- Sites where harm is readily apparent and the Applicant has elected not to perform a risk assessment but proceed directly to the remedy evaluation

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5.0 Remedy Selection and Remedial Action

5.1 REMEDY EVALUATION AND SELECTION

VRP sites vary greatly in terms of size, nature and extent of contamination, human health and ecological risks, physical conditions, and other pertinent factors. The process of remedy evaluation and selection must, therefore, be flexible to facilitate appropriate responses to the full range of sites and management issues. There is no intent to restrict the range and remedies considered or the process of remedy selection. Attachment 3 – *VRP Decision Trees* is provided to help in the remedy decision-making process. In some cases, it may not be necessary to consider a variety of candidate remedies so long as the selected remedy meets the criteria of the Rule. For example, if the LRS determines that one or more institutional controls can be used to eliminate any potential exposure to environmental media that exceed the applicable remediation standards, remedy selection and a stand-alone Remedial Action Work Plan (RAWP) are not required. In these cases, a remedy (draft Land Use Covenant) can be submitted as an appendix to the Risk Assessment Report and a post-remedy conceptual site model (CSM) can be used to demonstrate the effectiveness of the institutional control(s). This exception is limited to institutional controls and does not apply where an engineering control is required to prevent exposure. In cases where an engineering control is proposed, a separate RAWP must be submitted to provide detailed information regarding the proposed control.

The approaches to remedy identification and selection provided in this section are offered as guidance only. There is no regulatory mandate to apply the methods outlined in this section.

The guidance related to remedy evaluation and selection is organized in two parts, as follows:

1. Remedy identification with a bibliography of information sources on various types or categories; and
2. Remedy evaluation discussing the criteria established in the Rule with a bibliography of information sources on remedy evaluation.

The RAWP must demonstrate that the selected remedy or combination of remedies have been evaluated in relation to the criteria established in the Rule. If the site is divided into multiple units for the purpose of remediation, the remedy for each unit must be evaluated in relation to these criteria. The RAWP is not required to describe the selection process or the remedies considered and the reasons for their selection or non-selection. However, discussions of the remedy selection process, the candidate remedies considered, and the evaluation of each candidate remedy may be appropriate components of the RAWP to assist in demonstrating that the selected remedy or combination of remedies is appropriate for that particular site. Guidance provided in this section is not intended to restrict the range of candidate remedies considered and/or selected for any particular site as long as the selected remedy meets the evaluation criteria. Specifically, there is no intent to restrict or discourage use of innovative methods. Similarly, there is no

intent to recommend or give preference to any particular remedy, category of remedies or to any product, service, or vendor.

Use of the Design CSM Stage in the lifecycle CSM may assist with remedy selection and evaluation. CSM elements used in the design stage can help identify additional information requirements and integrate data supporting the application of a selected remedy. Physical property data, geologic or hydrogeologic conditions, or the concentration and distribution of COCs in the environment may need to be refined to optimize remedy design. Other elements, such as concentration ranges, mass estimates, location and spatial proportions of source materials may be used to help establish initial benchmarks, as well as short, medium, and long-term metrics to gauge and assess remedy/system performance. Design CSM elements may also be used to develop supporting documentation for solicitation of final design and construction contracts.

5.1.1 Identification of Candidate Remedies

The first step in remedy selection and evaluation is the identification of candidate remedies based on the analysis of the nature and extent of contamination and the cleanup objectives.

Table 5-1 provides a partial list of candidate remedies by environmental media. Although these lists are not complete, they do indicate the wide range of remedies available for each media. Table 5-1 should be viewed with the following notes or comments in mind:

- Many of the table entries represent categories of remedies, with different treatment reagents, microbes, process units, or methods available to address various site conditions, contaminants, and contaminant concentrations.
- Some candidate remedies will have beneficial impact on more than one environmental medium. In-situ chemical or biological treatments may address both soil and groundwater contamination.
- Many of the treatment processes identified in Table 5-1 are marketed and supported by process, reagent, and/or equipment vendors. Each process is usually supported by multiple vendors. Further, specialized consultants and laboratories offer services related to process evaluation, reagent or microbe selection, and treatment formula development.
- There are a variety of data sources available to assist in remedy selection and evaluation. These sources include government publications (federal and state agencies), reference books by commercial publishers and associations, buyer's guides in industry magazines, and internet-accessible electronic databases.

A partial bibliography of published and electronic data sources to assist in remedy identification and evaluation is provided at the end of this section.

Table 5-1: Partial Listing of Potential Candidate Remedies by Media

Soils	Groundwater	Surface Water	Sediment
• NO ACTION • Natural attenuation (passive or intrinsic remediation) • Excavation and off-site disposal with treatment (typically hazardous waste) • Excavation and off-site disposal without treatment (typically non-hazardous waste) • On-site, ex situ thermal treatment • On-site, ex situ chemical treatment • On-site, ex situ fixation/stabilization • On-site, ex situ biological treatment • Soil vapor extraction • Passive soil venting • Vapor barrier • Soil washing • Soil flushing • Cap/cover over source area • Containment around source area • In situ chemical treatment • In situ biological treatment • In situ fixation/stabilization	• NO ACTION • Monitored natural attenuation (passive or intrinsic remediation) • In-well aeration • Air sparging • Dual phase vacuum extraction and treatment • Extraction pumping and chemical treatment • Extraction pumping and biological treatment • Extraction pumping and physical treatment • In situ biological treatment • In situ chemical treatment • Funnel-and-gate technology • Vertical barriers • Interceptor trenches • Rock fracturing and enhanced groundwater collection (with appropriate treatment) • Cap and cover • Containment (e.g., slurry wall, tight sheeting, etc.)	• NO ACTION • Collection and chemical treatment • Collection and biological treatment • Collection and physical treatment (e.g., filtration, aeration) • Cut-off wall or flow barrier upgradient of source • Surface water flow diversion • Cap/cover over source area • Containment around source area	• NO ACTION • Removal • Capping • Biological treatment • Chemical Treatment • Electrochemical Oxidation • Immobilization Treatment • Phytoremediation

5.1.2 Initial Screening of Candidate Remedies

An initial screening should be conducted to select a short list of appropriate alternatives for evaluation from the universe of remediation technologies. Based on the available information, only those technologies that apply to the site media or source of contamination should pass the initial screening and be evaluated. The use of presumptive remedy guidance, where available, can in many cases provide immediate focus to the selection of alternatives. Presumptive remedies such as landfill caps (Presumptive Remedy: CERCLA Landfill Caps RI/FS Data Collection Guide, USEPA, 1995, USEPA Document # 540-F-95-009; see http://semspub.epa.gov/work/HQ/174913.pdf) involve the use of remedial technologies that have been consistently selected in the past at similar sites or for similar contaminants. The Federal Remediation Technologies Roundtable (FRTR) has developed a Technology Screening Matrix (among other remedial action guidance) that has additional information on presumptive remedies in Subsection 2.1 (see https://frtr.gov/scrntools.htm). Applicants should refer to the *Cover and Cap Guidance* (Appendix F) to determine the minimum requirements for covers and caps of contaminated sites and to help estimate costs.

Candidate remedies should be screened initially against the following broad criteria:

- Applicability and Appropriateness to Site
  Consider the specific contaminants present and their extent; the impacted media; the size of the site; the nature, extent, and status of the sources of contamination; and the physical condition of the site to identify potential remedies that appear to be applicable and appropriate to the specific site. Give further consideration only to those candidate remedies that are considered to be appropriate and applicable to the specific site.

- Technical Feasibility
  Consider the steps and procedures required to implement each potential remedy in relation to site-specific conditions (site size, topography, current land use, future land use – if known, drainage routes, surface conditions and materials, subsurface conditions, and other factors) to assess the technical feasibility, practicality, and probability of success of applying that remedy to the specific site. Also consider the performance history (beneficial impact, implementation problems, and other relevant information) of the candidate remedy at other sites with similar characteristics. Give further consideration only to those candidate remedies that are evaluated as technically feasible at the specific site.

The initial screening should be conducted in accordance with the following general methodology:

- Pass/fail evaluation of each candidate remedy against each screening criterion in Subsection 5.3.1.

- Further consideration only of remedies “passing” the two criteria – no further consideration of remedies “failing” either criteria.

- The initial screening should be considered as brief, focused, and informal, and is not required to be reported.

The candidates passing both screening criteria (i.e., the short list remedies) qualify for further evaluation.

5.1.3 Evaluation of Short-List Remedies

Each remedy passing the initial screening criteria should be further evaluated using the seven criteria outlined below.

1. Effectiveness in Protecting Human Health and the Environment
    - Each remedy is evaluated for the ability to eliminate, reduce, or control the identified exposure pathways. Short- and long-term impacts and potential cross-media impacts are identified and evaluated.
    - The remedy is evaluated relative to attainment of the identified remediation standard goals.
    - During assessment of this evaluation criterion, additional requirements to implement each remedy including institutional and/or engineering controls are identified.

2. Long-Term Reliability to Achieve Standards
    - Assessment of residual risks
    - Magnitude
    - Type (treatment residuals and/or residual contamination)
    - Assessment of reliability to meet cleanup goals
    - Nature and extent of long-term management
    - Long-term monitoring requirements
    - Operation and maintenance requirements
    - Identification of difficulties and uncertainties associated with implementation
    - Component replacement requirements
    - Duration of institutional and/or engineering controls

3. Short-Term Risks Posed by Implementation
    Each remedy is evaluated to identify short-term risks during implementation (construction phase through achievement of cleanup goals) by consideration of the following:
    - Risks to workers
    - Risks to site neighbors and the community
    - Risks to the environment
    - Time required for remediation implementation

4. Acceptability to the Affected Community

An assessment of the acceptability to the affected community involves identifying the affected community (if any), potential issues of concern, and review of any comments received. Although there is no requirement in the Rule, Applicants are encouraged to seek community input in reviewing remedial alternatives that may potentially cause off-site impacts. If permitting is a requirement, this also needs to be considered. As appropriate, mitigation measures are identified and evaluated.

5. Implementability and Technical Practicability

Technical and Engineering Feasibility:

- Technical difficulties and unknowns
- Reliability of technology
- Ease of implementation
- Monitoring requirements

Administrative Feasibility:

- Permit requirements
- Consistency with other applicable regulations

Availability of Services, Equipment, and Materials:

- Availability of treatment, storage, and disposal services
- Availability of equipment
- Requirements for specialized equipment
- Availability of workers
- Availability of technology

6. Cost

Capital Costs:

- Engineering costs, including process development, design services, and related support activities
- Process equipment, including ancillary equipment and process control devices
- Labor, materials, and equipment to install or construct the remedy, including earthwork, foundations, structures, and utilities (including cap, containment, or other site work items, if appropriate)
- Contractors' overheads, allowances for general tools and supplies, and profit
- Site costs during construction, such as support facilities, utilities, fencing, and security
- Permits and other fees
- Construction management, including procurement of equipment, contracted services, and construction supervision
- General administrative costs

- Health and safety items

Operating Costs:

- Operating and maintenance labor
- Maintenance parts and supplies
- Treatment reagents and/or other operating supplies
- Operating utilities
- Health and safety items
- Required reporting
- Site management and administration costs during the remedy operating period

Monitoring and Reporting Costs:

- Sampling and analysis of results, as required or appropriate
- Collection and analysis of perimeter and/or environmental monitoring samples
- Collection and analysis of progress and/or confirmatory samples

In many cases, candidate remedies will have variations in the projected timing of expenditures. This is most likely to be the case when remedy implementation extends into the future for several years or more. If the differences in the amounts and timing of these expenditures are significant, it may be appropriate to calculate the present worth of the stream of expenditure for each candidate remedy. Under these circumstances, present worth calculations will provide a more useful and valid economic comparison of the remedies being evaluated.

Present worth calculations provide estimates of the current values of future expenditures by considering both the time-value of money (i.e., the effective discount on money deposited now at interest to meet future obligations) and the increases of future costs due to inflation. Present worth calculations are performed using standard methods and formulas.

Making present worth evaluations requires estimation of future interest and inflation rates. This can be simplified by recognizing that the object of these calculations is the comparison of alternate remedies, so consistency in using the factors is more important than the actual factors applied. A useful approximation can often be developed by applying a risk-free, inflation-free interest rate and a zero-inflation rate to the present worth formulas. Specific information on project interest rates and inflation rates can be found in general business publications. Local bankers and/or librarians may be able to assist in developing this information.

7. Net Environmental Benefits

An evaluation of the net environmental benefits of a remedy includes the following:

- Consideration of the projected reduction in quantity, toxicity, mobility, and risk
- Consideration of potential site reuse
- Restrictions

- Ecosystem functions and services
- Timeframe for reuse

This evaluation may be done for a short list of candidate remedies. A concise report of the alternatives considered and the evaluation conducted should be provided to WVDEP to support the demonstration that the selected remedy meets the human health and environmental protection criteria. The remedy meeting the effectiveness in protection criteria, achieving remediation standards, and with the lowest overall cost (including present worth calculation, if appropriate) should be selected unless there are extenuating circumstances favoring the selection of another candidate remedy. The Rule leaves remedy selection to the discretion of the remediating party as long as the selected remedy meets the protectiveness criteria for both human health and the environment.

5.1.4 Inclusion of Natural Attenuation in Remedy Evaluation

A remediation plan which includes the natural attenuation of contaminants of concern contained in soils and/or groundwater for the entire site or portions of the site is permitted. However, certain conditions must be met and/or demonstrated for WVDEP to approve natural attenuation as a viable remedy. This section provides guidance for the regulated community to compile the evidence needed for such a strategy.

Several environmental criteria must be demonstrated before WVDEP will approve a natural attenuation remediation plan. These conditions include:

- The contaminants of concern have the capacity to degrade or attenuate under site-specific conditions.
- The contaminant plume in groundwater or soil volume is not increasing in size.
- All sources of contamination and free product have been controlled or removed, where practicable.
- The time and direction of contaminant travel can be predicted with reasonable certainty.
- The contaminant migration will not result in the violation of applicable groundwater standards at any existing or reasonably foreseeable receptor.
- If contaminants have migrated onto adjacent properties, the owner must demonstrate that such properties are served by a public water supply or that such properties have consented in writing to allow contaminant migration onto their property.
- A groundwater discharge to a surface water body will not result in contaminant concentrations at the sediment/water interface that result in violations to the surface water standards.
- A groundwater monitoring program will be in place to sufficiently track contaminant degradation and attenuation within and downgradient of the plume and to detect contaminant and contaminant byproducts prior to their reaching any existing or foreseeable receptor.

- All necessary access agreements needed to monitor groundwater quality have been or can be obtained.
- The proposed corrective action plan would be consistent with all other environmental laws.

Natural attenuation of inorganic and organic compounds in soils and groundwater can occur by a number of mechanisms, primarily biological and physical. Physician mechanisms for natural attenuation include sorption, dilution, volatilization, and dispersion. Biological mechanisms include biodegradation, which results in the destruction of contaminants by aerobic and anaerobic microorganisms. To support remediation by natural attenuation, it must be scientifically demonstrated that attenuation of site contaminants is occurring at rates sufficient to be protective of human health and the environment. The evidence needed to support natural attenuation is quite specific, and therefore, for efficiency, collection of data to support natural attenuation as a remedial option should be considered as part of the early phases of the investigation and continue throughout the project (for additional guidance, see OSWER Directive 9200.4-17P, "Use of Monitoring Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites": https://clu-in.org/download/contaminantfocus/mtbe/MTBE-Directive-9200.4-17.pdfpdf).

5.1.4.1 Developing Evidence in Support of Natural Attenuation

There are several steps to take in gathering the evidence needed to support natural attenuation. These steps are directed towards pursuing three technical lines of evidence:

1. Documented mass loss of contaminants;
2. Presence and distribution of geochemical and biochemical indicators; and
3. Direct microbiological evidence.

The following paragraphs outline the steps to be taken to gather the necessary evidence and provide guidance for completion. This guidance is primarily geared toward natural attenuation in groundwater; however, the same principles apply to the natural attenuation of contaminants in soil. Depending on the location and depth of the soil contamination, it may be necessary to utilize institutional or engineering controls to (1) prevent potential receptor exposure to contaminated soils from the site, and/or (2) mitigate soil that acts as a contaminant source to groundwater.

Review Available Site Data for Evidence of Natural Attenuation

In cases where historical data of contaminant concentrations are available, these data can provide some of the most defensible evidence for natural attenuation if there has been a loss of contaminant mass at the site. In addition, the existing data may provide evidence for both geochemical and biochemical indicators of intrinsic bioremediation (i.e., presence of daughter products, byproducts of microbial respiration, loss of electron acceptors, etc.). Historic data used as evidence of natural attenuation do not require Stage 4 validation but need to be collected and analyzed using procedures and methods that ensure data quality, subject to review and approval by OER. This review serves to define data needs and the locations of

additional monitoring points as well as determining the likelihood of exposure pathway completion. In cases where data have not been collected on a regular schedule (e.g., quarterly or semiannually) over a reasonable period (i.e., not less than four years), it will be necessary to develop that data over the course of the project.

Develop a Natural Attenuation Conceptual Site Model

The CSM is a presentation and explanation of the contaminant distribution in site groundwater in relation to contaminant fate and transport processes. This model should include:

- The location of the source(s) of contamination. As stated above, the source(s) of contamination must be controlled or removed, where practicable. If the source(s) of contamination cannot be controlled or removed, the effect of the continuing source(s) on contaminant fate and transport relative to the rate of the natural attenuation processes must be considered in the conceptual model.
- The relative distribution of the COCs, both vertically and horizontally, in soil and groundwater.
- The location of potential human and ecological receptors.
- Site-specific characteristics which make the site amenable to natural attenuation.
- A comprehensive characterization of the local stratigraphy for the site which includes a description of aquifer material to bedrock or through the uppermost aquifer, for aquifers in unconsolidated settings.
- An estimate of the contaminant transport velocity and direction of groundwater flow. § 60-3-9.9.c of the Rule requires that the travel time and direction of contaminant migration be predicted with reasonable certainty.
- Estimation of the length of time necessary to achieve site-specific remedial objectives.

Additional Data Requirements

The data required to support a natural attenuation remedial technology are specific to the site and the type of contaminants present. Table 5-2 lists several soil and groundwater parameters used to support natural attenuation; an explanation of each of these parameters is contained in several publications (ASTM 1996; Wiedemeier et al., 1995; Wiedemeier et al. 1996a; Wiedemeier et al., 1996; Remediation Technologies Development Forum (RTDF) Bioconsortium Guidance Handbook). These data should be evaluated for a number of monitoring points located:

- upgradient of the source area in a non-contaminated area;
- in the source area;
- downgradient of the source area in the dissolved phase contaminant plume; and

- downgradient of the plume.

Upgradient, or in some cases cross-gradient groundwater monitoring wells can be used to quantify background concentrations for several parameters being evaluated. For sites having more than one aquifer or a significant vertical component of flow, monitoring well locations should also be selected to adequately represent the vertical profile.

The analytical data collected during site characterization activities can be evaluated to better define the biodegradation kinetics (i.e., first order decay rate). An understanding of the biodegradation kinetics is a necessary component for quantifying input parameters used in models that incorporate natural attenuation equations. The biodegradation kinetics are site-specific: dependent on the contaminant type, microbiological community, and available nutrients. Contaminant type is important since various chemicals degrade at faster rates than others. Additionally, chemicals degrade under aerobic and/or anaerobic conditions at varying rates. A microbiological community is required for biodegradation within an environment that is favorable for organism growth (note: pH values outside of the 6-8 range and high levels of certain chemicals may slow community growth or be toxic to the microorganisms). The available nutrients involve naturally occurring or engineered electron acceptors (i.e., dissolved oxygen, nitrogen, sulfate, iron, carbon dioxide) and election donors (i.e., carbon sources) that are used by the microorganisms to break down the contaminants of concern through respiration.

Methods for calculating the first order decay rates are presented in Weidemeier (1995) and Buscheck and Alcantar (1995). Alternatively, literature values of first order decay rates may be obtained but must be clearly documented, justified, and qualified as subjective.

Table 5-2: Parameters Used to Assess Natural Attenuation

Field Parameters	Physical	Inorganics	Organics	Dissolved Gases	Microbiological	Hydrogeological
Dissolved oxygen Redox potential Conductivity Temperature pH	Grain size analysis Porosity	Ammonia/TKN Chloride Sulfide Sulfate Nitrate Nitrite Ortho-Phosphate Iron (total & dissolved - field filtered) Manganese (total and dissolved - field filtered)	VOCs (cis & trans isomers identified) Semi VOCs CO2 TOC COD/BOD Alkalinity (carbonate & bicarbonate) Daughter products	Methane Ethane Ethene	PLFA (Phospholipid Fatty Acid Analysis) Total heterotrophic and contaminant-specific bacterial plate counts	Subsurface and surficial geology including lithology, stratigraphy, and structure Hydraulic gradient

Microcosm studies are conducted only when the microbiological and chemical evidence for natural attenuation at the site is inconclusive. Wiedemeier et al. (1995) discusses protocols for setup and analysis of microcosm studies. Biodegradation rates obtained from microcosm studies are often much faster than the actual field rates (Rifai et al., 1995). Therefore, results of microcosm studies are generally used qualitatively to demonstrate that the biodegradation processes are occurring in the field, and not to develop biodegradation rates for modeling.

Collect Additional Data in Support of Natural Attenuation

Since in situ biodegradation can proceed under both aerobic and anaerobic conditions, sampling soils and groundwater for natural attenuation parameters must be performed in a manner that does not change the redox potential (Eh) of these materials. In general, exposure to oxygen and agitation of the samples must be minimized. Use of low flow purge and sample methods with submersible or peristaltic pumps and flow-through sampling cells are recommended (ASTM, 1992 and OER SOP-0110). Under no circumstances should bailers be used for this type of sampling.

Refine Conceptual Site Model

After the site data have been compiled and evaluated relative to natural attenuation processes, the CSM should be refined to more accurately reflect the fate and transport processes affecting the contaminants of concern. This data analysis should include an evaluation of the geological, chemical, and biological factors that affect the rate and extent of natural attenuation. The refined CSM can be used as a basis for analytical or numerical modeling designed to simulate the migration and attenuation of contaminants. It is mandatory that a natural attenuation strategy for a site be protective of human health and the environment, therefore, conservative model input parameters should be used. All input parameters should be clearly defined and justified.

5.1.4.2 Simulation of Natural Attenuation

Two classes of mathematical models (screening and advanced) can be used to demonstrate that natural attenuation is a viable remedial option. Simple analytical screening models are primarily designed to determine the feasibility of using natural attenuation as part of a remedial strategy. At smaller sites with apparently limited impacts, it may be appropriate to use a screening model as the primary groundwater model to simulate natural attenuation and predict the extent and duration of contaminant migration. One such model is BIOSCREEN, available at https://www.epa.gov/water-research/bioscreen-natural-attenuation-decision-support-system. A model used for sites with chlorinated contaminants is BIOCHLOR2.2 (https://www.epa.gov/water-research/biochlor-natural-attenuation-decision-support-system).

Sites with complex hydrogeology or multiple contaminant source areas may require the use of an advanced numerical groundwater contaminant fate and transport model to simulate natural attenuation and predict the extent and duration of contaminant migration. Examples of advanced numerical models include: Bioplume IV, RT3D, BIOMOD3-D, BioF&T3-D, and MT3D. Bioplume IV can simulate more

complex microbial processes, multiple chemical species, and aerobic/anaerobic processes (Newell et al., 1995, Rifai et al., 1987).

More advanced two- and three-dimensional numerical models include RT3D, BIOMOD 3-D, BioF&T 3-D (Scientific Software Group), and MT3D. MT3D, RT3D, and BIOMOD 3-D are typically used in conjunction with the USGS finite-difference groundwater flow model, MODFLOW 3-D. These models are capable of simulating groundwater flow and contaminant transport in the saturated and unsaturated zones in heterogeneous, anisotropic porous media or fractured media. Each of these models simulate complex microbial processes based on oxygen-limited, anaerobic, first-order, or Monod type biodegradation kinetics, as well as anaerobic or first-order sequential degradation involving multiple daughter species. Given the capabilities of RT3D, BIOMOD 3-D, and BioF&T 3-D, these models can be used at sites with the most complex hydrogeology (e.g., interbedded sands and clay, fractured bedrock, and multiple aquifers) and complex contaminant distribution (e.g., multiple source areas and non-aqueous phase contamination), and are applicable to most contaminants (e.g., petroleum hydrocarbons, chlorinated solvents, and heavy metals).

5.1.4.3 Conduct an Exposure-Pathway Analysis

After calculating the rate of natural attenuation and predicting the future concentration and extent of the contaminant plume, it is necessary to evaluate whether the plume has the potential to impact receptors before contaminant concentrations have degraded to the applicable groundwater and/or surface water standards. Both ecological and human receptors need to be identified as well as points of exposure under current and future land, surface water, and groundwater use scenarios. Before the agency can accept a proposal for natural attenuation, it must demonstrated that the contaminant migration will not result in the exceedance of any groundwater standards at any existing or reasonably foreseeable human receptor, or the exceedance of any surface water standard if the receptor is a surface water body, or cause exceedance of any vapor intrusion standards. The standards for surface waters are contained in W. Va. Legislative Rule 47CSR2 (Requirements Governing Water Quality Standards), and the groundwater quality standards are contained in W. Va. Legislative Rule 47CSR12 (Requirements Governing Groundwater Standards).

The location of potential receptors can be ascertained in several ways, such as:

- Search state and local records for the locations of private and public drinking water wells within the expected path of plume migration.
- Request from a public water surveyor for a listing of their service area within the expected path of plume migration.
- Survey streams and rivers within the expected path of plume migration.
- Contact the local, county, or state planning boards to determine potential future land uses of adjacent properties within the expected path of plume migration.
- Conduct field survey/resident interviews.

If the contaminant plume is, or will be, migrating onto adjacent properties, it must be demonstrated that either the properties are served by an existing public water supply which uses surface water or hydraulically isolated groundwater; or the written consent from the property owners allowing contaminant migration onto their property has been obtained. This is important even if adjacent properties are currently vacant; the Rule requires consideration of potential receptors in the reasonably foreseeable future. LUCs and local groundwater ordinances provide effective means to restrict groundwater use and prevent exposure risks. Implementing an LUC to restrict groundwater use may still require monitored natural attenuation to meet the requirements of W. Va. Legislative Rule 47CSR12 (Requirements Governing Groundwater Standards).

If the contaminant plume is expected to intercept surface waters, the groundwater discharge beyond the sediment/water interface cannot exhibit contaminant concentrations that would result in violations of standards for surface waters contained in W. Va. Legislative Rule 47CSR2 (Requirements Governing Water Quality Standards). This can be determined through one or more of the following techniques:

- Install groundwater monitoring wells at the upgradient boundary of the surface water body.
- Model the expected effect of the groundwater discharge using mass balance modeling techniques.
- Other methods/strategies acceptable to and approved by OER.

The choice of the method(s) used to assess potential surface water impacts must be considered on a case by case basis dependent upon site-specific issues, such as the ability to gain access to off-site properties, the potential for a regional impact or other downgradient sources, potential upstream sources, seasonal conditions, etc.

5.1.4.4 Develop a Natural Attenuation Monitoring Plan

Unless a robust dataset has already been developed and is supported using a natural attenuation models and a sensitive receptor is not present or likely in the future, a natural attenuation monitoring plan is necessary to monitor plume migration and to verify that natural attenuation is ongoing, and its rate is adequate to preclude impact to receptors. This monitoring plan should include periodic sampling of wells in the different areas of the site, for example: (a) upgradient of the source area in a non-contaminated area; (b) in the source area; (c) downgradient of the source area in the dissolved contaminant plume; (e) downgradient of the plume; and (f) surface water collection points. Downgradient compliance monitoring points need to include one or more monitoring wells at least one year's advective time of travel upgradient of any potential receptor, and at least one monitoring well no further away from the leading edge of the contaminated groundwater than five years advective travel time. These wells should be sampled a minimum of four years, at least semiannually (preferably during periods of high and low groundwater elevations), for all of the parameters used to support the natural attenuation strategy for the site including parent and daughter compounds, dissolved gasses, electron donors and electron acceptors. Information regarding the long-term monitoring plan, analytical suite, sampling frequency, etc., is discussed in Wiedemeier, et al (1995). An annual natural attenuation monitoring report should be

submitted for review each year as data are collected. The report should include results of previous sampling events in graphic format to assess parameter trends and analysis to determine if continued monitoring is needed.

5.2 REMEDIAL ACTION WORK PLAN

The purpose of the RAWP is to describe the remedy or remedies to be employed at a site and provide a statement of work and schedule for the remediation. The RAWP should address the rationale for remedy selection. The work plan should include at a minimum, but is not limited to, a description of information used in the decision-making process, a discussion of potential remediation alternatives, and any uncertainty or risks which exist.

Note that this guidance also applies to any Interim RAWP prepared for the site. An interim plan may target one or more media but is not intended to be the final RAWP for the site. For instance, institutional or engineering controls may still be needed after implementation of the interim remedial action. Information to be submitted for an interim plan should essentially be the same as that outlined in this section. Institutional/engineering controls and natural attenuation would not be considered in interim plans. An interim remedial action would also require an Interim Remedial Action Completion Report to document results of the interim remediation efforts. If institutional/engineering controls and/or natural attenuation are still warranted following interim remediation, a final RAWP would need to be submitted with details of the site controls or natural attenuation proposal; the interim remedial action would need to be referenced in the final RAWP.

However, it is important to note that a stand-alone RAWP is not required if the LRS determines that one or more institutional controls can be used to eliminate any potential exposure to environmental media that exceed the applicable remediation standards. In these cases, a remedy (draft LUC) can be submitted as an appendix to the Risk Assessment Report and a post-remedy CSM can be used to demonstrate the effectiveness of the institutional control(s). This exception is limited to institutional controls and does not apply where an engineering control is required to prevent exposure. In cases where an engineering control is proposed, a separate RAWP must be submitted to provide detailed information regarding the proposed control.

5.2.1 Information Required

The RAWP must address, directly or by reference, the investigation conducted to further determine the nature and extent of actual or threatened releases that led to the preparation of the work plan. It will also describe assessments to be performed to further characterize the site or contaminants before remedial action is initiated. Risk assessment conducted to show the appropriateness of remedy selection should be documented in detail. The statement of work to accomplish the remediation and an implementation schedule must be submitted and must be carried out in accordance with the risk protocol and remediation standards in the Rule. The sampling plan to be implemented following remediation to determine the adequacy of the remediation program must also be addressed in the work plan and should follow the protocol for SAWPs.

The Remediation/Mitigation CSM Stage may provide useful information for the RAWP and during implementation of the remedy. The Remediation/Mitigation Stage CSM may be used to plan and guide remediation efforts, such as:

- Directing and documenting excavation activities.
- Managing phased remediation programs.
- Managing remediation at separate sub-units of a site.
- Responding to changed conditions encountered in the field.
- Optimizing in-situ and ex-situ treatment remedy implementation.
- Operation and maintenance (O&M) and long-term monitoring activities.

The Remediation/Mitigation CSM may also be used to assess remedy performance indicators to ensure that systems are operating according to design or other project parameters. This CSM can identify focus areas of sites that may require special design considerations, such as source zones, non-aqueous phase liquid (NAPL) areas, dissolved-phase contamination and residual contamination areas.

5.2.2 Remediation Standards

Remediation standards may be attained through one or more remediation activities that can include treatment, removal, engineering or institutional controls, natural attenuation, and innovative or other demonstrated measures. Remediation standards are to be defined where appropriate for soil, sediment, surface water, and groundwater. These standards are to be established using the following considerations as described in § 60-3-9:

- potential receptors of concern based on the current and reasonably anticipated future use of the site;
- site-specific sources of contaminants;
- natural environmental conditions affecting the fate and transport of contaminants, such as natural attenuation processes, as determined by approved scientific methods; and
- institutional and engineering controls.

The remediation standards or combination of standards selected by each Applicant for the protection of human health and ecological receptors must be described, including the rationale for the selection of each standard.

5.2.3 Remediation Measures

Specific remediation measures to be implemented for the site must be described. These may include treatment, removal, engineering or institutional controls, natural attenuation, and innovative or other demonstrated measures.

5.2.3.1 Selection of Alternative(s)

In selecting a remedial action from among various remedial alternatives considered, the RAWP must address the remedial action selected to achieve the goal of cost-effective protection of human health and the environment, while balancing the following factors to ensure that no single factor predominates over the others:

- the effectiveness of the remedy in protecting human health and the environment;
- the reliability of the remedial action in achieving the standards over the long term;
- the short-term risks to the affected community, those engaged in the remedial action effort, and to the environment (for example, controls for noise, dust, and traffic);
- the acceptability of the remedial action to the affected community;
- the implementability and technical practicability of the remedial action from an engineering perspective;
- the cost effectiveness of the action; and
- the net environmental benefits of the action.

5.2.3.2 Natural Attenuation

Where the remedy selected is based upon natural processes of degradation and attenuation of contaminants, the RAWP must include a description of relevant site-specific conditions, including written documentation of projected groundwater use in the contaminated area based on current state or local government planning efforts; the technical basis for the request; and any other information requested by the OER Project Manager. It must also be demonstrated that all conditions described in § 60-3-9.9 of the Rule have been satisfied. The plan should also address the schedule and physical and chemical parameters for monitoring of the contaminated media to demonstrate that natural attenuation will meet all applicable standards.

5.2.3.3 Uncertainty or Risks

The RAWP will include a discussion of any risk or uncertainty associated with selection and implementation of remedial alternatives. It will fully describe any assumptions made in the selection of remediation alternatives and the reason that assumptions are acceptable and defensible. The RAWP will also describe the risks and uncertainties associated with remediation and defend the acceptability of the risks.

5.2.4 Organization and Content

The following items, which provide details of the remediation activity, must be included in the RAWP:

- statement of work to be conducted to accomplish the proposed remediation;
- schedule for implementation and completion of remedial actions;

- details of any proposed engineering measures, including schematics, cross sections, material specifications, and a plan view of the proposed control area;
- a sampling protocol consistent with that developed for samples used in the risk assessment;
- verification sampling plan to determine the adequacy of the remediation; and
- any additional information or supporting plans.

5.2.5 Submittal and Approval

The RAWP will be approved or disapproved within 30 days of receipt based on quality and completeness. If a work plan is disapproved, the Applicant must either resubmit the work plan or formally terminate the VRA.

5.3 REMEDIAL ACTION COMPLETION REPORT

The purpose of the Remedial Action Completion Report is to describe and provide supporting documentation confirming that the RAWP has been implemented. In some cases, a residual risk assessment may also be needed as a part of the voluntary remediation project. A Remedial Action Completion Report is not required if the only remedies for a site are limited to institutional controls. However, the use of any engineering control or contaminant removal requires a Remedial Action Completion Report. The Remedial Action Completion Report may be combined with the Final Report.

The Remediation/Mitigation Stage CSM may assist with documentation of the remedy in the Remedial Action Completion Report. As the remedy begins to achieve applicable standards, components of the Remediation/Mitigation CSM can be used to support documentation of site completion activities. When the Remediation/Mitigation CSM is appropriately and fully evolved throughout the performance of a remedial action, its end state will generally serve as a Post-Remedy CSM.

A Post-Remedy CSM may help to:

- Evaluate remedy effectiveness and performance.
- Document identified best management and technical practices associated with the remedy success.
- Document site remediation activities including locations, dimensions and concentrations of wastes left on-site, institutional/engineering controls, and other important remedy features.
- Facilitate reuse planning.

The Remedial Action Completion Report should include, at a minimum, the information listed below. In addition, the following sections provide more details on information that should be included, if applicable due to the selected remedy, in the Remedial Action Completion Report.

- Site background, location, and description
- Summary of the remedy provided in the RAWP and the basis for the remedy
- Discussion of deviations from the RAWP (if any)
- Summary of the activities completed to implement the remedy (e.g., site preparation, cover installation, site restoration, etc.)
- Summary of permits obtained (e.g., storm water permit, air permit, underground injection control permit, etc.) and work completed to comply with these permits (e.g., developing a storm water pollution prevention plan, installation of temporary erosion controls, stack testing, inspections, etc.)
- Discussion of system commissioning and performance testing (if applicable)
- Record drawings (if applicable)
- Construction photographs (if applicable)

5.3.1 Institutional Controls

If institutional controls are one part of the overall remedy for the site, the Remedial Action Completion Report should include the following information regarding the institutional controls:

- Description of the institutional controls and the mechanism for implementing them (e.g., LUCs, ordinances, etc.)
- Map showing the restricted areas (if the restricted area is a smaller parcel, the parcel must be surveyed)
- Discussion of inspection components and frequency
- Example inspection form

5.3.2 Engineering Controls

Engineering controls are remedial actions directed exclusively toward containing or controlling the migration of contaminants through the environment. These include, but are not limited to, slurry walls, liner systems, caps, leachate collection systems, and hydraulic groundwater control systems. Some common engineering controls are listed below, along with information that should be included in the Remedial Action Completion Report if they are part of the remedy for the site.

5.3.2.1 Access Restrictions

Access restrictions typically include fences and signage to prohibit unauthorized access to the site that could result in potential contact with contaminated media. The Remedial Action Completion Report should describe the access restrictions at the site (e.g., 8-foot tall chain link fence with barbwire at the top) and indicate on a map where the access restrictions are located.

5.3.2.2 Surface Barriers – Caps and Covers

Surface barriers (i.e., caps and covers) mitigate direct contact with waste or impacted media and reduce or eliminate infiltration. Detailed guidance regarding the requirements for these remedial approaches is provided in Appendix F. A cap typically involves multiple layers (e.g., clay layer, geomembrane liner, drainage layer, etc.) and is designed to prevent storm water infiltration, while a cover is typically a simpler barrier (e.g., a vegetated soil cover, paving, or building slab) to prevent direct contact with contaminated soil. The Remedial Action Completion Report should include the following information for any barriers installed at the site:

- Description of the barrier (cap or cover) including the type and thickness of each layer of the barrier and its intended function
- Summary of the construction activities to install the barrier
- Summary of any temporary/permanent drainage and erosion control measures
- A map that shows the extent and final elevations of the barrier
- Pre-installation testing results (if applicable) of the borrowed source material for the barrier
- Post-installation testing results to demonstrate the barrier meets the design specifications in the RAWP (e.g., compaction, hydraulic conductivity, etc.)
- Discussion of inspection and maintenance frequency
- Example inspection form

5.3.2.3 Groundwater Containment

Groundwater containment includes remedial actions directed exclusively toward containing or controlling the migration of contaminated groundwater. These include, but are not limited to, slurry walls, sheet piling, and hydraulic groundwater control systems. The Remedial Action Completion Report should include the following information for any groundwater containment remedies installed at the site:

- Description of the groundwater containment remedy (e.g., number and location of extraction wells, material of construction and depth of slurry wall, etc.) and the receptor(s) requiring the containment
- Summary of the construction activities to install the groundwater containment remedy
- Post-installation testing results to demonstrate the groundwater containment remedy meets the design specifications in the RAWP (e.g., achieves hydraulic control of the entire containment area)
- A map showing the containment area and receptor(s)
- Discussion of system commissioning and performance testing (if applicable)

5.3.2.4 Vapor Intrusion Mitigation

A vapor intrusion mitigation system (VIMS) is used to prevent contaminants in subsurface vapors from entering a building. A VIMS could include a vapor barrier and/or a sub-slab depressurization system and/or a passive venting system. The Remedial Action Completion Report should include the following information for any VIMS installed at the site:

- Description of the VIMS (e.g., thickness and type of vapor barrier, depressurization system mechanism, etc.)
- Summary of the construction activities to install the VIMS
- Figures/maps of the VIMS
- Post-installation testing to demonstrate that the VIMS is effective
- Discussion of inspection frequency
- Example inspection form

5.3.2.5 Drainage and Erosion Controls

Drainage and erosion controls can be a component of a remedy; however, they can also be implemented as a stand-alone remedy (e.g., address contaminated soil being transported to a stream by storm water runoff). The Remedial Action Completion Report should include the following information for any drainage and erosion controls implemented at the site:

- Description of the drainage and erosion controls
- Summary of the construction activities to implement the drainage and erosion controls
- A map that depicts the type and the location of the controls
- Discussion of the inspection frequency
- Example inspection form

5.3.3 Contaminant Removal

Contaminated media (e.g. soil or sediment), may be removed from a location to prevent a continuing source of contamination. Contaminant removal may include, but is not limited to, excavation, dredging, or multi-phase extraction. The removed contaminated medium is typically sent off-site for disposal. The Remedial Action Completion Report should include the following information for any contaminant removal remedy implemented at the site:

- Description of the contaminant removal remedy
- A list of the target contaminants and their cleanup levels
- Summary of the construction activities to implement the contaminant removal remedy

- Summary of any temporary/permanent drainage and erosion control measures
- Volume of each contaminated medium removed from site
- A map depicting where contaminants were removed
- Pre-installation analytical results (if applicable) for the material used to backfill the excavation
- Post-installation testing results (if applicable) to demonstrate the backfilled excavation meets the design specifications in the RAWP (e.g., compaction)
- Confirmation sampling information (if applicable), including
    - Figure depicting the confirmation sample locations
    - Discussion of the confirmation sample results
    - Laboratory reports
- Laboratory reports for waste profile samples
- Waste manifests

5.3.4 Contaminant Treatment

Contaminant treatment includes any remedy that treats contaminated media. A contaminant treatment remedy may include, but is not limited to, thermal remediation, in situ chemical oxidation, air sparging/soil vapor extraction, permeable reactive barriers, phytoremediation, and bioremediation. The Remedial Action Completion Report should include the following information for any contaminant treatment remedy implemented at the site:

- Description of the contaminant treatment remedy
- A list of the target contaminants and their cleanup levels
- Summary of the construction activities to implement the contaminant treatment remedy
- Quantity and type of injected/mixed materials (if applicable)
- Volume of media treated ex-situ (if applicable)
- Post-installation testing results (if applicable)
- A map showing the treatment area and locations of monitoring wells, recovery wells, injection points, etc.
- Discussion of system commissioning and performance testing (if applicable)
- Waste manifests (if applicable)
- Discussion of system decommissioning and remediation goal attainment testing (if applicable)

5.3.5 Natural Attenuation

Natural attenuation is a remedy in which naturally occurring processes are utilized to reduce levels of site contaminants. This remedy involves demonstrating that these natural processes are acting as anticipated to reduce contaminants and achieve the applicable standards for the site. The Remedial Action Completion Report should include the following information if a natural attenuation remedy is implemented at the site:

- A list of the target contaminants and description of the degradation pathways (if applicable)
- Hydrogeologic parameters (e.g., groundwater flow and velocity)
- A figure depicting monitoring locations
- A description of any groundwater modeling used to support a natural attenuation remedy
- A description of the supporting geochemical parameters and microbial populations (if applicable)
- A graphical and/or statistical analysis of data trends that supports a natural attenuation remedy

5.4 REFERENCES

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5.18.3 Remedy Evaluation

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5.18.4 Electronic Databases

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6.0 Land Use Covenants

When it is not possible or practical to completely remove or treat all contamination on a site, limiting exposure to contaminated environmental media will often achieve the selected remediation standard(s). This is accomplished using institutional controls or engineering controls. Institutional controls are administrative and legal controls that prohibit certain activities on and uses of the site to minimize the potential for human exposure or contamination and protect the integrity of the cleanup (e.g., restrictive covenants or city ordinances). Engineering controls are physical barriers constructed to prevent exposure, or isolate materials from people, animals, and the environment (e.g., fences or soil caps). If such controls are used, in whole or in part, to achieve a remediation standard, a Land Use Covenant must be applied to the property.

An LUC—often referred to as an environmental covenant—is a legal instrument that imposes activity and use limitations (AULs) where residual contamination is present on a property. The LUC serves the following purposes:

1. Informs prospective owners or tenants of the environmental conditions on the property.
2. Ensures long-term compliance with AULs that are necessary to prevent unacceptable exposure to environmental contamination.
3. Maintains the integrity of the remedy over time.

LUCs are recorded to property deed(s) located in the office of the county clerk. With the LUC remaining in the "chain of title", it reliably communicates environmental conditions and restrictions to current and future persons who own or have an interest in the property through property transactions.

6.1 CONTENTS

All LUCs are executed pursuant to the Uniform Environmental Covenants Act (W. Va. Code § 22-22B, et seq.), which specifies the minimum content requirements. The Rule further specifies content requirements for LUCs filed in association with VRP projects, and a standard LUC format is provided in the Rule as Appendix 60-3D. All LUCs will include the following basic information:

- Legally sufficient description of the property and map
- Brief narrative of the contamination and remedy
- Description of AULs and any engineering controls
- Name and location of any administrative record for the environmental response project
- List of covenant holders
- Requirements for notice following property transfer or other specified interests
- Requirements for periodic compliance reporting

Common AULs imposed on properties include:

- Residential Land Use
  Properties that are remediated to industrial standards (rather than more stringent residential standards) may only be used for nonresidential purposes (e.g., commercial, industrial, or manufacturing activities).
- Groundwater Usage
  When contaminants in groundwater are in excess of drinking water standards, use of the groundwater is prohibited, except for monitoring or remediation purposes.
- Excavation, Drilling, or Penetration of the Land Surface
  When certain engineering controls, such as a soil cap, are used as a remedy for the site, excavation, drilling, or penetration of the land surface is prohibited without a knowledgeable contractor to safely handle potentially contaminated soil.
- Building Construction
  When vapor intrusion from contaminated soil and/or groundwater is a concern, new building construction may be prohibited, unless vapor barriers and/or ventilation systems are installed.

6.2 PREPARATION AND EXECUTION

Because the LUC is a remedy that is used to achieve a remediation standard, the LRS must submit it as part of a Remedial Action Work Plan. If the site assessment and risk assessment determine that AULs through an LUC is the only remedy required (i.e., no engineering controls, treatment, or removal are required), the draft LUC may be submitted as an appendix to the Risk Assessment. In all cases, the LUC must be approved by WVDEP and filed by the Applicant prior to the LRS issuing the Final Report.

The LRS should use the standard LUC template available on the OER website to develop a draft document and submit the draft (in Microsoft Word format) to the OER Project Manager for review, comment, editing, and concurrence. Detailed instructions for completing the LUC template and inspection form, and for preparing the required site map, are also provided on the OER website. In addition to the site map that must be attached to the LUC, a georeferenced file, in either ESRI® shapefile or a computer aided drafting (CAD) format, must be provided to the agency.

Once agreement is reached and the document is approved by the OER Project Manager, the LUC must be signed and notarized by the property owner(s), any other holders of the covenant, and WVDEP. Only the original version of the signed LUC may be submitted to WVDEP for signature. County clerks throughout WV require that recorded documents include original signatures (no electronic or facsimile signatures are accepted); therefore, the LUC submitted to WVDEP for execution must contain original signatures.

6.3 FILING

WVDEP will provide the final signed LUC to the Applicant, and it is the Applicant's responsibility to file the LUC. The LUC must be recorded in the deed book of each county in which any portion of the site is located, and a certified copy of the recorded covenant must be returned to WVDEP and every covenant holder.

6.4 INSPECTIONS, LONG-TERM MONITORING, AND ENFORCEMENT

Upon filing, there are certain responsibilities imposed upon property owners. As stated in every LUC, property owners are required to conduct annual inspections—unless a more frequent schedule is proposed—to monitor compliance with the LUC and submit the inspection forms to WVDEP headquarters. In addition, owners are required to provide written notice to WVDEP within ten (10) days following transfer of a specified interest in the property subject to the covenant, changes in use of the property, or applications for building permits or proposals for any site work affecting the contamination on the property.

In addition to reporting requirements imposed on property owners and/or covenant holders, WVDEP continuously monitors and regularly inspects properties with recorded Land Use Covenants to protect citizens from coming into contact with contamination at a site. If violation of an LUC occurs, the agency, affected persons, and municipality or other unit of local government may file a civil action for injunctive or other equitable relief.

6.5 AMENDMENTS OR TERMINATION

An LUC remains on the property deed in perpetuity. If it is determined that residual contamination no longer presents an unacceptable risk to human health or environment (typically through additional remediation and sampling at the site), it is possible for the LUC to be amended or terminated. This requires consent by the agency, current property owner(s), and all original signers of the LUC (provided that those persons are still in existence).

7.0 Final Report

The Final Report is issued by the LRS to the Applicant in order to document and certify that all applicable remediation standards have been met and all requirements of the VRA have been satisfied. The VRP regulations require that the Final Report explain how the Applicant has completed all activities specified in the VRA and include all data and information needed to document and verify that the site meets the selected remediation standards.

7.1 CONTENTS

The requirements of the Final Report are specified in the Rule. A Final Report that includes the following information organized in the following manner will facilitate efficient review by OER.

7.1.1 Request for Certificate of Completion

After the Final Report is issued by the LRS, the Applicant should request a Certificate of Completion from WVDEP. The request should be made in writing (email acceptable) at the same time the Final Report is submitted to WVDEP. Upon receiving a request from the Applicant, OER will review the Final Report and determine if it was properly issued by the LRS. If OER agrees that the report was properly issued, a Certificate of Completion will be issued within 60 days of receipt of the request from the Applicant, unless the VRP site is also regulated by another program such as CERCLA or RCRA Corrective Action. In these cases, WVDEP will typically request an extension from the Applicant to allow time for the other regulatory programs to complete review and approval.

7.1.2 Site Information

Site information includes the following information:

- VRP Site Name
- VRP Number
- Street Address, City, County, Zip Code
- Size in Acres
- Latitude/Longitude (decimal degrees)
- Legal Description (including tax parcel ID numbers)
- Scaled maps depicting the location of the site and clearly depicting the site layout and any subdivided areas

If the VRP site was divided into separate areas for purposes of obtaining a Certificate of Completion, a list of all areas to which the Final Report applies should also be included.

7.1.3 Assessment and Remediation Summary

The assessment and remediation summary includes an executive summary of all environmental assessment and remediation performed at the site (including prior to entering the VRP), as well as all

remedial action taken to achieve the selected remediation standard(s). Specifically, any and all of the following should be listed:

- Institutional controls
- Engineering controls
- Treatment actions
- Removal actions
- Monitoring well abandonment documentation (or schedule for abandonment)

This section provides a general description of the results of the assessments and remediation in clear, simple, and straightforward language. Reports listed in the bibliographic reference may be referred to as necessary for additional detail.

7.1.4 Remediation Standards

This section lists the selected remediation standard(s) by media.

- Human Health Standards
  - Surface soil, Subsurface soil, Groundwater, Sediment, Surface water
- Ecological Standards
  - Soil, Groundwater, Sediment, Surface water

7.1.5 Bibliographic Reference

The bibliographic reference lists every document submitted to OER, including pre-VRP reports, plans, and/or other relevant documents, which are necessary to verify that the Applicant has completed all activities specified in the VRA. This should also include relevant OER correspondence such as work plan and report approval letters.

7.1.6 Contact Information

The contact information section lists the management contacts and titles for the following parties associated with the voluntary remediation project, including contact person names, addresses, telephone numbers, and email addresses (if available):

- Owner of the site
- Operator (*if different*)
- Owners and/or operators conducting the remediation (*if different*)
- Licensed Remediation Specialist(s)

7.1.7 Ongoing Work Related to the Remediation Project

If applicable, this section describes any ongoing work (e.g., treatment system operation and maintenance, groundwater or surface water monitoring, etc.) with descriptions of planned activities and schedules.

Where ongoing work will continue after issuance of the Certificate of Completion, this should include a provision for recovery of costs incurred by OER in overseeing remediation activities.

7.1.8 Institutional Controls

If institutional controls such as a Land Use Covenant (LUC) or governmental ordinance are part of the remedy, this section will include a description of any documents that have been recorded (or documents that are to be recorded and have been approved by OER). Copies of these documents should be in an appendix, including a site map showing the area(s) subject to institutional controls. An electronic map depicting the area of institutional/engineering controls must also be submitted to OER.

7.1.9 Certification

A Final Report must be certified and signed by the Applicant, the Applicant's authorized agent, and the LRS. The following certification regarding the completeness and accuracy of the Final Report is required:

> *I hereby certify that the information presented in this report is, to the best of my knowledge and belief, true, accurate, and complete, having been prepared under a system and organization designed to produce true, accurate, and complete information.*

7.2 REVIEW AND APPROVAL

The OER Project Manager must evaluate the Final Report and determine, within 60 days, whether the Final Report was properly issued by the LRS. For eligible CERCLA and RCRA Corrective Action sites entered into the VRP, the USEPA must also approve the Final Report. If WVDEP (or USEPA, in the case of CERCLA and RCRA CA sites) does not agree that the Final Report was properly issued, the Applicant will be notified with specific details why the report was not deemed properly issued. The notification must indicate whether any further action must be taken to allow the Certificate of Completion to be issued. Upon receipt of such notification, the Applicant may take one of the following actions:

(1) Undertake further actions identified by WVDEP as necessary to cause the Certificate of Completion to be issued.

(2) Appeal the decision to the Environmental Quality Board.

(3) Terminate the VRA.

8.0 Certificate of Completion

Remediation is complete when a site meets applicable standards and all work has been completed as outlined in the Voluntary Remediation Agreement (VRA). Upon receipt of a Final Report from the LRS, the Applicant may request a Certificate of Completion (COC) from WVDEP, or, under certain circumstances, from the LRS.

8.1 CONTENTS

The COC template is provided in the Rule as Appendix 60-3C. Each issued COC references the corresponding VRA and Final Report and incorporates site-specific information, including a description of the site, a site map, and a description of contaminants for which the standards have been met.

Most importantly, the COC contains a provision relieving the person who undertook the remediation and their subsequent successors and assigns from all liability to the state for the release that caused the contamination that was the subject of the voluntary remediation. The state will not institute any civil, criminal, or administrative action arising from the release and resulting contamination. Furthermore, the Applicant and subsequent successors and assigns may not be subjected to citizen suits or contribution actions with regard to the contamination that was the subject of the VRA. These liability protections remain effective as long as the site complies with the applicable standards in effect at the time the COC was issued. The duties and benefits of the COC are transferrable to successors and assigns of the Applicant, subject to the obligations of any LUC referred to in the COC.

8.2 WVDEP ISSUED CERTIFICATE OF COMPLETION

An Applicant may request a COC from WVDEP at the time of the Final Report submission or anytime thereafter. Upon consideration and determination that the applicable standards have been met, the Applicant has complied with the VRA, and the Final Report was properly issued, the COC will be issued by WVDEP within 60 days of the request.

If WVDEP does not agree that that the Final Report was properly issued, WVDEP may instead respond within 60 days with a notification stating reasons why the report was not properly issued and indicating any further action the Applicant must take in order for the COC to be issued. In return, the Applicant may take one of the following actions:

(1) Undertake further actions identified by WVDEP as necessary to cause the COC to be issued.

(2) Terminate the VRA.

8.3 LRS ISSUED CERTIFICATE OF COMPLETION

When a site meets the De Minimis Human Health Standards and passes the De Minimis Ecological Screening Evaluation, the LRS is permitted to issue the COC to the Applicant. The COC will be developed using the template appended to the Rule.

WVDEP may object to the issuance of a COC by the LRS. The LRS must notify WVDEP of their intent to issue a COC when remediation is completed within the Final Report. Following the notification, WVDEP has 30 days to object. If WVDEP does not object, or fails to object within this time period, the COC may be properly issued by the LRS. However, if WVDEP objects within the time period, the Applicant may take one of the following actions:

(1) Undertake further actions identified by WVDEP as necessary to cause the COC to be issued.

(2) Appeal the decision to the Environmental Quality Board.

(3) Terminate the VRA.

8.4 POST-COC REMEDIATION

If the remediation plan for a site requires that actions be completed after the COC is issued, the COC remains in effect while those actions (e.g., excavations, capping, groundwater monitoring, etc.) are carried out. After post-COC remedial actions are completed, a Remedial Action Completion Report must be submitted and approved by WVDEP. If the results of the post-COC actions are such that the remediation standard(s) specified in the VRA are not being met, or continued compliance with the applicable standard(s) is threatened, a reopener is triggered.

8.5 PUBLIC DOCUMENTS

Six months after the COC is issued (unless the site remediation plan requires post-COC actions), the Applicant is responsible for removing all documents from the county public library, county commission offices, or municipal offices where documents were placed for public inspection. For sites requiring post-COC actions, the LRS may remove documents after notice is received that the Remedial Action Completion Report is approved, and all monitoring wells associated with the site have been abandoned.

9.0 Reopeners

Any Applicant that completes remediation in compliance with the VRP shall not be required to undertake additional remediation actions for contaminants subject to the remediation, unless a reopener provision is identified, or the Applicant or new property owner chooses to reopen the Voluntary Remediation Agreement.

9.1 REOPENER PROVISIONS

The Certificate of Completion may be revoked, or further remediation may be required, if a reopener of the VRA has been triggered. Reopeners can occur when any of the following situations arise:

Failed Remediation Method	The remediation method fails to meet the remediation standard(s) set in the VRA.
Fraud	Fraud was committed in demonstrating attainment of the remediation standard(s) set in the VRA and resulted in avoiding the need for further remediation of the site.
Increased Level of Risk	The level of risk at a site significantly increases beyond the level of protection established through the VRA. This condition only applies where the level of risk is increased by a factor of at least five or the hazard index exceeds 1.0, or 10.0 where it is not determined whether multiple systemic toxicants affect the same organ.
New Information	New information confirms the existence of previously unknown contamination within the site, and that contamination exceeds the remediation standard(s) set in the VRA. New information means any information obtained by WVDEP after issuance of a Certificate of Completion, but does not include information WVDEP has received in the VRP Application or other information to WVDEP under the VRP prior to the execution of the Certificate of Completion. Information that does not qualify as new information may be considered by WVDEP, along with new information if necessary, to determine whether any of the conditions for reopening have occurred.
Technical and Economical Practicability	The release addressed by the VRA occurred after July 1, 1996, on a site not used for industrial activity before that date and (1) the remedy selected for the remediation relied, in some respects, on institutional or engineering controls, and (2) treatment, removal, or destruction of the contaminant has become technically and economically practical.

In the event that any of these circumstances occur, WVDEP issues a notice of such determination to the initial remediator (Applicant), the current occupant, and any other person who has asked to be notified of any actions regarding the site (e.g., a Land Use Covenant holder). The notice identifies the obligations that are not being satisfied and the appropriate corrective action that must be taken to bring the site into compliance.

9.2 RESTORING A CERTIFICATE OF COMPLETION

The COC becomes null and void 60 days after WVDEP issues the reopener notice, unless one of the following occurs prior to that time:

(1) If the initial remediator seeks to maintain the COC then in effect, the remediator must reopen and revise the VRA.

(2) If some person other than the initial remediator seeks to maintain the COC then in effect, that person must enter into a VRA.

In either case, the VRA must contain provisions to return the site to its previously agreed to state of remediation or to the extent necessary to achieve an alternative appropriate standard as determined by WVDEP.

9.3 NULL AND VOID CERTIFICATES OF COMPLETION

The COC becomes null and void 60 days after WVDEP issues the reopener notice. At that time, any Land Use Covenants placed on the property as a result of the voluntary remediation project will be rescinded.

9.4 CHANGING REMEDIATION STANDARDS POST-COC

The protections of the Certificate of Completion are transferrable beyond the current owners. However, it is possible that at some point in the future, a new owner may wish to alter the institutional and/or engineering controls for the site or take steps to have the site meet residential usage standards. WVDEP requires the party that changes the use of the property causing the level of risk to increase beyond established protection levels to undertake the additional remediation measures.

10.0 UECA-LUST Program

Leaking underground storage tank (LUST) sites with free product, extensive and/or deep soil contamination, and/or groundwater contamination may be very difficult and expensive to remediate to the soil target cleanup levels and groundwater standards provided in WVDEP's Corrective Action Guidance Document (CAGD) for LUST sites. In conjunction with the passage of the Uniform Environmental Covenants Act (W. Va. Code § 22-22B, et seq.) in 2008, OER staff developed the Uniform Environmental Covenants Act-Leaking Underground Storage Tank (UECA-LUST) process as an alternate remediation option for releases from underground storage tanks (USTs). The UECA-LUST process is a "risk-based" cleanup option, similar to the VRP, and uses the technical procedures outlined in this guidance manual. However, there are several major differences from the VRP:

1. In the UECA-LUST Program, the Applicant/Responsible Party is only required to address the contamination for which the assigned LUST leak number (Leak #) was issued, pursuant to the Confirmed Release – Notice to Comply, as opposed to addressing all historical sources of contamination as required under the VRP.
2. The UECA-LUST Program offers several presumptive Closure Tiers (described in this section), which allow for a more streamlined closure process if the site and the environmental impacts meet specific criteria.
3. Timeframes for OER Project Manager report reviews are not mandated as with VRP sites per the Voluntary Remediation and Redevelopment Rule (60CSR3).
4. There is no application or application fee associated with the UECA-LUST process.
5. The initial public notice is not required for UECA-LUST sites as required under the VRP; however, public participation is required for UECA-LUST sites once the Remedial Action Work Plan is approved, as described in 40CFR280.67.
6. Split sampling by the OER Project Manager is not required for UECA-LUST sites.
7. Once all activities required under the UECA-LUST Agreement have been completed and the site has been remediated to risk-based standards, the Applicant will receive a "No Further Action" (NFA) letter, similar to the LUST Program, as opposed to the liability protection provided by the Certificate of Completion issued under the VRP.

The Applicant is required to follow the VRP Guidance Manual for investigation and remediation of the UECA-LUST site. Therefore, a Licensed Remediation Specialist (LRS) must oversee all investigation/remediation activities, similar to the VRP.

UECA-LUST PROGRAM

10.1 PRE-APPLICATION CONSIDERATIONS

Prior to considering the UECA-LUST process, the Applicant/LRS should determine if contamination from the LUST release has migrated off-site. If contamination has migrated off-site, the Applicant/LRS should contact the off-site property owner(s) to determine if they will consent to activity and use limitations (AULs) on their property. If not, any off-site contamination will need to be remediated to residential (i.e., unrestricted) standards, or a governmental ordinance prohibiting groundwater withdrawal must be obtained. For groundwater contamination, this would be the same standard as required under the LUST Program (i.e., WV Groundwater Standards per 47CSR12). It is important to note that off-site properties may include city or state roadways and associated rights-of-way. Land Use Covenants require annual inspections by the property owner(s) or their designated agent to verify that restrictions placed on the properties have not been violated.

The Applicant must notify both OER and TCAU of their intent to follow the UECA-LUST process for investigation/cleanup by completing a Notice of Intent, located on the OER website. OER also recommends a pre-meeting with all applicable stakeholders to discuss the site and the UECA-LUST process. It is advisable, though not required, to have any impacted off-site property owners included in initial site discussions.

Once the Notice of Intent is received, TCAU will review the LUST file, and if no violations are found, the LUST site will then be formally referred to OER to enter the UECA-LUST Program.

10.2 UECA-LUST AGREEMENT

Because there is no UECA-LUST application, the next step in the process is negotiation of the UECA-LUST Agreement. The Applicant/LRS should submit a draft copy of the Agreement in Microsoft Word format via e-mail to the OER Project Manager. Similar to the VRP Agreement, no changes should be made to the UECA-LUST Agreement template. Information should only be supplied where specified. Important information in the Agreement includes:

- Documents to be submitted and the schedule for submittal.
- The LRS name and license number.
- Contact information for the OER Project Manager, Applicant, and LRS.
- Provision for reimbursement of the OER Project Manager's and OER Environmental Toxicologist's time spent on the project at a rate of 3.5 times their hourly rate, plus the actual and direct expenses of the project (i.e., public notice costs, etc.), plus any contractor cost (as applicable).
- Provision to allow the Applicant to review the scope of work and projected costs for any contractor, as well as the schedule for review and approval.
- Process for documenting delays in work outside the Applicant's reasonable control (force majeure).

Once the Applicant/LRS and OER concur on the language in the Agreement, the Applicant will sign the Agreement and will also procure signatures from the site property owner (if different from the Applicant) with their consent to AULs on the property, and email the Agreement to the OER Project Manager for the DLR Director's signature. The Applicant/LRS must also provide information on the billable party (contact name and address) to be invoiced by OER at this time.

Any change to the LRS, schedule, or contacts for the site must be made through a UECA-LUST Agreement Modification.

Because the UECA-LUST process is a convenience offered by WVDEP to owners and operators of LUST systems to allow responsible parties to achieve closure (NFA) at a lower cost and is offered in lieu of the standard enforcement track, WVDEP expects UECA-LUST Applicants to make steady progress through the assessment and remediation process. If delays in the process occur that are not due to unavoidable circumstances, WVDEP will withdraw from the UECA-LUST Agreement and refer the leak to the TCAU LUST Program for remediation using the traditional enforcement process.

10.3 WORK PLAN

Generally, the first submittal under the UECA-LUST Agreement is the Site Assessment Work Plan. The SAWP must also contain a CSM, which is updated throughout the life of the project (see information concerning the CSM below). Note that, similar to the VRP, the UECA-LUST site investigation will require sampling of additional media than that required under the LUST Program, including surface soil and possibly surface water and sediment. The potential for vapor intrusion into on-site and off-site structures must also be evaluated and may include vapor sampling. However, if these sampling requirements were met in the TCAU LUST Program, and the site received approval for completion of their Site Assessment Report, the number of samples and media to be sampled may be reduced or entirely eliminated. If extensive investigation has been completed under the TCAU LUST Program, this should be discussed between the Applicant/LRS and the OER Project Manager and reflected in the UECA-LUST Agreement (Paragraph 6, regarding report submittal schedule). In cases where the nature and extent of contamination are relatively limited and well defined, the LRS should evaluate using one of the UECA-LUST Closure Tiers and discuss this approach with the OER Project Manager.

Work Plans will require a site-specific Quality Assurance Project Plan and a site-specific Health and Safety Plan. Analytical data packages from DEP Certified laboratories will typically be Contract Laboratory Program (CLP)-like data deliverable packages. (See the WVDEP/DLR/OER QAPP for more information on quality assurance/quality control issues.)

For LUST sites with gasoline releases, the following analytes must be sampled:

- Benzene, Toluene, Ethylbenzene, and Xylene (BTEX)
- Methyl Tertiary Butyl Ether (MTBE) (*only for releases occurring between 1990-2006*)

- Naphthalene
- Tert-butyl Alcohol (TBA) (*only for releases occurring between 1990-2006*)

Note that TPH (GRO, DRO, or ORO) does not need to be sampled for UECA-LUST sites. Also, if the release occurred prior to 1988, the site will need to be sampled for lead, given the likelihood the gas station sold leaded gasoline.

For LUST sites with diesel releases, the following analytes must be sampled:

- Benzene, Toluene, Ethylbenzene, and Xylene (BTEX)
- PAHs including *Acenaphthene, Acenaphthylene, Anthracene, Benz(a)anthracene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(g,h,i)perylene, Benzo(a)pyrene, Chrysene, Dibenz(a,h)anthracene, Fluoranthene, Fluorene, Indeno(1,2,3-cd)pyrene, 1-Methylnaphthalene, 2-Methylnaphthalene, Naphthalene, Phenanthrene,* and *Pyrene*

10.4 REPORTS

Other reports (including Site Assessment Reports, Human Health and Ecological Risk Assessments, Remedial Action Work Plans, and Remedial Action Completion Reports) will be completed and submitted as needed in accordance with the schedule in the UECA-LUST Agreement. Note that, similar to the VRP Agreement, the Final Report is not listed in the reporting schedule paragraph, but the Final Report is a required report submittal.

10.4.1 Site Assessment Report

The Site Assessment Report should focus on the following objectives:

- Identify potential site-related contaminants reasonably expected to be at or near the site.
- Determine the presence or absence of those contaminants in the media of concern.
- Identify the nature and extent of contamination.
- Identify potential pathways for contaminant migration.
- Identify the potential receptors of the contamination.

A CSM is an iterative, “living interpretation” of a site that summarizes contaminant sources, impacted media, migration pathways, potential receptors, and exposure routes, which assists the project team in visualizing and understanding available information. The creation and revision of a CSM is widely accepted as a critical project planning and management tool. The CSM will be used for development of the sampling plan, risk evaluation, and remedial design. Because of the model’s importance to all aspects of the project, it should be developed early in the project when the SAWP is being developed.

In general, the content of a UECA-LUST Site Assessment Report will mirror a typical VRP Site Assessment Report. However, because the source of the release is known and well defined, and because the contaminants of concern are limited to the petroleum constituents listed above, the Site Assessment Report may be less extensive and more focused on the known impacts.

10.4.2 Human Health and Ecological Risk Assessment

Once the Site Assessment Report is approved by the OER Project Manager, a Human Health and Ecological Risk Assessment (HHERA) is typically the next required report submittal. However, in some cases, the Applicant/LRS may choose to conduct remediation prior to risk assessment. In these cases, a Remedial Action Work Plan would be the next submittal. The risk-based standards identified in the HHERA provide for the protection of human health and the environment relative to current and reasonably anticipated future land and water uses of the site. Risk-based standards are used to determine whether remediation is necessary, to identify target cleanup levels in the event that a remedial action is required, and to document that a site meets required levels of protectiveness for human health and the environment.

Three options are available for developing risk-based human health standards at a site:

1. De Minimis Standards are default benchmark values calculated for a number of chemicals using established risk equations and default exposure assumptions. The De Minimis Standards Table is attached to the Rule as Table 60-3B.

   Note that natural background concentrations can be used as alternative De Minimis standards when they exceed risk-based values (e.g., arsenic). In addition, De Minimis Standards based on migration from soil to groundwater are also provided in Table 60-3B; these values should be considered as additional stand-alone De Minimis Standards, unless groundwater data is available for the applicable parameters.

2. Uniform Standards are determined by the LRS using default equations provided on USEPA's Regional Screening Level website. They differ from De Minimis standards in that some assumptions incorporating site-specific information may be substituted for generic exposure assumptions, where applicable. In addition, uniform standards can be calculated for constituents not included in the De Minimis Table.

3. Site-Specific Standards use baseline and/or residual risk assessments to establish protective cleanup standards based on site-specific conditions and reasonably anticipated future land and water uses and can incorporate properly implemented engineering and institutional controls. They may be expressed as specific potential risk values (Excess Lifetime Cancer Risk) and non-cancer hazard quotients/indices that meet the prescribed levels, or as risk-based concentrations meeting the same levels.

All Applicants are expected to perform a De Minimis Ecological Screening Evaluation. If the results of the De Minimis analysis indicate the presence of potential receptors of concern and complete pathways of exposure, then the Applicant may elect to either undertake a Uniform Ecological Evaluation or proceed directly to the development of Site-Specific Ecological Standards.

10.4.3 Remedial Action Work Plan

The purpose of the Remedial Action Work Plan (RAWP) is to describe the remedy or remedies to be employed at a site and provide a statement of work and schedule for the remediation. The RAWP should include, at a minimum, a description of information used in the decision-making process, a discussion of potential remediation alternatives, and any uncertainty or risks which exist.

Remediation standards may be attained through one or more remediation activities that can include treatment, removal, engineering or institutional controls, natural attenuation, and innovative or other demonstrated measures. Remediation standards are to be defined, where appropriate, for surface soil, subsurface soil, sediment, surface water, and groundwater. These standards are to be established using the following considerations:

- potential receptors of concern based on the current and reasonably anticipated future use of the site;
- site-specific sources of contaminants;
- natural environmental conditions affecting the fate and transport of contaminants, such as natural attenuation processes, as determined by approved scientific methods; and
- institutional and engineering controls.

In selecting a remedial action from among various remedial alternatives considered, the RAWP must address the remedial action selected to achieve the goal of cost effective protection of human health and the environment, while balancing the following factors to ensure that no single factor predominates over the others:

- the effectiveness of the remedy in protecting human health and the environment;
- the reliability of the remedial action in achieving the standards over the long term;
- the short-term risks to the affected community, those engaged in the remedial action effort, and to the environment (for example, controls for noise, dust, and traffic);
- the acceptability of the remedial action to the affected community;
- the implementability and technical practicability of the remedial action from an engineering perspective;
- the cost effectiveness of the action; and

- the net environmental benefits of the action.

If the only remedial action for the site is implementation of institutional controls, the RAWP may be combined with the HHERA. A draft LUC must be provided with the combined HHERA/RAWP report.

Natural attenuation is a viable remedial option for UECA-LUST sites. However, there are several environmental criteria which must be demonstrated before WVDEP will approve a natural attenuation remediation plan. These criteria include:

- The contaminants of concern have the capacity to degrade or attenuate under site-specific conditions.
- The contaminant plume in groundwater or soil volume is not increasing in size.
- All sources of contamination and free product have been controlled or removed, where practicable.
- The time and direction of contaminant travel can be predicted with reasonable certainty.
- The contaminant migration will not result in the violation of applicable groundwater standards at any existing or reasonably foreseeable receptor.
- If contaminants have migrated onto adjacent properties, the owner must demonstrate that such properties are served by a public water supply or that such properties have consented in writing to allow contaminant migration onto their property.
- A groundwater discharge to a surface water body will not result in contaminant concentrations at the sediment/water interface that result in violations to the surface water standards.
- A groundwater monitoring program will be in place to sufficiently track contaminant degradation and attenuation within and downgradient of the plume and to detect contaminant and contaminant byproducts prior to their reaching any existing or foreseeable receptor.
- All necessary access agreements needed to monitor groundwater quality have been or can be obtained.
- The proposed corrective action plan would be consistent with all other environmental laws.

Note that the monitoring wells being utilized to demonstrate compliance with natural attenuation should be sampled a minimum of 4 years, at least semiannually (preferably during periods of high and low groundwater elevations), for all of the parameters used to support the natural attenuation strategy for the site.

UECA-LUST sites that have free product are also eligible to utilize the LNAPL Closure Policy outlined in the Appendix E – *LNAPL Sites Closure Policy*. The policy outlines necessary primary and secondary criteria in order to be eligible to close the site with measurable free product. The RAWP must also

contain a full description of the institutional and engineering controls that will be applied to limit potential risks as necessary to achieve the selected remediation standard.

Once the RAWP is approved, the UECA-LUST Applicant is responsible for fulfilling public participation requirements mandated by 40CFR280.67 for any corrective actions proposed for the site. The public notice template is available on the OER webpage and should be drafted by the LRS for the OER Project Manager to review and approve. The public notice outlines the corrective action proposed for the site as well as the remediation standards achieved for the site. The OER Project Manager will publish the public notice in a local newspaper in the county where the site is located. Any costs incurred by WVDEP associated with the public notice will be invoiced to the Applicant.

10.4.4 Remedial Action Completion Report

The Remedial Action Completion Report will not always be necessary, but if active remediation was implemented at the site after the RAWP approval, then the Remedial Action Completion Report should be submitted. The Remedial Action Completion Report may be combined with the Final Report. The report should include, at a minimum, the information listed below.

- Site background, location, and description
- Summary of the remedy provided in the RAWP and the basis for the remedy
- Discussion of deviations from the RAWP (if any)
- Summary of the activities completed to implement the remedy (e.g., site preparation, cover installation, site restoration, etc.)
- Summary of permits obtained (e.g., storm water permit, air permit, underground injection control permit, etc.) and work completed to comply with these permits (e.g., developing a storm water pollution prevention plan, installation of temporary erosion controls, stack testing, inspections, etc.)
- Discussion of system commissioning and performance testing (if applicable)
- Record drawings (if applicable)
- Construction photographs (if applicable)

10.5 ACTIVITY AND USE LIMITATIONS

The Applicant may achieve the selected remediation standards by restricting certain activities on the future use of the property (with the property owner's consent) via institutional and/or engineering controls (and on off-site properties, if agreed to by the off-site property owners) by recording an LUC to the property deed with the county clerk.

A draft of the LUC must be included in the RAWP and the draft LUC must be submitted in Microsoft Word format to the OER Project Manager via e-mail. Similar to the UECA-LUST Agreement, no changes should be made to the LUC template; information should only be supplied where specified. Specific details regarding LUC preparation, execution, and filing can be found in Section 6 of this guidance manual.

10.6 FINAL REPORT

The Final Report is a summary document that references the previous reports submitted to WVDEP with the coordinating WVDEP approval date. The Final Report must also list the contaminants of concern as well as the remediation standards achieved at the site. Specific details regarding information required in the Final Report can be found in Section 7 of this guidance manual.

10.7 NO FURTHER ACTION

Once the LUC has been recorded, monitoring wells not being used for future monitoring must be properly abandoned by a certified well driller and documentation must be submitted to the WVDEP Groundwater Section, as well as to the OER Project Manager. The OER Project Manager must also ensure all outstanding invoices older than 6 months are paid in full before issuing the NFA. When these actions are completed and the Final Report is approved, the OER Project Manager may issue the NFA for the site. Only an OER Project Manager can close a site under the UECA-LUST Program; the LRS cannot issue an NFA. The NFA letter stipulates that the site has been issued closure only for the subject release from the regulated UST system. The NFA letter does not apply to any previous or subsequent release(s) from the same or other UST system(s), or releases of other hazardous materials that may have occurred at the property where the subject UST system was located. The NFA letter also states the site was closed under risk-based standards and outlines the specific remediation standards achieved at the site.

10.8 CLOSURE TIERS

To qualify for a streamlined UECA-LUST closure using one of the risk-based closure tiers described below, all of the following initial criteria must be fully satisfied:

1. A site characterization has been performed by an LRS that fully delineates impacts to all environmental media and evaluates the vapor intrusion pathway.
2. Site assessment data are representative of worst-case conditions (i.e., release/source areas).
3. Contaminant concentrations and aerial extent of any groundwater plume are stable, as demonstrated through statistical analysis of monitoring data and a properly constructed and calibrated groundwater model.
4. LNAPL is not present in the groundwater at measurable thicknesses.
5. Laboratory analysis has been performed by a WVDEP Certified Laboratory, and 10% of the data for each media can be validated to Stage 4.

Leak sites that fully satisfy these initial criteria may be eligible for an NFA classification if they also meet one of the following risk-based closure tiers. If the LRS believes that the site meets these criteria, they must discuss their findings with the OER Project Manager to determine eligibility. If OER agrees that the site is eligible for one of the Closure Tiers, this will be reflected in the UECA-LUST Agreement. If the site is not immediately eligible (e.g., a limited amount of site assessment data would be required), the LRS and OER Project Manager may design the UECA-LUST Agreement submittals to collect the additional data necessary to qualify for one of the Closure Tiers. At sites where the criteria cannot be met, the RP/Applicant must follow the typical UECA-LUST process in accordance with technical guidance provided in this guidance. These steps may include (as applicable, based on site conditions) additional site assessment, risk assessment, a remedial action work plan, residual risk assessment, and/or a remedial action completion report. If at any time the LRS believes that adequate data is available to demonstrate that the site meets one of the presumptive closure criteria, they may request a UECA-LUST Agreement Modification to close the site under one of the Closure Tiers.

10.8.1 Tier 1

Closure Tier 1 is applicable where residential land use will be permitted but groundwater withdrawal will be prohibited. Upon demonstration by the LRS that all of the following criteria are met, the site may receive a NFA classification using the Tier 1 Closure Tier:

1. Concentrations in surface soil are less than residential de minimis standards.
2. Concentrations in subsurface soil 2-10 ft. bgs (typical excavation zone) are less than industrial de minimis standards.
3. Groundwater impacts are not present off-site above de minimis groundwater standards.
4. Measured or model-predicted indoor vapor concentrations are less than residential standards.

If the site meets the Tier 1 criteria, the LRS may submit a Final Report that documents and certifies that both the Initial Criteria and Tier 1 Criteria have been met and provides a draft institutional control which prohibits groundwater withdrawal from the site. Note that the Final Report must also address the requirements of 60CSR3, Section 9.9 regarding natural attenuation if contaminants are present in groundwater above the De Minimis Groundwater Standards. Upon approval of the Final Report, the RP/Applicant completes the public participation requirements of 40CFR280.67, records the institutional control to prohibit groundwater withdrawal, provides documentation of monitoring well closure, and the OER issues the NFA.

10.8.2 Tier 1a (Off-Site Groundwater Impact)

Closure Tier 1a is identical to Tier 1, except that off-site groundwater impacts have occurred. The Tier 1a Closure Tier includes the following criteria:

1. Concentrations in surface soil are less than residential de minimis standards.

2. Concentrations in subsurface soil 2-10 ft. bgs (typical excavation zone) are less than industrial de minimis standards.
3. A groundwater use restriction is available for all off-site groundwater impacts (e.g., LUC can be recorded on all impacted off-site properties or a governmental restriction/ordinance is available).
4. Measured or model-predicted indoor vapor concentrations are less than residential standards on all potentially impacted property (off-site and on-site).

If the site meets the Tier 1a criteria, the LRS may submit a Final Report that documents and certifies that both the Initial Criteria and Tier 1a Criteria have been met and provides draft institutional controls which prohibit groundwater withdrawal from the site and off-site impacted properties. The Final Report must also address the requirements of 60CSR3, Section 9.9 regarding natural attenuation. Upon approval of the Final Report, the RP/Applicant completes the public participation requirements of 40CFR280.67, records the institutional controls to prohibit on-site and off-site groundwater withdrawal, provides documentation of monitoring well closure, and the OER issues the NFA.

10.8.3 Tier 2

Closure Tier 2 is appropriate for sites where both residential land use and groundwater withdrawal will be prohibited at the property, but off-site impacts have not occurred. The Tier 2 Closure Tier includes the following criteria:

1. Concentrations in surface soil and subsurface soil are less than industrial de minimis standards above 10 ft.
2. Groundwater impacts are not present off-site above de minimis groundwater standards.
3. Measured or model-predicted indoor vapor concentrations are less than industrial standards.

If the site meets the Tier 2 criteria, the LRS may submit a Final Report that documents and certifies that both the Initial Criteria and Tier 2 Criteria have been met and provides draft institutional controls which prohibit residential use and groundwater withdrawal at the site. Note that the Final Report must also address the requirements of 60CSR3, Section 9.9 regarding natural attenuation if contaminants are present in groundwater above the De Minimis Groundwater Standards. Upon approval of the Final Report, the RP/Applicant completes the public participation requirements of 40CFR280.67, records the institutional controls, provides documentation of monitoring well closure, and the OER issues the NFA.

10.8.4 Tier 2a (Off-Site Groundwater Impact)

Closure Tier 2a is identical to Tier 2, except that off-site groundwater impacts have occurred. The Tier 2a Closure Tier includes the following criteria:

1. Concentrations in surface soil and subsurface soil are less than industrial de minimis standards above 10 ft.

2. A groundwater use restriction is available for all off-site groundwater impacts (e.g., LUC can be recorded on all impacted off-site properties or a governmental restriction/ordinance is available).
3. Measured or model-predicted indoor vapor concentrations are less than industrial standards on-site and are less than residential standards off-site.

If the site meets the Tier 2a criteria, the LRS may submit a Final Report that documents and certifies that both the Initial Criteria and Tier 2a Criteria have been met and provides draft institutional controls which prohibit residential use at the site and groundwater withdrawal both on-site and off-site. The Final Report must also address the requirements of 60CSR3, Section 9.9 regarding natural attenuation. Upon approval of the Final Report, the RP/Applicant completes the public participation requirements of 40CFR280.67, records the institutional controls, provides documentation of monitoring well closure, and OER issues the NFA.

10.8.5 Tier 3

Closure Tier 3 is appropriate for sites where both residential land use and groundwater withdrawal can be prohibited at the property, where excavation restrictions can be applied to the property, and where off-site impacts have not occurred. The Tier 3 Closure Tier includes the following criteria:

1. Concentrations in surface soil is less than industrial de minimis standards, but subsurface soil does not meet industrial standards.
2. Groundwater impacts are not present off-site above de minimis groundwater standards.
3. Measured or model-predicted indoor vapor concentrations are less than industrial standards.

If the site meets the Tier 3 criteria, the LRS may submit a Final Report that documents and certifies that both the Initial Criteria and Tier 3 Criteria have been met and provides draft institutional controls which prohibit residential use, unrestricted excavation, and groundwater withdrawal at the site. Note that the Final Report must also address the requirements of 60CSR3, Section 9.9 regarding natural attenuation if contaminants are present in groundwater above the De Minimis Groundwater Standards. Upon approval of the Final Report, the RP/Applicant completes the public participation requirements of 40CFR280.67, records the institutional controls, provides documentation of monitoring well closure, and the OER issues the NFA.

10.8.6 Tier 3a (Off-Site Groundwater Impact)

Closure Tier 3a is identical to Tier 3, except that off-site groundwater impacts have occurred. The Tier 3a Closure Tier includes the following criteria:

1. Concentrations in surface soil are less than industrial de minimis standards, but subsurface soil does not meet industrial standards.
2. A groundwater use restriction is available for all off-site groundwater impacts (e.g., LUC can be recorded on all impacted off-site properties or a governmental restriction/ordinance is available).

3. Measured or model-predicted indoor vapor concentrations are less than industrial standards on-site and are less than residential standards off-site.

If the site meets the Tier 3a criteria, the LRS may submit a Final Report that documents and certifies that both the Initial Criteria and Tier 3a Criteria have been met and provides draft institutional controls which prohibit residential use, unrestricted excavation, and groundwater withdrawal both on-site and off-site. The Final Report must also address the requirements of 60CSR3, Section 9.9 regarding natural attenuation. Upon approval of the Final Report, the RP/Applicant completes the public participation requirements of 40CFR280.67, records the institutional controls, provides documentation of monitoring well closure, and the OER issues the NFA.

Appendices

Appendix A: Determining Background Concentrations

Appendix B: Assessing Non-Point Source Stream Impacts

Appendix C: Exposure and Chemical Parameters

Appendix D: Relative Absorption Factors and Bioavailability

Appendix E: LNAPL Sites Closure Policy

Appendix F: Cover and Cap Guidance

Appendix G: Rail Trail Guidance

APPENDIX A

Appendix A: Determining Background Concentrations

A.1. BACKGROUND DETERMINATIONS

In the case of soils, background concentrations should first be compared to the default background concentrations derived from USGS data (Table 3-3). There are currently no default background concentrations for any other media (e.g., groundwater, surface water, and soil gas). When screening against default background concentrations is not possible, or if the site concentrations exceed the default background concentrations, the Applicant has the option to use statistical methods to determine site-specific background concentrations. Generally, if there are at least 10 samples of both site data and background data, the background determination should be done using hypothesis testing methods (e.g., t-tests or Wilcoxon-Mann-Whitney tests). However, if there are fewer than 10 samples for either the site data or the background data, then a Background Threshold Value (BTV) determination can be made using the Upper Tolerance Limit (UTL) method. All of these analyses can and should be conducted using *ProUCL*.

A.2. CHOOSING SAMPLE LOCATIONS

Background concentrations must be determined by sampling areas not affected by site contamination. The selection of a sampling area for background samples is a site-specific decision. The samples should be collected from locations determined in an unbiased, random fashion. To the extent practical in selecting locations for samples to determine the background levels, the following criteria should be considered as appropriate for soils, sediments, and groundwater. Additional criteria for each media are given below.

The samples must be taken up-wind, up-stream, and/or upgradient from suspected or known contamination from the site under study or other sites that are suspected or known to be contaminated. In addition:

- The samples should be taken from areas beyond the contamination boundary, but subject to similar non-site-related anthropogenic influences as the site under investigation.
- Samples should be taken from areas that have the same basic characteristics as the medium of concern at the site. The samples should be taken from the same geologic strata as is found at the site.
- Depth intervals similar to that from which samples will be collected at the site are also to be analyzed. More than one sample at each depth interval and medium within a stratum should be collected.

The same sampling and analysis procedures must be used for the proposed background areas as were used on the site. To the extent practical, the include a complete and detailed description of the anthropogenic impact history of the areas selected, any basis for concluding anthropogenic contaminants in these areas are not site-contamination related, and a justification for their selection as representative of anthropogenic impacts to the site.

A.2.1 Soils

Areas chosen to represent background and the potentially contaminated site should be of the same soil type, as determined by USDA Natural Resources Conservation Service soil surveys, or the same geologic stratum, and should have no large-scale spatial variations. If the site exhibits large-scale spatial variations, it should be subdivided into characteristically similar subsections and, to the extent practicable, matching background areas should be found for each subsection.

A.2.2 Sediments

For sediments, background samples should be matched for particle size distribution, acid volatile sulfides, total organic carbon, and water content; this may require identifying matching watersheds, or sampling sediment at sites upstream of the site, or sufficiently far downstream to dilute any site influence on sediment contaminant levels. Priority should be given to finding background sites that are in the same watershed as the potentially contaminated site, and then move to identify matching watersheds if no suitable sites can be found within the same watershed. If the site exhibits large-scale spatial variations, it should be subdivided into similar subsections and, if possible, matching background areas should be found for each subsection. Where closely matched sediments cannot be found, the impact should be described in the uncertainty analysis.

A.2.3 Groundwater

Determination of background in groundwater is usually based on comparisons with upgradient wells of similar geologic setting not affected by the site. Background wells do not necessarily have to be located off-site. On-site wells, or wells adjacent to the site, that are unaffected by site-related contaminants may also provide a meaningful indication of background conditions.

A.3 CHOOSING SAMPLE SIZE

OER recommends using statistical software such as USEPA's *ProUCL* (USEPA, 2015) or the U.S. Department of Energy's (DOE) *Visual Sample Plan* to assist in sample plan development. *ProUCL* was developed by statisticians familiar with statistical applications to environmental sampling data. Therefore, this program is highly recommended for most of the statistical evaluation discussed herein.

Should an estimate of the background standard deviation be available, a statistical package routinely given in basic statistic textbooks may be used to estimate the number of individual samples to be collected. If more than one contaminant is under investigation, a statistical procedure most likely will indicate a different number of samples for each contaminant to achieve the same confidence interval. As such, the requisite number of samples should be based on the standard deviations of the primary risk

drivers under evaluation. The sampler should specify the sampling model, expected error, and rationale (or explanation of approach) for the sample number to assess the validity of their assumptions.

The User Guide to USEPA's *ProUCL* 5.1 recommends "… collecting a minimum of 10 observations when data sets of a size determined by a DQOs process (USEPA 2006) cannot be collected. This, however, should not be interpreted as a general recommendation and every effort should be made to collect the DQO based number of samples. Some recent guidance documents (e.g., USEPA 2009) have also adopted this rule of thumb and suggest collecting a minimum of about 8-10 samples in the circumstance that data cannot be collected using a DQO-based process." This is a "rule of thumb" recommendation and may—or may not—be an adequate number of samples to characterize the background mean at the preferred confidence level.

Whether a statistical method or the "rule of thumb" is adopted, the statistical significance of the actual number of samples collected should be determined in retrospect and referenced in the report.

A.4 REPORT REQUIREMENTS FOR SITE-SPECIFC BACKGROUND

Reports must identify how site background was established and for which media (soil, groundwater, surface water, and/or sediments). The investigative methods used must be identified (e.g., monitoring wells, soil borings, water samples, etc.). The sample locations need to be shown on a map (enclosed with the results). The tabular presentation of sample results will facilitate review. The presentation of the results will include, but is not limited to:

- Description of media sampled (soil, groundwater, surface water, or sediments)
- List of background constituents under investigation and the associated analytical methods
- Justification for the number of samples to be collected including a statistical evaluation of the confidence level on the mean based on the mean and standard deviation
- Description of methods used in collecting background data (e.g., soil borings, existing literature, etc.)
- Background sample location map and rationale for sample locations
- Description of sampling procedure and sampling equipment used, which should be the same as on the potentially contaminated site
- Description of monitoring well and/or soil boring installations (if appropriate) and associated soil boring logs and monitoring well construction diagrams
- Description of field screening procedures used and tabulated results of the field screening procedures
- Description of blanks and controls used
- Presentation of background data in tabular form (media, parameters, concentrations, depth of samples, etc.)
- Statistical evaluation of background results
- Presence and disposition of outliers

- Handling of non-detect or censored values
- Documentation procedures, waste disposal data and manifests, laboratory data reports, and chain-of-custody forms

All the samples taken for the intent of determining background levels are to be included in the final report. Statistical analyses must consider all data that are not known to be in error, and the source of data quality errors must be described fully for any data which are excluded. The sampling protocols must be the same as will be applied to the samples collected at the site.

A.5 STATISTICAL METHODS FOR COMPARISON OF SITE CONCENTRATIONS WITH BACKGROUND

Initially, the evaluation should begin with the following evaluation of the measured values:

- Compute the summary descriptive statistics of the measured values, including the number of samples, mean, median, standard deviation, coefficient of variance, and range.
- Determine the likely probability distribution. *ProUCL* assesses the data for fitting either the Normal, Gamma, Lognormal, or Non-Parametric distributions.
- Identify potential outliers.

Once the measured data is in a tabular format, graphical plots can be produced quickly with the assistance of statistical software to visualize the data distribution. A thorough discussion on the use of graphical representations is provided in *Data Quality Assessment: Statistical Methods for Practitioners* (USEPA, 2006). Before proceeding with statistical comparisons, the nature of the distribution should be evaluated with goodness of fit comparisons available in most statistical software packages, including *ProUCL*.

A number of statistical methods have been recommended for comparing site and background concentrations. These methods are independent of the media sampled and include the following:

- Comparisons of distributions or medians of site and background concentrations (e.g., quantile test, Wilcoxon rank sum test)
- Comparisons of site and background means (e.g., t-test)
- Comparisons of high concentrations (e.g., hot measurement comparison, using 95% upper tolerance limit on 95th percentile to represent hot measurement)

A number of documents describe the various methods, such as USEPA (1989), USEPA (2002), ASTM (1993), and Gilbert (1993, 1987). Statistical comparisons of downgradient vs. upgradient well samples may include multiple comparisons (e.g., ANOVA), upper tolerance limits, or other approved methods as described in 33CSR1.4.11. The statistical tests described in these sources, like most statistical tests, are designed to show that two distributions (or two quantities representing distributions) are different. Failure

to show that two distributions are different, however, does not necessarily imply they are the same. If the test fails to show a statistically significant difference, there are two possibilities:

1. The distributions are the same, or
2. The distributions are different, but the test did not have enough power (i.e., there were not enough samples to demonstrate a statistically significant difference).

This guidance discusses two methods of comparing site data to background. In order to determine whether the site data fall within the range of background concentrations, it is most appropriate to use both a comparison of central tendency and a comparison of individual site concentrations with an upper tolerance limit (UTL) background concentration. Both comparisons are recommended because failure of either alone can indicate that some portion of the site concentrations exceed background. Figures A-1 and A-2 show sample distributions for site and background. Figure A-1 illustrates a situation where the site mean is less than the background mean, but greater than 5% of site concentrations exceed background in the upper "tail" of the distribution. Figure A-2 illustrates a situation where the site mean exceeds the background mean, but less than 5% of site concentrations exceed background in the upper tail of the distribution. These represent situations where site concentrations may exceed background even though one of the statistical tests is passed. Figure A-3 indicates a situation where both the site mean and 95th percentile exceed background.

Figure A-1

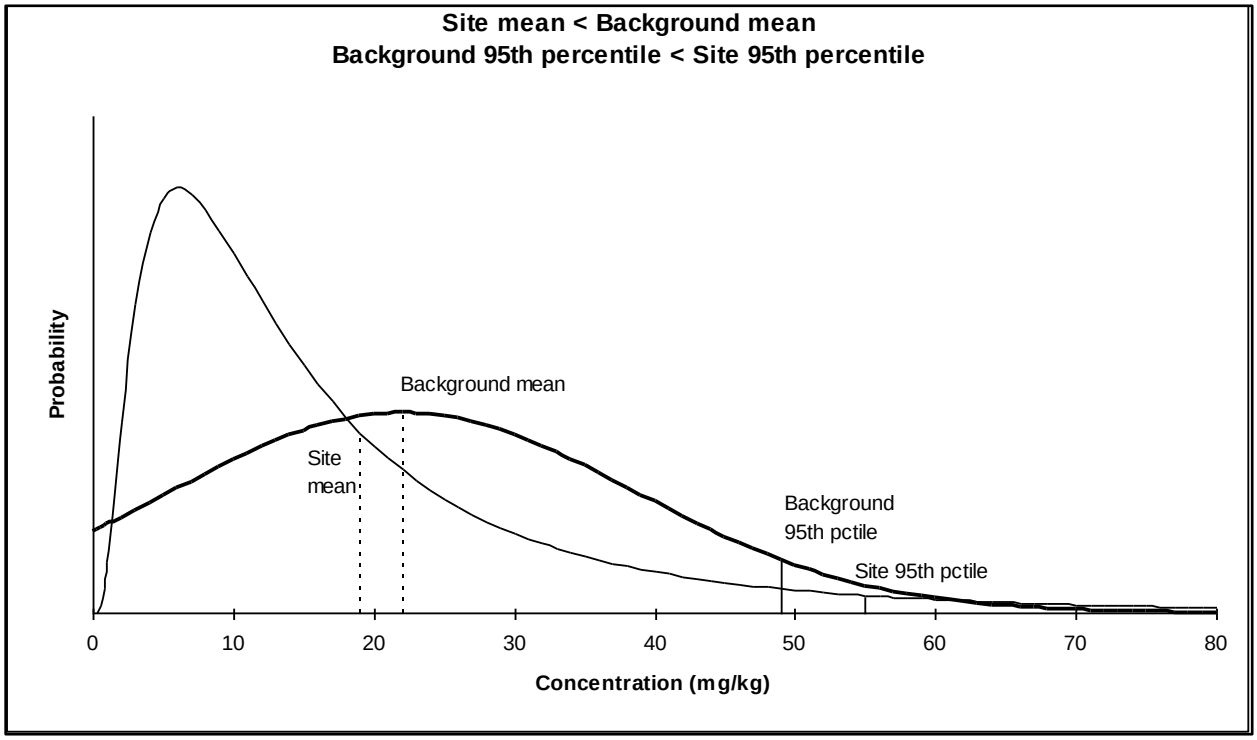


Figure A-2

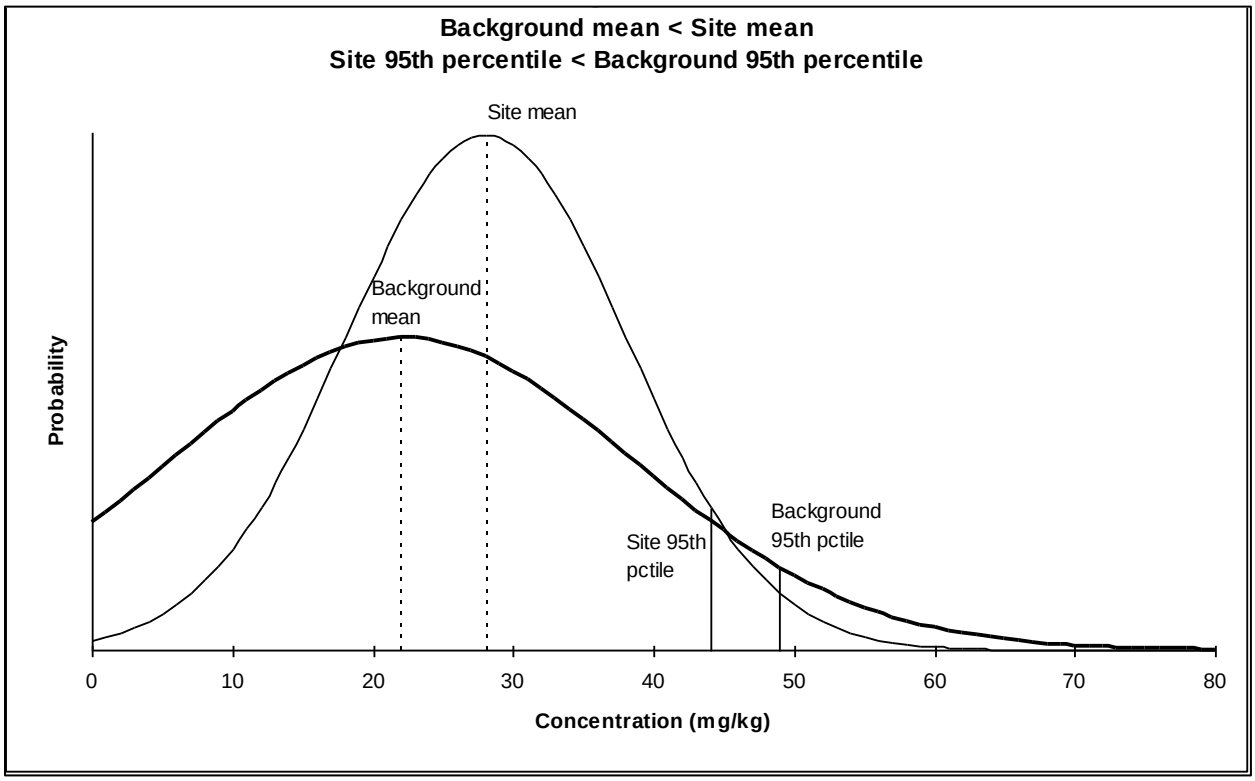
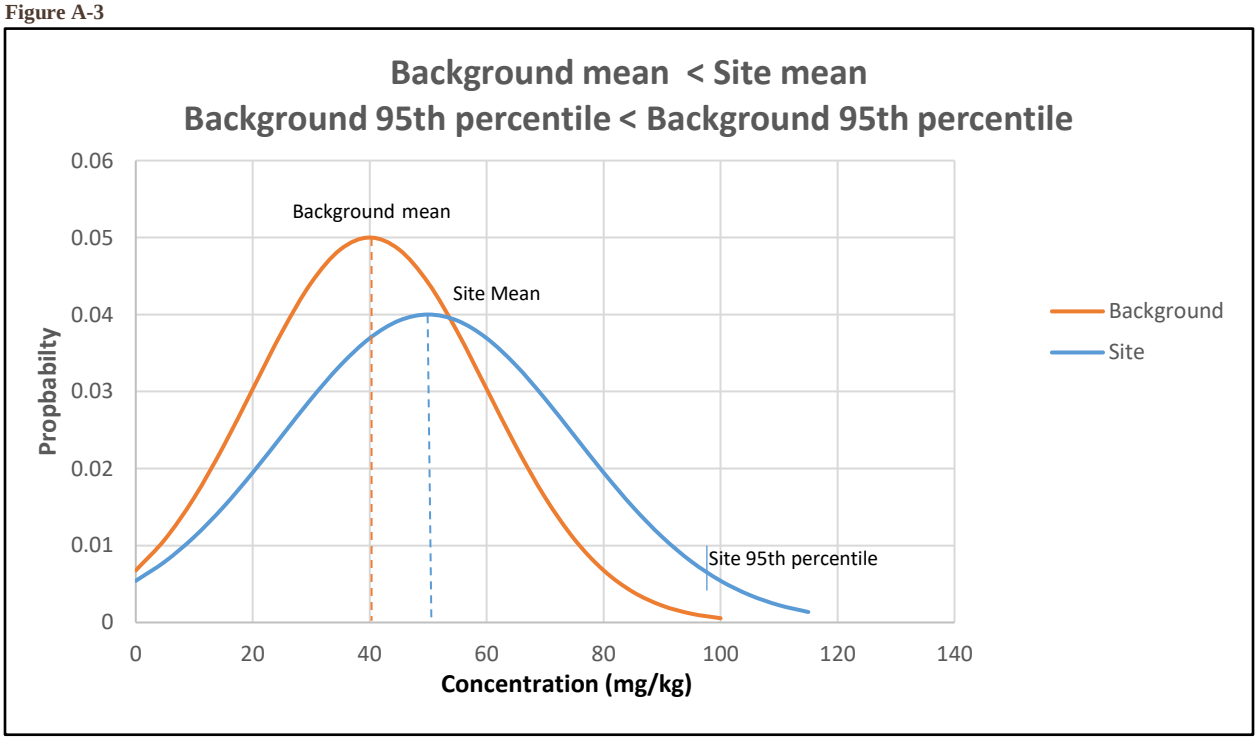


Figure A-3



The following terminology is used in this guidance:

- **Sample mean:** The sample mean is the arithmetic average calculated from a sample consisting of a number of observations.
- **True mean:** The true mean is the mean of the underlying distribution from which the sample is drawn. The true mean is unknown, but it can be estimated by the sample mean. The precision of this estimate improves as the sample size increases.
- **Standard error:** The standard error on the mean is a measure of the uncertainty in the estimate of the true mean. The standard error is defined as $SD/\sqrt{N}$, where SD is the sample standard deviation and N is the number of observations.
- **Distribution of the mean:** The distribution of the mean describes the uncertainty in the sample mean as an estimate of the true mean. There are many plausible values for the true mean, which is unknown, and probability of each of these values is given by the distribution of the mean. The spread of this distribution is determined by the standard error on the mean.

A.5.1 Comparison of Means

A two-tiered approach is recommended. At sites for which both site and background concentrations are well characterized, so that there is little uncertainty in the two means, the Tier 1 method may be used. As discussed in Subsection A.4.1.1, this method is a simple comparison of means, where complicated statistical calculations are not required. If background concentrations are well characterized, but site concentrations are not as well characterized, so that there is significant uncertainty in the site mean, the Tier 2 method is applicable. The Tier 2 method, presented in Subsection A.4.1.2, is more complicated but can be used in a wider range of situations.

Both methods depend on the definition of an acceptable difference, represented by the symbol Δ, between the true site mean and the true background mean. Selection of an appropriate value for Δ is discussed in Subsection A.5.1.3. Subsection A.4.1.4 discusses how all of the methods encourage more complete characterization of both site and background concentrations. A flow chart for comparing the site measure of central tendency to the background measure of central tendency is provided in Figure A-4.

Before any comparison of site data to background, both background and site data sets must be examined for outliers. High value outliers may adversely affect the calculated UTL and will skew the arithmetic mean. These data sets should be carefully evaluated to examine if, in fact, they belong to the population under examination. Outliers from site-related data may indicate the presence of a hot spot that may require corrective action. OER recommends calculation of UCLs and UTLs with, and without, outliers.

Another consideration is the handling of non-detects in the comparative process. The effect of non-detect values on statistical conclusions is dependent upon the number of samples and proportion of non-detect values. For large data sets with few non-detections, the effects may be minimal. This will not usually be the case for small data sets. Methods of handling non-detects include:

- Simple substitution (i.e., ½ DL)
- The sign test for non-normally distributed data
- Wilcoxon Mann Whitney Test
- The Gehan Test
- Kaplan Meier method
- Regression order Statistics
- Maximum Likely Estimation

OER recommends the use of statistical software, such as *ProUCL*, to assist with the evaluation of both outliers and the handling of non-detect values.

A.5.1.1 Tier 1 Method for Comparing Means

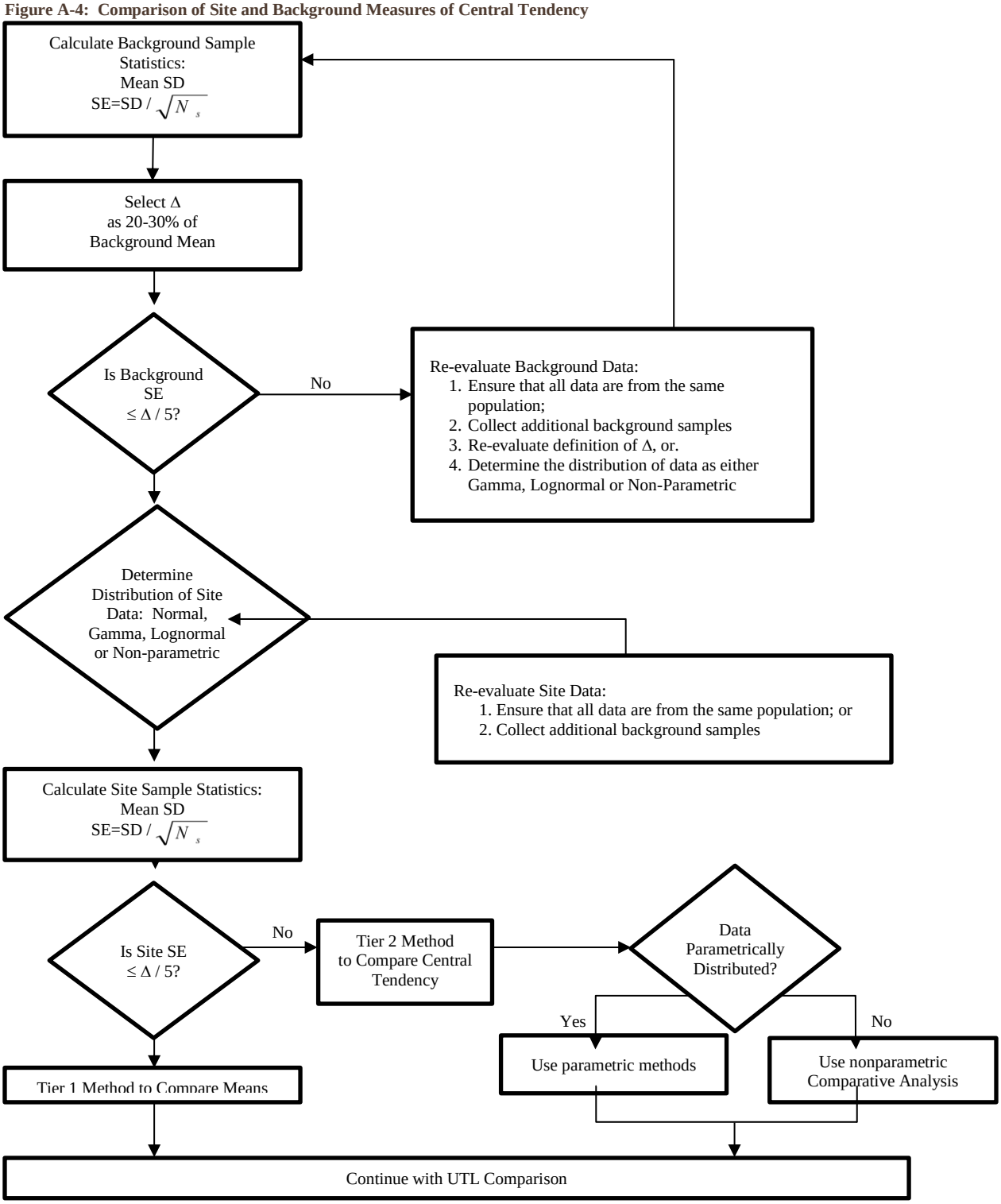
The Tier 1 method depends on two critical assumptions: both the site mean and the background mean are known precisely enough that it is not necessary to consider uncertainty in the means. In other words, it is assumed that the true means are equal to the sample means. If these assumptions are made, then the appropriate test is a simple comparison of sample means. If the site mean is less than or equal to the background mean plus Δ, then the two means are effectively the same, so site and background concentrations can be considered equivalent.

For the two assumptions to be justified, the standard errors on both the site mean and the background mean must be small compared to Δ (e.g., both standard errors should be less than Δ/5)[3].

Otherwise, the true site mean could be substantially higher than the sample mean, or the true background mean could be substantially lower than the sample mean, or both. In either case, the simple comparison of the sample means would not show conclusively that the true means are effectively the same. Consequently, if the standard errors on the means are not small compared to Δ, the Tier 1 method should not be used.

[3] Standard error less than Δ/5 is used throughout this guidance as an example of a reasonable criterion for ignoring the uncertainty in the mean. A different criterion could be used without changing the ideas presented here.

Figure A-4: Comparison of Site and Background Measures of Central Tendency



For example, consider the site and background data sets described by the summary statistics in Table A-1.

Table A- 1: Summary Statistics for Example Data Sets

	Site Data	Background Data
N	100	25
Sample Mean (ppm)	27	25
Sample Standard Deviation (ppm)	10	5
Standard Error (ppm)	1	1

If Δ, the acceptable difference between the site and background means, is defined as 20% of the background mean (5 ppm, in this case), then both the site and background data sets meet the criterion that the standard error is less than or equal to Δ/5. In this case the site mean is less than the background mean plus Δ (i.e., 25 + 5 = 30; 27 <30), so the conclusion is that the site and background means are equivalent for risk assessment purposes.

A.5.1.2 Tier 2 Method for Comparing Measures of Central Tendency

The Tier 2 method requires less restrictive assumptions than Tier 1, but the statistical tests are more complicated. WVDEP assumes that the following tests will be conducted by personnel familiar with Hypothesis Testing procedures. The Tier 2 method utilizes *ProUCL* in the following steps:

STEP 1: Determine if both the site data and the background data are normally distributed using the Normal Goodness-of-Fit test in *ProUCL* at the 95% confidence level.

STEP 2: If both site data and background data are normally distributed, then proceed to conduct a Two-sample Hypothesis t-test in *ProUCL* using the procedure in Step 3 to compare the sample means. If either the site data or background data are not normally distributed, proceed to conduct a Two-sample Hypothesis Wilcoxon-Mann-Whitney test in *ProUCL* using the procedure in Step 4 to compare the sample medians using a rank sum test.

STEP 3: Conduct a Two-sample Hypothesis t-test using a Null Hypothesis Form where "*Sample 1* >= *Sample 2* + *S* (Form 2)." *Sample 1* will be the site data, and *Sample 2* will be the background data and *S* = Δ. Select a 95% Confidence Coefficient and be certain to enter the value of Δ for the Substantial Difference. Run the test in *ProUCL* and read the output. First determine if the variances of the two samples were equal by reading the *ProUCL* output section on "Test of Equality of Variances." If the variances were determined to be equal, then report the "HO: Mean of Sample 1 – Mean of Sample 2 >= Δ" results that correspond to the "Pooled (Equal Variance)" results. If the variances were determined not to be equal, then report the "HO: Mean of Sample 1 – Mean of Sample 2 >= Δ" results that correspond to the "Welch-Satterthwaite (Unequal Variance)" results. In either case, report the DF, t-test value, and P-value along with the mean and standard deviation of the samples in your determination of background concentrations. Note that

groundwater and vapor data may best be compared using the Classical ANOVA test comparing each chemical among the various sample locations.

STEP 4: Conduct a Two-sample Hypothesis Wilcoxon-Mann-Whitney test using a Null Hypothesis Form where "*Sample 1* >= *Sample 2* + *S* (Form 2)." *Sample 1* will be the site data. *Sample 2* will be the background data and $S = \Delta$. Select a 95% Confidence Coefficient and be certain to enter the value of Δ for the Substantial Difference. Run the test in *ProUCL* and read the output. Determine if the site sample is significantly greater than the background sample in the *ProUCL* output and report WMW U-Stat Critical Value (0.05), the Approximate P-value, mean and standard deviation of the samples in your determination of background concentrations. Note that groundwater and vapor data may best be compared using the Nonparametric ANOVA test comparing each chemical among the various sample locations.

A.5.1.3 Selection of Δ

All of the methods discussed here depend on the selection of an appropriate Δ. The choice of Δ is a risk management decision. One possibility is to define Δ, which should be chemical-specific, as a percentage of the background mean. For example, if Δ is 20% of the background mean, then an acceptable site mean would be no more than 20% higher than the background mean.

If Δ is too small, then a very large data set would be required to show that the means are effectively the same with any reasonable degree of confidence. For example, consider the case in which Δ = zero. If the site and background data sets are drawn from the same distribution (so that the means are identical), then it would never be possible to show that $\mu_s \geq \mu_b + \Delta$ with greater than 50% confidence. If 80% or 90% confidence is required, then Δ must exceed zero. Alternatives to a percentage may be the use of either the standard error or standard deviation of the background mean. Consult with the OER Environmental Toxicologist to determine the appropriate value of Δ. Generally, WVDEP recommends 95% confidence ($\alpha = 0.05$) as outlined in the procedures in Subsection A.4.1.2, which requires a lower Δ; however, a lower confidence level (80-90%) may be used with proper justification and a WVDEP-approved value for Δ.

A.5.1.4 Required Characterization of Site and Background Concentrations

Both recommended methods encourage more complete characterization of both site and background concentrations. The Tier 1 method requires that the uncertainty in both the background and site means be small compared to Δ. This condition can only be met if both site and background concentrations are well characterized. The number of samples required depends on the value of Δ and on the variance of the underlying distributions. A distribution with high variance requires more samples to reduce the uncertainty in the mean.

The Tier 2 method requires that the uncertainty in the background mean be small compared to Δ, which means that background concentrations must be well characterized. In addition, this method rewards a

more complete characterization of the site, which increases the precision of the estimate of the true site mean. Assuming that site and background are nearly equivalent, the probability of determining the true site mean is significantly greater than the true background mean plus Δ will increase as the precision in the estimate of the true site mean increases, showing more conclusively that the site and background means are effectively the same.

A.5.2 Comparison of Individual Samples to an Upper Tolerance Limit

Individual data points from a site should be compared with a value that represents the upper end of the range of background concentrations, with the criteria that a large percentage of them (e.g., 95%) should fall within the range of background. (It would be inappropriate to compare each data point to the background mean, because as many as 50% of the data points could exceed this value even if all site data fell within the range of background). The level that individual data points are compared to is termed an upper tolerance limit (UTL). A UTL is usually specified as the 95th percent upper confidence limit on the 95th percentile of the distribution describing the data, where the 95th percentile is the value below which 95% of the data fall. Conceptually, this means that there is a 95% certainty, or probability, that 95% of the concentrations fall below the UTL. Or, if multiple sets of samples are taken from the same area and the 95th percentile of each sample set is assessed, then 95% of the 95th percentiles would fall below the UTL. A flow chart for comparison of individual site data to background is provided in Figure A-5. The UTL can be calculated using the analyses of Upper Limits/BTVs in *ProUCL* or the procedures below.

A.5.2.1 Calculating the Upper Tolerance Limit on Normally Distributed Data

The UTL on a normally distributed data set is calculated with the *k* statistic, as described in USEPA (1989) and Gilbert (1987, 1993). The formula is:

$$UTL = \bar{x} + k \cdot s$$

where $\bar{x}$ is the sample mean, *s* is the sample standard deviation, and *k* is the *k* statistic, which is a function of sample size, the percentile for which a UTL is to be estimated (95th in this case), and the confidence limit on this percentile (95th% upper confidence limit). Values of the *k* statistic are tabulated in USEPA (1989), Table A.4. Table A.3 of Gilbert 1987 also contains values for the *k* statistic.

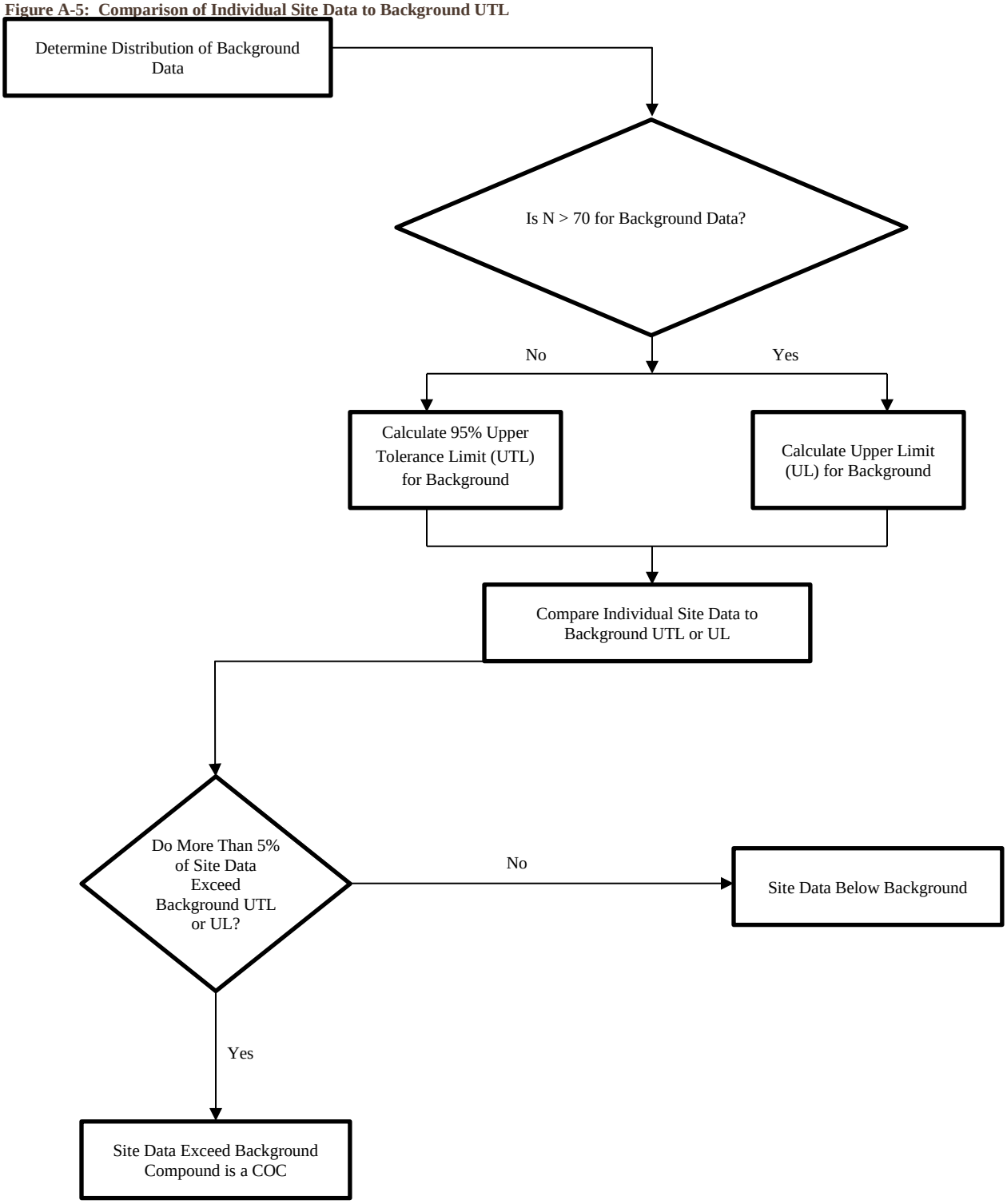
A.5.2.2 Calculating the Upper Tolerance Limit on Lognormally Distributed Data

A simple method to estimate a UTL on a lognormally distributed data set is calculated with the *k* statistic, as described in USEPA (1989):

$$UTL = \exp\left(\bar{x} + k \cdot s\right)$$

where $\bar{x}$ and *s* are the mean and standard deviation, respectively, of the log-transformed concentrations, and *k* is the *k* statistic, which is a function of sample size, the percentile for which a UTL is to be estimated (95th in this case), and the confidence limit on this percentile (95th% upper confidence limit). Values of the *k* statistic are tabulated in USEPA (1989), Table A.4 and Gilbert (1987), Table 3.

Figure A-5: Comparison of Individual Site Data to Background UTL



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APPENDIX B

Appendix B: Assessing Non-Point Source Stream Impacts

B.1 BACKGROUND

W. Va. Legislative Rule 47CSR2 (Requirements Governing Water Quality Standards) allows the Director of the Division of Water and Waste Management (DWWM) to determine, on a case-by-case basis, definable geometric limits for mixing zones for a discharge or a pollutant or pollutants within a discharge, upon the request of a permit applicant or permittee. These rules are tailored for point source discharges in order to further protect water quality after the imposition of technology-based treatment standards and best available treatment on the point source discharge. Site remediation projects which constitute non-point sources are not required to obtain permits. Therefore, in order to protect water quality and achieve compliance with the rules, the DWWM Director will require implementation of the following in-stream monitoring procedures to be used to determine the impact on the receiving stream, in conjunction with site remediation projects. Should site conditions warrant, variations to the procedures outlined below may be modified upon approval from the OER Project Manager.

B.1.1 In-Stream Monitoring Procedures

All samples will be collected for the specific pollutants of concern and using accepted QA/QC procedures. Surface water samples will be collected during low to normal flow conditions as follows:

Transect Locations:

One transect 25′ from the upstream property line and one transect located 25′ from the downstream property line. The number and location of transects along the reach of stream adjacent to the site is site-specific, depending upon information gleaned during the site characterization process and the site conceptual model, with regard to groundwater delineation and flow direction. At a minimum, one transect will be located in the reach of stream where groundwater is projected to discharge for each 75’ of plume width. Individual samples are to be collected from the lower 1′ of the water column. During development of the stream characterization component of the Sampling and Analysis Plan, coordination with the OER Project Manager is encouraged.

Sample Locations per Transect:

1. For a stream less than 30′ in width, one sample collected at the approximate mid- channel location.
2. For streams between 30′ and 60′ in width, two samples collected at locations equally spaced between mid-channel and the shoreline.

3. For streams between 60′ and 100′ in width, 3 samples collected at locations equally spaced between mid-channel and the shoreline.
4. For streams greater than 100′ in width, 4 samples at locations equally spaced between the lesser of 75 ′ from the shoreline, or mid-channel and the shoreline.

B.2 DERIVATION OF A DILUTION FACTOR FOR A GROUNDWATER DISCHARGE TO LARGE STREAMS (7Q10 GREATER THAN 5 CFS)

Before development of a dilution factor, the LRS should confer with the OER Project Manager to determine if, given the specifics of the site, the following procedures discussed below are appropriate. The WVDEP DWWM has promulgated water quality standards in consideration of two categories: (1) Use Categories B1 and B2 for the protection of aquatic life, and (2) Use Categories A and C for the protection of human health. In general, both the aquatic life and human health categories must be considered separately.

OER has attempted to evaluate groundwater/surface water interactions in a manner consistent with the DWWM's mixing zone regulations and policies. The following sections from W. Va. Legislative Rule 47CSR2 (Requirements for Governing Water Quality Standards) and DWWM's mixing zone guidance (WVDEP, Office of Water Resources, Water Quality Standards/Mixing Zones Implementation Guidance, June 30, 1997) have been applied in these situations:

1. § 47-2 5.2.e. *The mixing zone shall not exceed one-third (1/3) of the width of the receiving stream, and in no case shall the mixing zone exceed one-half (1/2) of the cross-sectional area of the receiving stream.*
2. DWWM/Mixing Zone Guidance, p. 6: *The percentage of cross-sectional area of the receiving stream established for the mixing zone should be assumed equal to the percentage of the 7Q10 of the receiving stream that is available for dilution under a complete mix assessment*.

B.2.1. Dilution factor in consideration of Human Health

For the development of a dilution factor specific to human health, the LRS may use up to one-third (1/3) of the minimum 7 consecutive day drought flow with a ten-year return frequency (7Q10) for the reach of stream adjacent to the site.

$$Dilution\ Factor_{human\ health} = \frac{\frac{1}{3}(7Q10)}{Qgw}$$

Groundwater discharge, Qgw, is calculated from the known or assumed horizontal and vertical contaminant plume dimensions, coupled with the known or assumed groundwater flow velocity. 7Q10 values are available on the WVDEP TAGIS stream flow data webpage.

There are two exceptions to this general approach regarding the Human Health Water Quality Criteria. The first relates to minimal 7Q10 for which zones are allowed per 47CSR2 § 2.5.2.c.:

> § 2.5.2.c. …. *No mixing zone for human health criteria shall be established on a stream which has a seven (7) day, ten (10) year return frequency of 5 cfs or less.*

The second exception would apply if the groundwater discharge occurs within ½ mile of a public water supply intake per §7.2.a.2. of 47CSR2:

> *§ 7.2.a.2. Each segment extending from the intake of a water supply public (Water Use Category A), for a distance of one half mile or to the headwater, must be protected by prohibiting the discharge of any pollutants in excess of the concentrations designated for this Water Use Category in section 8, herein.*

B.2.2 Dilution Factor in Consideration of Aquatic Life

For criteria involving protection of aquatic life, in consideration of protection of the benthic ecological community, the amount of the 7Q10 stream flow available for dilution of groundwater discharge was calculated by considerations affecting the cross-sectional area in which groundwater discharge and stream flow are anticipated to mix. First, the stream width available for mixing was reduced to one-third (1/3) the stream width. Second, the cross-sectional area involved in mixing was limited to the lower 3 inches of the water column (0.25ft.). Based on assumptions related to estimates of channel width, slope or stream gradient, and the Manning coefficient, a channel depth was estimated with the application of the Manning equation. This approach is employed to assure compliance the Voluntary Remediation and Redevelopment Rule (§ 60-3-*9.9.f*) which states:

> *"That, if the contaminant plume is expected to intercept surface waters, the groundwater discharge beyond the sediment/water interface will not possess contaminant concentrations that would result in violations of standards for surface waters contained in the Legislative Rule entitled 'Requirements Governing Water Quality Standards' (47CSR2)."*

Additionally, the applied average velocity through the reduced area was adjusted via a velocity profile analysis. Note that velocities in a stream vary with depth, asymptotically approaching zero toward the bottom. The combination of reduced stream velocity and area allows for the calculation of flow available for dilution protective of benthic organisms, ova, and developing aquatic embryos. The thicker alluvial aquifers in WV are typically within a 35- to 45-foot range. The majority of discharge from these thicker aquifers would be expected to occur in the first 50 to 75 feet from the shoreline. Therefore, for large streams such as the Kanawha and Ohio Rivers, the stream width over which groundwater is expected to discharge was limited to 75 feet in the analysis, rather than 1/3 stream width. Results from this analysis are tabulated below.

$$Dilution\ Factor_{aquatic\ life} = \frac{(7Q10)_{available}}{Qgw_{1.}}$$

Table B-1

7Q10 cubic feet per second (cfs)	Amount of 7Q10 available for dilution
5.0 to 20.0	3.0%
20 to 50	2.0%
50 to 150	1.0%
Greater than 150	2.0 cfs

Note that when WVDEP has not developed a water quality standard for aquatic life, the default becomes the freshwater screening values developed by the USEPA Biological Technical Assistance Group.

Figure B-1: Manning Equation

$$Q(cfs) = \frac{1.49}{n} A {R_h}^{2/3} {S_o}^{1/2}$$

Where:

Q = 7Q10 or regulated stream flow in cubic feet per second

n = Manning coefficient (0.025-Earth channel w/some stones/weeds

A = Cross sectional area of the water bearing section of the stream

R_h = Hydraulic radius (ration of the cross-sectional area to the wetted perimeter

S_o = Channel Slope

The Manning equation is solved using a given 7Q10 to estimate a normal depth.

The normal depth is used in the integrated form of Prandtl universal logarithmic velocity distribution equation to estimate the velocity profile for a given stream.

$$u = V + \frac{1}{K} \sqrt{g y_0 \ S} \ (1 + 2.3 log \frac{y}{t_0})$$

Where:

u = the velocity at a depth of y/y_0

V = mean stream velocity: V = 7Q10/A

K = von Karman constant taken as 0.40

g = acceleration due to gravity 32.2 ft/sec^2

S = Channel Slope

y = Specific height in the channel

Reference: Robert L. Daugherty, Joseph B. Franzini, E. John Finnemore, "Fluid Mechanics with Engineering Applications, Chapter 11, *Steady Flow in Open Channels."* 8th Edition, McGraw-Hill.

APPENDIX C

Appendix C: Exposure and Chemical Parameters

C.1 INTRODUCTION

If the De Minimis Human Health Standard is not appropriate for a site or the Applicant does not choose to evaluate the site under the De Minimis Standard, then assessment can proceed under the Uniform Standard or Site-Specific Standard. The equations for the Uniform Standard are available on the USEPA Regional Screening Levels (RSLs) website, and the equations for the Site-Specific Standard are available in the USEPA Risk Assessment Guidance for Superfund (RAGS) and USEPA Soil Screening Guidance (SSG) documents. However, the values used in these equations need to be scientifically justifiable. Validated site-specific values for the equation parameters are preferred but often cost- or time-prohibitive to obtain. The default parameters below should be used in risk assessment calculations unless validated site-specific information is available.

C.2 EXPOSURE PATHWAYS

The equations excerpted from RSLs, RAGS, and SSG consider human exposure to contaminants of potential concern (COPCs) in soil, air, and water and assess exposures that might occur under a variety of land uses, including residential, recreational, construction work, outdoor work, and indoor work. Exposures from several potential exposure pathways are taken into account and are summarized in Table C-1.

Table C-1: Typical Exposure Pathways by Medium/Pathway for Potential Receptors

Exposure Pathways Evaluated				
Medium	**Residents**	**Construction/Utility Workers**	**Commercial/Industrial Workers**	**Recreation / Trespass**
Groundwater	Ingestion from drinking Inhalation of volatiles Dermal contact	**If groundwater is <10' deep for Construction Workers or <4' deep for Utility Workers:** Inhalation of volatiles Dermal contact	Inhalation of volatiles **If plume is in potable source:** Ingestion Dermal contact	
Surface Water	Ingestion from drinking Inhalation of volatiles Dermal contact	Ingestion from drinking Inhalation of volatiles Dermal contact	Ingestion from drinking Inhalation of volatiles Dermal contact	Ingestion from drinking / swimming Inhalation of volatiles Dermal contact
Soil	Ingestion Inhalation of particulates Inhalation of volatiles Dermal contact Leaching to groundwater	Ingestion Inhalation of particulates Inhalation of volatiles Dermal contact Leaching to groundwater	Ingestion Inhalation of particulates Inhalation of volatiles Dermal contact Leaching to groundwater	Ingestion Inhalation of particulates Inhalation of volatiles Dermal contact

C.3 Input Parameters

C.3.1 Exposure Parameters

Table C-2 provides a listing of the default input parameters for calculating residential or industrial remediation standards. The default parameters provided are consistent with the concept of evaluating a Reasonable Maximum Exposure (RME) and ensure that the calculated standards are health protective. Default input parameters were obtained primarily from the Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors (OSWER Directive 9200.1-120, February 2014).

Table C-2: Standard Default Exposure Factors

Symbol	Definition (units)	Default	Reference
TR_o	Target cancer risk, commercial/industrial	10^{-5}	WV VRP Rule (WVDEP, 1997)
TR_r	Target cancer risk, residential	10^{-6}	WV VRP Rule (WVDEP, 1997)
THQ	Target hazard quotient	1	WV VRP Rule (WVDEP, 1997)
BW_a	Body weight, adult (kg)	80	EPA's Recommended Default Exposure Parameters (EPA 2014b)
BW_c	Body weight, child (kg)	15	EPA's Recommended Default Exposure Parameters (EPA 2014b)
SA_a	Skin Surface Area, adult (cm^2)	6032	EPA's Recommended Default Exposure Parameters (EPA 2014b)
SA_c	Skin Surface Area, child (cm^2)	2373	EPA's Recommended Default Exposure Parameters (EPA 2014b)
SA_o	Skin Surface Area, commercial/industrial (cm^2)	3527	EPA's Recommended Default Exposure Parameters (EPA 2014b)
AF_a	Dermal Adherence Factor, adult (mg/cm^2)	0.07	EPA's Recommended Default Exposure Parameters (EPA 2014b)
AF_c	Dermal Adherence Factor, child (mg/cm^2)	0.2	EPA's Recommended Default Exposure Parameters (EPA 2014b)
AF_o	Dermal Adherence Factor, commercial/industrial (mg/cm^2)	0.12	EPA's Recommended Default Exposure Parameters (EPA 2014b)
ET_r	Inhalation Exposure Time, Residential (hrs)	24	EPA's Recommended Default Exposure Parameters (EPA 2014b)
ET_o	Inhalation Exposure Time, commercial/industrial (hrs)	8	EPA's Recommended Default Exposure Parameters (EPA 2014b)
AT_c	Averaging time-carcinogens (days)	25550	RAGS (Part A), USEPA 1989 (EPA/540/1-89/002)
AT_n	Averaging time-noncarcinogens (days)	ED*365	
IRW_a	Drinking Water ingestion – adult (L/day)	2.5	EPA's Recommended Default Exposure Parameters (EPA 2014b)
IRW_c	Drinking Water ingestion – child (L/day)	0.78	EPA's Recommended Default Exposure Parameters (EPA 2014b)
IRS_a	Soil ingestion – adult (mg/day)	100	Consistent with de minimis values
IRS_c	Soil ingestion – child (mg/day)	200	Consistent with de minimis values
IRS_o	Soil ingestion – commercial/industrial – indoor worker (mg/day)	50	EPA's Recommended Default Exposure Parameters (EPA 2014b)

Symbol	Definition (units)	Default	Reference
IRS_{ow}	Soil ingestion – outdoor worker (mg/day)	100	EPA's Recommended Default Exposure Parameters (EPA 2014b)
IRF	Fish Consumption Rate – adult (g/day)	26	Estimated Fish Consumption Rates for the U.S. Population and Selected Subpopulations (NHANES 2003-2010); Table 9b (EPA 2014a)
EF_r	Exposure frequency – residential (d/y)	350	EPA's Recommended Default Exposure Parameters (EPA 2014b)
EF_o	Exposure frequency – commercial/industrial (d/y)	250	EPA's Recommended Default Exposure Parameters (EPA 2014b)
ED_r	Exposure duration – residential (years)	26[a]	EPA's Recommended Default Exposure Parameters (EPA 2014b)
ED_c	Exposure duration – child (years)	6	EPA's Recommended Default Exposure Parameters (EPA 2014b)
ED_a	Exposure duration – adult (years)	20	EPA's Recommended Default Exposure Parameters (EPA 2014b)
ED_{0-2}	Mutagen Exposure Duration – Age 0-2	2	EPA's Recommended Default Exposure Parameters (EPA 2014b)
ED_{2-6}	Mutagen Exposure Duration – Age 2-6	4	EPA's Recommended Default Exposure Parameters (EPA 2014b)
ED_{6-16}	Mutagen Exposure Duration – Age 6-16	10	EPA's Recommended Default Exposure Parameters (EPA 2014b)
ED_{16-26}	Mutagen Exposure Duration – Age 16-26	10	EPA's Recommended Default Exposure Parameters (EPA 2014b)
ED_o	Exposure duration – commercial/industrial (years)	25	EPA's Recommended Default Exposure Parameters (EPA 2014b)
Age-adjusted factors for carcinogens:			
IFS_{adj}	Ingestion factor, soils ([mg·yr]/[kg·d])	105	Calculated using age-adjusted intake factors
DFS_{adj}	Dermal intake factor, soils ([mg·yr]/[kg·d])	295.4	Calculated using age-adjusted intake factors
IFW_{adj}	Ingestion factor, water ([l·yr]/[kg·d])	0.937	Calculated using age-adjusted intake factors
Age-adjusted factors for mutagens:			
IFS_{mut}	Ingestion factor-mutagens, soils ([mg·yr]/[kg·d])	476.7	Calculated using age-adjusted intake factors
DFS_{mut}	Dermal intake factor-mutagens, soils ([mg·yr]/[kg·d])	1223.6	Calculated using age-adjusted intake factors
IFW_{mut}	Ingestion factor-mutagens, water ([l·yr]/[kg·d])	2.9	Calculated using age-adjusted intake factors
K	Andelman Volatilization Constant (L/m^3)	0.5	RAGS (Part B), USEPA 1991 (OSWER No. 9285.7-01B)
PEF	Particulate emission factor (m^3/kg)	See RSL Supporting Equations	Soil Screening Guidance (USEPA 1996a,b)
VF_s	Volatilization factor for soil (m^3/kg))		Soil Screening Guidance (USEPA 1996a,b)
C_{sat}	Soil saturation concentration (mg/kg)		Soil Screening Guidance (USEPA 1996a,b)

[a] Exposure duration for lifetime residents is assumed to be 26 years total. For carcinogens, exposures are combined for children (6 years) and adults (20 years).

C.3.2 Chemical Toxicity Criteria

Chemical-specific toxicity criteria include oral and dermal reference doses (RfDo and RfDd, respectively), reference concentrations (RfC), oral and dermal slope factors (CSFo and CSFd, respectively), and inhalation unit risk factors (IURF). Reference doses and concentrations are defined on the basis of non-cancer toxic endpoints, while slope and risk factors are based on potential carcinogenic endpoints. All of these values are available from multiple sources; however, as defined in the Rule, sources are consulted in the following order:

1. The USEPA Integrated Risk Information System (IRIS): http://www.epa.gov/iris/
2. Provisional Peer Reviewed Toxicity Values (PPRTV) prepared by the USEPA Office of Solid Waste and Emergency Response (OSWER): http://hhpprtv.ornl.gov/index.html
3. Other scientifically valid documents or information developed from governmental or non-governmental sources, such as the California OEHHA, Health Effects Assessment Summary Tables (HEAST), and ATSDR. In most instances, documents from government sources subjected to formal peer review and public comment are acceptable. In addition, other peer-reviewed technical documents, or, in some cases, technical documents without peer-review may also be acceptable. In the event that toxicity criteria are not available from the primary source (i.e., IRIS), consultation with the OER Environmental Toxicologist prior to the use of data from alternative sources is strongly recommended.

Please note that many of the USEPA values are subject to revision. For this reason, it is advisable to consult these sources prior to deriving any risk-based standard. The USEPA RSLs uses the same prioritized approach to toxicity criteria as WVDEP, and the USEPA RSLs Calculator is updated regularly with the most current toxicity information.

C.3.3 Physical-Chemical Data

In addition to toxicity criteria, additional chemical-specific parameters are required to calculate risk-based standards. These values are listed in Table C-3 with the preferred data source, RAIS.

Table C-3: List of Required Physical-Chemical Data

Symbol	Definition	Units	Source
MW	Molecular Weight		RAIS – Chemical Specific Parameters
MP	Melting Point	°C	RAIS – Chemical Specific Parameters
ABS_D	Dermal Absorption Fraction	Unitless	RAIS – Chemical Specific Parameters
ABS_{GI}	Gastrointestinal Absorption Fraction	Unitless	RAIS – Chemical Specific Parameters
HLC	Henry's Law Constant	atm-m^3/mol	RAIS – Chemical Specific Parameters
H'	Henry's Law Constant - Dimensionless	Unitless	RAIS – Chemical Specific Parameters
D_i	Air Diffusivity	cm^2/s	RAIS – Chemical Specific Parameters
D_w	Water Diffusivity	cm^2/s	RAIS – Chemical Specific Parameters
K_{oc}	Organic Carbon-Water Partition Coefficient	L/kg	RAIS – Chemical Specific Parameters
K_d	Soil-Water Partition Coefficient	L/kg	RAIS – Chemical Specific Parameters
S	Water Solubility	mg/L	RAIS – Chemical Specific Parameters

C.3.4 Calculation of Volatilization and Particulate Emission Factors

To address the soil-to-air pathway, the calculations incorporate volatilization factors (VFs) for volatile contaminants and particulate emission factors (PEFs) for nonvolatile contaminants. These factors relate soil contaminant concentrations to air contaminant concentrations that may be inhaled on-site. The USEPA RSLs account for default VFs and PEFs and provide equations to calculate site-specific values. The VF and PEF equations can be broken into two separate models: (1) an emission model to estimate emissions of the contaminant from the soil, and (2) a dispersion model to simulate the dispersion of the contaminant in the atmosphere. The dispersion model for both volatiles and particulates is the AREA-ST, an updated version of the Office of Air Quality Planning and Standards, Industrial Source Complex Model (ISC2). However, different Q/C terms are used in the VF and PEF equations. Los Angeles was selected as the 90th percentile data set for volatiles, and Minneapolis was selected as the 90th percentile data set for fugitive dusts (USEPA, 1996b,c). A default source size of 0.5 acres was chosen for the calculations. If unusual site conditions exist such that the area source is substantially larger than the default source size assumed here, an alternative Q/C could be applied (see USEPA, 1996b,c).

In addition to chemical-specific data listed in Table C-3 used in calculating volatile emissions, additional data describing soil conditions on-site are required to calculate both emission factors. These data, including acceptable default values, are listed in Table C-4.

Table C-4: Soil Data Used to Calculate Emission Terms

Parameter	Definition (units)	Default	Reference
Terms required to calculate VFs:			
$(Q/C)_V$	Inverse of the mean conc. at the center of a 0.5-acre square source (g/m^2-s per kg/m^3)	68.18 (residential)	Soil Screening Guidance
T	Exposure interval (s)	9.5×10^8	Soil Screening Guidance
θ_a	Air filled soil porosity (L_{air}/L_{soil})	0.284 or n-θ_w	Soil Screening Guidance
θ_w	Water-filled soil porosity (L_{water}/L_{soil})	0.15	Soil Screening Guidance
n	Total soil porosity (L_{pore}/L_{soil})	0.434 or 1 – (ρ_b/ρ_s)	Soil Screening Guidance
ρ_b	Dry soil bulk density (g/cm^3)	1.5	Soil Screening Guidance
ρ_s	Soil particle density (g/cm^3)	2.65	Soil Screening Guidance
f_{oc}	Fraction organic carbon in shallow soil (g/g)	0.006 (0.6%)	Soil Screening Guidance
Terms required to calculate PEF:			
$(Q/C)_P$	Inverse of the mean concentration at the center of a 0.5-acre-square source (g/m^2-s per kg/m^3)	93.77 (residential)	Soil Screening Guidance
V	Fraction of vegetative cover (unitless)	0.5	Soil Screening Guidance
U_m	Mean annual windspeed (m/s)	4.69	Soil Screening Guidance
U_t	Equivalent threshold value of windspeed at 7 m (m/s)	11.32	Soil Screening Guidance
F(x)	Function dependent on U_m/U_t derived using Cowherd (1985) (unitless)	0.194	Soil Screening Guidance

C.3.5 Recreator Exposure Factors

In recent years, WVDEP has seen an increase in the number of sites planning to have recreation as the designated use, such as rail trails, ATV parks, community parks, campgrounds, and athletic fields. Recreational activities tend to create less exposure to contamination than residential scenarios and sometimes more than industrial scenarios. For example, residential scenarios assume a person is exposed

at the site 350 days/year and 24 hours/day, which is considered overly conservative for sites that will only be used for recreational activities. Industrial scenarios assume exposures of 250 days/year and 8 hours/day, which is also more than expected by a recreator. However, recreators may immerse themselves in water to a far greater extent than expected for industrial receptors, are less likely to have personal protective equipment, and are often not aware that they are at risk. Thus, industrial standards may be too conservative or too liberal. VRP De Minimis Standards are based only on residential or industrial scenarios and do not account for different recreator activities, requiring the development of specific recreator exposure factors.

Acceptable risk and hazard levels for recreators exposed to carcinogenic and noncarcinogenic contaminants are the same as those established for a residential receptor (i.e., 1 x 10-6 cumulative cancer risk and a hazard quotient not exceeding 1.0). Cumulative risks representing an excess upper bound lifetime risk of cancer between one in ten thousand (1 x 10-4) to one in one million (1 x 10-6) will require special public notification.

The USEPA has developed recreator equations as part of the RSLs and includes them in the online RSLs Calculator with default exposure values. Generally, the RSLs default exposure values (e.g., body mass, skin surface area, and soil-to-skin adherence factor) are the same as those assumed for other RSLs receptor pathways. However, the USEPA has not developed default recreator exposure values for Exposure Frequency (EF, in days/year) or Exposure Time (ET, in hours/day).

When developing recreator standards for VRP, there are 3 options: Default Recreator Exposure Option 1, Default Recreator Exposure Option 2, and Site-Specific Recreator Exposure. Both of the Default Recreator Exposure options require the use of the default RSLs recreator exposure values and default EF and ET values developed by WVDEP as detailed below. For the Site-Specific Recreator Exposure option, default values may be replaced with site-specific values in the RSLs recreator equations or RSLs Calculator but must provide supporting data for WVDEP to approve use. In all options, if a site has multiple recreational activities available, the site will need to meet the standards for the activity that poses the greatest risk to human health and assume receptors participate in multiple activities.

<u>Default Recreator Exposure Option 1:</u>

> When sufficient published data or manuscripts were available, WVDEP developed default EF and ET values for common recreational activities for Default Recreator Exposure Option 1 (Table C-5). However, there was insufficient data to estimate EF and ET for several recreational activities. Many sites may have multiple recreational activities planned, and the absence of a default value for one or more of those activities would be prohibitive to using this option. Thus, WVDEP developed some EF values based on Best Professional Judgement (BPJ) estimates for activities with insufficient data. Applicants may negotiate alternative default BPJ values with WVDEP that will allow for the calculation of a Reasonable Maximum Exposure (RME) without investing in site-specific information but must provide evidence to support any change.

Table C-5: Default Exposure Frequency (EF) and Exposure Time (ET) Values for Recreational Activities to Use in the VRP

Recreational Activity	EF (days/year)	ET (hours/day)	Sources / Rationale
Rail Trail and Other Trails Any activity (e.g., bike, walk, jog, run, skate, and roller blade)	250*[,1]	4.0[2]	[1] Gordon, PM, SJ Zizzi, and J Pauline. 2004. Use of a Community Trail among new and habitual exercisers: A preliminary assessment. Preventing Chronic Disease: Public Health Research, Practice and Policy 1:1-11. [2] Gobster, PH. 2005. Recreation and Leisure research from an active living perspective: Taking a second look at urban trail use data. Leisure Sciences 27:367-383.
ATV and OHV	46[3]	3.0‡	[3] Kuehn, DM, PD D'Luhosch, VA Luzodis, RW Malmsheimer, and RM Schuster. 2011. Attitudes and intentions of Off-Highway Vehicle riders toward trail use: Implications for forest managers. Journal of Forestry. July/August:281-287.
Swimming, Boating, Water-skiing, and Zip-lining	42†	3.0‡	Two days per week for 21 weeks in May thru September.
Horseback Riding	62†	3.0‡	Two days per week for 31 weeks in April thru October.
Skiing, Tubing, and Sledding	26†	3.0‡	Two days per week for 13 weeks in December thru February.
Fishing, Hunting, and Wildlife-Watching	50[4,5]	3.0‡	[4] Sport Fish Restoration. 2016. 2016 Special Report on Fishing. Recreational Boating and Fishing Foundation and Outdoor Foundation. [5] Zinke, R, GJ Sheehan, W Ross, KD Kelley, and RS Jarmin. 2018. 2016 National Survey of Fishing, Hunting and Wildlife-Associated Recreation. FHW/16-NAT.
Community Parks	52[6]	3.0‡	[6] National Recreation and Park Association. 2016. NRPA Americans' Engagement with Parks Survey.
Camping	14†	24†	Two weeks of annual vacation spent camping.
Athletic Fields	117†	3.0‡	Three days per week for 39 weeks in March thru November.

*Estimated based on an average of 3.4 ±2.1 days per week yielding a 95th percentile of 7 days per week. WVDEP subtracted two weeks of vacation and two days of inclement weather per week to reach the default value of 250 days per year.
† = Best Professional Judgement, due to the absence of available research. Applicants can negotiate with WVDEP for alternative Best Professional Judgement default values to be used in Recreator risk assessments but must provide supporting evidence.
‡ Estimated by calculating the 90th Percentile from the mean daily time spent outdoors (min/day) values from USEPA. 2011. Exposure factors handbook: 2011 edition. National Center for Environmental Assessment, Washington, DC; EPA/600/R-09/052F, Table 16-92.

Default Recreator Exposure Option 2:

WVDEP developed EF and ET values using a tiered-approach for Default Recreator Exposure Option 2 (Table C-6) based on a combination of expected exposure due to the recreational activity itself and the restrictions of the recreational uses due to the nature of the property (e.g., locked fences and natural barriers). The Unrestricted Recreation tier includes all activities that could potentially occur throughout the year (e.g., rail trails and community parks) and sites that provide unrestricted access to the public or members for those activities. The Restricted Activities includes all activities not included in the Unrestricted Recreation category. Additionally, any site that has WVDEP-approved restrictions to exposures for an otherwise

Unrestricted Recreation activity may also be included in the Restricted Recreation category. Default Recreator Exposure Option 2 represents a way to calculate an RME for any recreational activity not listed in Default Recreator Exposure Option 1 or to account for differences in expected exposures due to the site conditions without having to invest in site-specific information.

Table C-6: Default Exposure Frequency (EF) and Exposure Time (ET) Values for Recreational Activities to Use in the VRP

Recreational Tier	EF (days/year)	ET (hours/day)	Description
Unrestricted	250*	4*	Includes sites designated for any recreational activity that have unrestricted public access throughout the year. ***Unrestricted Recreation*** activities include: Rail Trails ATV/OHV Fishing Community Parks Camping Athletic Fields Wildlife-Watching
Restricted	100†	3.0‡	***Restricted Recreation*** activities include all activities not listed in the ***Unrestricted Recreation*** category. Also includes ***Unrestricted Recreational*** activities that have WVDEP-approved restrictions in place, such as locked fences, natural barriers, or other access controls.

* Based on the Recreator Activity the yields the highest EF and ET product in Table C-5.
† EF based on an average of two days per week for 50 weeks of the year, subtracting two weeks of vacation.
‡ Estimated by calculating the 90th Percentile from the mean daily time spent outdoors (min/day) values from USEPA. 2011. Exposure factors handbook: 2011 edition. National Center for Environmental Assessment, Washington, DC; EPA/600/R-09/052F, Table 16-92.

C.3.6 Soil Saturation Concentration

Soil saturation (Csat) corresponds to the contaminant concentration in soil at which the adsorptive limits of the soil particles and the solubility limits of the available soil moisture have been reached. Above this point, the contaminant is likely to be present in the soil as free phase, either as a liquid or solid, depending on its melting point, relative to soil temperature. Any risk-based standard should be compared to a corresponding Csat. In instances where the risk-based standard exceeds Csat, the standard should be set to Csat. For more information on calculating Csat please see Equation 4-9 in the USEPA *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*.

C.3.7 Migration to Groundwater Pathway

The methodology for calculating site-specific Migration to Groundwater screening levels follows the procedures described in the USEPA *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*. Similar to the calculation of volatilization factors discussed above (Table C-4), the calculation of Migration to Groundwater screening levels requires site-specific soil parameters that

describe the physical conditions between the source area and the saturated zone. Alternately, a measured site-specific screening level can be developed by analyzing site-specific soil samples for the COPCs using the Synthetic Precipitation Leaching Procedure (SPLP) method. The SPLP method should be used to evaluate leaching from soil unless there is a potential for highly acidic leachate to be present, such as may be associated with a landfill or coal mining operation. More details on SPLP can be found from the USEPA (*SW-846 Test Method 1312*). Guidance from the New Jersey Department of Environmental Protection should be utilized for the *Development of Site-Specific Impact to Ground Water Soil Remediation Standards Using the Synthetic Precipitation Leaching Procedure*. However, the applicable health-based groundwater quality criterion will be the WV Groundwater De Minimis Standards. In cases where the actual water leaching contaminants from the soil is known to be or suspected to be highly acidic, the relative acidity of the leachate water must be evaluated, based on site-specific geochemical conditions. Factors to consider include the presence of municipal waste; coal mine spoil or refuse that produces acidic leachate; acidic soils or bedrock that result in acidic conditions; or other site-specific factors. In these cases, the Toxicity Characteristic Leaching Procedure (TCLP, *SW-846 Test Method 1311*) should be used to develop site-specific measured screening levels for migration to groundwater.

Because many of these parameters are the same, but are intended to characterize deeper soils, several of the values must be changed. For this reason, and to avoid any confusion with values listed above, the parameters and their default values for deeper soils are listed in Table C-7.

Table C-7: Soil Parameters for Deeper Soils Used to Calculate Leach-Based Standards

Parameter	Definition (units)	Default	Reference
f_{oc}	Fraction organic carbon (g/g)	0.002 (0.2%)	Soil Screening Guidance
θ_w	Water-filled soil porosity (L_{water}/L_{soil})	0.3	Soil Screening Guidance
θ_a	Air filled soil porosity (L_{air}/L_{soil})	0.134 or n-θ_w	Soil Screening Guidance
n	Total soil porosity (L_{pore}/L_{soil})	0.434 or 1 – (ρ_b/ρ_s)	Soil Screening Guidance
ρ_b	Dry soil bulk density (g/cm3)	1.5	Soil Screening Guidance
ρ_s	Soil particle density (g/cm^3)	2.65	Soil Screening Guidance
C_w	Target leachate concentration	Groundwater De Minimis x DAF	Calculated

The initial calculation is intended to determine the degree to which contaminant leachate will be diluted or attenuated in the aquifer prior to reaching potential receptors. Although a site-specific dilution/attenuation factor (DAF) can be calculated using the method outlined in the USEPA *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*, Equation 4-11, a default DAF of 1 is used to calculate default leach-based standards. As described by USEPA, this value is intended to be protective of groundwater for source areas that have little or no dilution or attenuation of soil leachate. Note that USEPA also allows a default DAF value of 20 for relatively small sources areas, 0.05 – 0.50 acres in size, with limited capacity for leaching. Once a DAF is determined, it is used to calculate a target leachate concentration (Cw) by multiplying the DAF times the applicable Groundwater De Minimis Standard.

Once a Cw is determined, the value is used in the USEPA *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*, Equation 4-10, to back-calculate a total soil concentration that would result in the calculated soil leachate concentration. For further information regarding the calculations of standards based on leaching from soil to groundwater, the reader is referred to USEPA Soil Screening Guidance: User's Guide (USEPA, 1996c).

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APPENDIX D

Appendix D: Relative Absorption Factors and Bioavailability

D.1 INTRODUCTION

This appendix provides an overview of relative absorption factors and bioavailability adjustments, the methods for measuring them, and their use in risk assessments. The two primary issues addressed are adjustment of oral toxicity values used in assessing dermal exposures, and adjustment of dermal and oral intake values to account for variations in absorption from different media. Further guidance on adjustments for absorption efficiency, including adjustments of toxicity values from administered to absorbed dose, can be found in the Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual, Part E, Supplemental Guidance for Dermal Risk Assessment (USEPA, 2004).

Absorption adjustments are used in the risk characterization step to ensure that the site exposure estimate and the toxicity value for comparison are both expressed as absorbed doses, or that both are expressed as intake values. Adjustments may be necessary to match the exposure estimate with the toxicity value, if one is based on an absorbed dose and the other is based on an intake (i.e., administered dose). For the dermal route of exposure, toxicity values that are expressed as administered dose will need to be adjusted to absorbed doses for comparison. This adjustment is discussed below.

Adjustments also may be necessary to account for the different absorption efficiencies associated with different exposure media (e.g., contaminants ingested with food or soil may be less completely absorbed than contaminants ingested with water). If the medium of oral exposure in the site exposure assessment differs from the medium of exposure assumed by the toxicity value, an absorption adjustment may be appropriate to express the site exposure in terms that are comparable to the toxicity value. This adjustment is a relative absorption factor (RAF). For example, a substance might be more completely absorbed following exposure to the substance in drinking water than following exposure to food or soil containing the substance. A relative absorption factor would then be used to adjust the food or soil ingestion exposure estimate to match a reference dose (RfD) or cancer slope factor (CSF) based on an assumption of drinking water ingestion. This adjustment is discussed below.

D.2 DEFINITIONS

- **Absorbed dose:** The amount of a substance that penetrates the exchange boundaries of an organism after contact. Absorbed dose is calculated from the intake and the absorption efficiency and is usually expressed as mass of a substance absorbed into the body per unit body weight per unit time (e.g., mg/kg-day).

- **Administered dose:** The mass of substance administered to an organism and in contact with an exchange boundary (e.g., gastrointestinal tract) per unit body weight per unit time (e.g., mg/kg-day).
- **Bioavailability:** The bioavailability of a substance may be defined in a variety of ways, depending upon the interests of the investigator and the specific objectives of a given study. For the purpose of this guidance, bioavailability is defined as the fraction of an administered dose that reaches the central (blood) compartment. Bioavailability defined in this manner is commonly referred to as "absolute bioavailability".
- **Cancer Slope Factor:** An upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. The CSF is used to estimate an upper-bound probability of an individual developing cancer as a result of a lifetime of exposure to a particular level of a carcinogen.
- **Exposure Medium:** The various materials to which an organism may be exposed (e.g., water, food, or soil).
- **Exposure Route:** The way a chemical or physical agent comes in contact with an organism (i.e., by ingestion, inhalation, or dermal contact).
- **Intake:** A measure of exposure expressed as the mass of substance in contact with the exchange boundary per unit body weight per unit time (e.g., mg/kg-day). Also termed the normalized exposure rate, and equivalent to administered dose.
- **Reference Dose:** An estimate (with uncertainty spanning perhaps an order of magnitude or greater) of a daily dose for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime. It is USEPA's preferred toxicity value for evaluating noncarcinogenic effects resulting from exposures to toxic substances.
- **Relative Absorption Factor:** The RAF describes the absorbed fraction of a contaminant from a particular exposure medium relative to the fraction absorbed from the dosing vehicle used in the toxicity study for that compound.
- **Relative Bioavailability:** Relative bioavailability refers to comparative bioavailabilities from different exposure media (e.g., bioavailability from soil relative to bioavailability from water), expressed in this guidance as a fractional relative absorption factor (RAF).

D.3 BIOAVAILABILITY ADJUSTMENTS FOR ASSESSING DERMAL EXPOSURES

D.3.1 Converting Oral Toxicity Values from Administered to Absorbed Doses

Because there are few, if any, toxicity values for dermal exposure, oral toxicity values must be used to assess risks from dermal exposure following the procedures in USEPA's *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual, Part E., Supplemental Guidance for Dermal Risk Assessment, Section 4.3* (USEPA, 2004). In addition, updated or additional values may be listed on the Risk Assessment Information System (RAIS) database provided by U.S. DOE, Oak Ridge National

Laboratory. In the absence of any information on absorption for a specific substance, a default ABS_{GI} of 100% is assumed.

D.3.2 Dermal Absorption Estimates for Sediment and Soil Contact

When assessing dermal exposures to chemicals in sediments or soil, it is also necessary to account for the efficiency with which contaminants enter the body through the dermal pathway. This efficiency is expressed as dermal absorption fraction (ABS_D) values and are listed in USEPA risk assessment guidance for dermal risk assessment (USEPA, 2004), with values developed subsequent to the 2004 guidance. All available updated values are also provided on the RAIS Database.

D.4 RELATIVE ABSORPTION FACTORS FOR ASSESSING ORAL EXPOSURES

D.4.1 Adjustment for Medium of Exposure

As discussed above, if the medium of oral exposure in the site exposure assessment differs from the medium of exposure assumed in the oral toxicity assessment, then an accurate assessment of site risks may require an absorption adjustment to express the exposures in the same terms. Such adjustments may be applied in assessing oral exposures to metals, pesticides, and other semivolatile organic compounds. Generally, bioavailability is expected to decrease as volatility decreases, and soil residence times increase. Frequently, toxicity values have been adjusted to reflect exposures to chemicals in drinking water or diet, while the site exposure of concern is to chemicals in soil. Because the absorption of chemicals in soil is often less than their absorption from drinking water, a comparison of relative absorption efficiencies is necessary to adjust the site exposure to that on which the RfD or slope factor is based. In some cases, the absorption of a chemical from the dosing medium and the absorption from soil are both known, and an RAF can be calculated by dividing the absorption from soil by the absorption from the dosing medium. This RAF is used to adjust the chronic daily intake (CDI) value; i.e.,

$$\text{CDI} \times \text{RAF} = \text{adjusted CDI}$$

An example calculation to adjust for medium of exposure is given in Example D-3.

In most cases, the RAF will be determined experimentally without specifically identifying absorption from the dosing medium. Methods for conducting such studies are described below. Table D-1 presents default values that may be applied for some chemicals in soil.

D.4.2 Methods of Assessing Bioavailability

Several methods are available for estimating the extent of oral absorption of compounds from environmental matrices. The method selected for a specific study will depend on the characteristics of the compound being studied and on the end use of the resulting data. Data requirements for an accurate assessment of relative bioavailability (i.e., absorption from an environmental matrix relative to absorption from the dose formulation used in the toxicity study) are substantially less rigorous than those for an accurate determination of absolute bioavailability. For this reason, and because measures of relative bioavailability are generally most useful for risk assessment, most studies are designed to determine

relative bioavailability. Relative bioavailability may be determined by comparing tissue concentrations after doses are administered, or by comparing the likely extent of dissolution of different formulations in the gastrointestinal tract. Such comparisons of extent of dissolution may be conducted using *in vitro* test systems that mimic gastrointestinal tract processes. Both *in vivo* and *in vitro* methods of assessing oral bioavailability are reviewed below.

D.4.2.1 In Vivo Methods of Assessing Bioavailability

Animal models have been developed for evaluating the relative bioavailability of arsenic (swine and monkeys), cadmium (weanling rats), mercury, lead (weanling rats and weanling swine), polycyclic aromatic hydrocarbons (PAHs; mice), polychlorinated biphenyls (PCBs; rats), petroleum hydrocarbons (mice), and tetrachlorodibenzo-p-dioxin (TCDD; rats). The reader is referred to the references in Table D-2 for further information on the design and application of these animal models.

D.4.2.2 In Vitro Methods of Assessing Bioavailability

Physiologically based *in vitro* models have been developed for assessing relative lead bioavailability from soil and have been validated against results from *in vivo* studies in weanling rats (Ruby et al, 1996) and weanling swine (Medlin, 1997). The *in vitro* method presented in Medlin (1997) is recommended for assessing relative lead bioavailability from soil.

A physiologically available cyanide *in vitro* method has been developed by Magee et al. (1996a) in conjunction with the Massachusetts Department of Environmental Protection. This method is appropriate for evaluating the bioavailability of complexed cyanide from soil.

Additional *in vitro* methods for assessment of various chemicals may be acceptable for use in human health risk assessment as they are validated. Consult with the OER Environmental Toxicologist about these additional methods prior to applying them to a site.

D.4.3 Other Methods of Assessing Bioavailability

Less precise information about relative bioavailability can also be obtained using less rigorous methods (i.e., the methods described below yield qualitative information that is not appropriate for use in quantitative adjustments to risk assessments). Standard leaching tests, such as the Toxicity Characteristics Leaching Procedure (TCLP) or the Synthetic Precipitation Leaching Procedure (SPLP) indicate whether a chemical will have limited potential to dissolve in the gastrointestinal tract. Limited ability to leach a chemical from soil may also indicate a limited ability to remove the chemical from soil during remediation.

For metals, mineralogical studies may be used to identify the specific metal compounds present in soil. If the bioavailability of the individual metal compounds – relative to the compound tested in toxicity studies relied upon by USEPA – is known, it may be possible to predict the relative bioavailability of the metal in soil. Such predictions are not likely to be as accurate as directly testing the soil, however, due to interactions of metal ions with soil constituents. Such interactions are likely to further modify the solubility and bioavailability of the metal in soil.

D.4.4 Guidance for Selecting Study Methods

This brief summary of methods for assessing oral bioavailability provides a hierarchy for evaluating bioavailability data. Animal studies are generally considered the most reliable but are also more expensive and time consuming than *in vitro* studies. Protocols for these studies must be evaluated carefully to ensure that the study design and animal model selected are appropriate for the chemical being tested. *In vitro* methods that simulate the function of the gastrointestinal tract are generally more robust than *in vivo* studies and are rapid and relatively inexpensive. Finally, simple leaching tests and mineralogical analyses may provide useful information for risk management and selection of remediation options but are not expected to provide reliable quantitative bioavailability adjustments for use in deriving risk-based cleanup levels.

For a number of organic and inorganic contaminants, sufficient data are available from animal (*in vivo*) studies to provide default RAFs for these compounds in soil. Table D-1 provides a list of these default values, along with references to the studies on which they are based. If a default RAF is not provided for a specific contaminant, or a more accurate (site-specific) RAF is desired, a site-specific value may be derived using the methods discussed below.

Table D-1: Default RAFs for Oral Exposure to Contaminants in Soil

Contaminant	RAF	Basis
Arsenic	0.60	USEPA, 2012
Cadmium	0.50	Schoof and Freeman, 1995
Lead	0.60[a]	Dieter et al., 1993; Freeman et al., 1992; USEPA (as cited in Medlin, 1997)
Mercury	0.30[b]	DOE, 1995; Smucker, 1994
PAHs	0.30	Magee et al., 1996b
TCDD	0.50	Shu et al., 1988

[a] Numerous studies in weanling animals have indicated that RAFs for lead in soil vary widely, depending on the source and form of lead present. These results indicated that site-specific data is necessary to justify the use of a value other than the default. Use of the lead RAF for risk assessment requires converting the RAF to absolute bioavailability for use in the Integrated Exposure Uptake Biokinetic Model (IEUBK, see USEPA, 1994a) or the Adult Lead Model (see USEPA, 1996).

[b] Value is applicable to soils that contain predominantly elemental mercury or mercuric sulfide.

Table D-2: References for the Design of Animal Models for Oral Bioavailability Assessment

Element	Animal Model	Reference
Arsenic	Monkeys Swine	Freeman et al., 1995 Region VIII reference
Cadmium	Rats	Schoof and Freeman, 1995
Lead	Weanling Rats Weanling Swine	Freeman et al. 1992; Schoof et al., 1995 USEPA, 1994b
Mercury	Various	Schoof and Nielsen, Risk Analysis, in press
PAHs	Rats Mice	Goon et al., 1990, 1991 Weyand et al., 1996
PCBs	Rats	[ref.]
Petroleum Hydrocarbons	Mice	Air Force study reference
TCDD	Rats	Shu et al., 1988

Example D-1: Adjusting an Administered Dose RfD to an Absorbed Dose RfD

An oral Rfd, unadjusted for absorption, equals 10 mg/kg-day.

Other information (or an assumption) indicates a 20% oral absorption efficiency in the species on which the RfD is based.

The adjusted RfD that would correspond to the absorbed dose would be:

$$10 \text{ mg/kg-day} \times 0.20 = 2 \text{ mg/kg-day},$$

The adjusted RfD of 2 mg/kg-day would be compared with the amount estimated to be absorbed dermally each day.

Example D-2: Adjusting an Administered Dose Slop Factor to an Absorbed Dose Slope Factor

An oral slope factor, unadjusted for absorption, equals 1.6 $(\text{mg/kg-day})^{-1}$.

Other information (or an assumption) indicated a 20% absorption efficiency in the species on which the slope factor is based.

The adjusted slope factor that would correspond to the absorbed dose would be:

$$1.6\ (\text{mg/kg-day})^{-1} / 0.20 = 8\ (\text{mg/kg-day})^{-1}.$$

The adjusted slope factor of 8 $(\text{mg/kg-day})^{-1}$ would be used to estimate the cancer risk associated with the estimated absorbed dose for the dermal route of exposure.

Example D-3: Adjustment for Medium of Exposure

The daily oral intake of a chemical in soil is estimated to be 5 mg/kg-day.

The toxicity factor (e.g., CSF or RfD) is based on administered dose from drinking water.

The absorption of the chemical in drinking water is known to be 90% and the absorption of the chemical from soil is measured to be 45%.

The relative absorption of the chemical in soil is 0.5 (i.e., the RAF = 0.45 / 0.90).

The oral intake of the chemical in soil may be adjusted by the RAF, to be comparable with the oral toxicity factor (i.e., the RfD or cancer slope factor).

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APPENDIX E

Appendix E: LNAPL Sites Closure Policy

E.1 INTRODUCTION

Through many years of experience with the recovery of Light Non-Aqueous Phase Liquids (LNAPL), environmental regulators, practitioners, and responsible parties have learned that complete removal or removal to remedial objectives (such as the appearance of sheen or less than one-eighth of an inch in monitoring wells) are sometimes difficult to achieve, even after years of aggressive, sustained efforts. The USEPA document, *A Decision-Making Framework for Cleanup of Sites Impacted with Light Non-Aqueous Phase Liquids* (USEPA, 2005), observes in the introduction:

> *"Some regulatory agencies are now recognizing that goals set for these sites may be difficult to achieve within a realistic timeframe. It is also recognized, that at some time after LNAPL removal is implemented, recovery rate will asymptotically approach zero. Further attempts at removal will become more costly; further removal may be impracticable."*

Recovery of LNAPL by extractive removal techniques such as skimming, vacuum extraction, and hydraulic pumping is limited to recovery of the mobile fraction only. The optimal result of these technologies is reduction to residual NAPL remaining in the matrix pore space. This remaining non-recoverable NAPL fraction will continue to present a long-term source of groundwater and soil vapor concentrations. As the applied extractive technologies approach their asymptotic end-point, the value of continued operation (or implementation of alternative extractive technologies) should be evaluated to assess whether additional significant risk reduction can be achieved relative to risk reduction naturally occurring at the site, specifically in light of the level of effort and cost to Applicants.

This protocol may be used to evaluate the feasibility and practicability of LNAPL removal and to determine when LNAPL removal can be discontinued with no increased risk to human health and the environment, consistent with existing regulation. This guidance requires that technical data demonstrate that LNAPL is stable and not migrating, and that the associated dissolved and vapor phases will not pose an unacceptable risk. This section provides general guidance and a list of resources that users can use to make these decisions. The resources referenced herein serve as the basis for, and are intended to be used in conjunction with, this guidance. This guidance uses the more general term "LNAPL" in lieu of the more specific term "free product", though in many cases LNAPL may be comprised of petroleum product.

E.2 REGULATORY FRAMEWORK

Any remedial action must meet the regulatory requirements in force at the time of implementation. The following information provides the basis for addressing LNAPL under WV regulations. In the case of remedial actions conducted in WV under the authority of the Voluntary Remediation and Redevelopment

Act (VRRA) and the Uniform Environmental Covenant Act (UECA), three separate environmental regulatory criteria have applied.

In the WV Leaking Underground Storage Tank (LUST) Program, WVDEP has incorporated by reference into W. Va. Legislative Rule 33CSR30 (Underground Storage Tanks), the federal provisions contained in 40CFR280. Requirements for LNAPL recovery at leaking underground storage tank sites (40CFR280.64) is specified as follows:

> *"At sites where investigations … indicate the presence of free product, owners and operators must remove free product to the maximum extent practicable as determined by the implementing agency…"*

The WV Groundwater Protection Act (W. Va. Code § 22-12, et seq.) states as one of the objectives:

> *"…it is the public policy of the State of West Virginia to maintain and protect the state's groundwater so as to support the present and future beneficial uses and further to maintain and protect groundwater at existing quality where the existing quality is better than that required to maintain and protect the present and future beneficial uses. Such existing quality shall be maintained and protected unless it is established that (1) the measures necessary to preserve existing quality are not technically feasible or economically practical and (2) a change in groundwater quality is justified based upon economic or societal objectives. Such a change shall maintain and protect groundwater quality so as to support the present and future beneficial uses of such groundwater."*

The WV Groundwater Protection Act elaborates on the above section as follows (§ 22-12-4):

> *"Where the concentration of a certain constituent exceeds such standard due to human-induced contamination, no further contamination by that constituent is allowed and every reasonable effort shall be made to identify, remove or mitigate the source of such contamination and to strive where practical to reduce the level of contamination over time to support drinking water use."*

The following sections of the Voluntary Remediation and Redevelopment Rule (60CSR3), specifically address the presence of free product and are considered to be relevant and appropriate for VRP sites, as well as those LUST sites pursuing a risk-based closure under the UECA-LUST Program.

> *§ 60-3-9.1.a.5. In all cases, the presence of free product at a site requires remediation.*
>
> *§ 60-3-9.8.a. Remedy Evaluation. – In selecting a remedial action from among alternatives that achieve the goal of cost-effective protection of human health and the environment, Applicant shall balance the following factors, ensuring that no single factor predominates over the others. The Applicant shall select the remedy that protects human health and the environmental using the following criteria:*

9.8.a.1. The effectiveness of the remedy in protecting human health and the environment;

9.8.a.2. The reliability of the remedial action in achieving the standards over the long term;

9.8.a.3. Short-term risk to the affected community, those engaged in the remedial action effort, and to the environment posed by the implementation of the remedial action;

9.8.a.4. The acceptability of the remedial action to the affected community;

9.8.a.5. The implementability and technical practicability of the remedial action from an engineering perspective;

9.8.a.6. Meets protectiveness goal at lowest cost; and

9.8.a.7. Considers net environmental benefits of the remedial action.

Finally, § 60-3-9.9.b (Natural Attenuation) of the Rule requires the following:

> *"That the contaminant area, such as a groundwater plume or soil volume, is not increasing in size or, because of natural attenuation processes, that the rate of contaminant degradation is demonstrably more rapid than the rate of contaminant migration, and that all sources of contamination and free product have been controlled or removed where practicable."*

A review of these different and complimentary regulatory requirements clearly indicates that responsible parties must make all reasonable efforts to remove sources of groundwater contamination. However, the regulations also clearly direct those efforts to be practicable and implementable. Therefore, each site must be carefully evaluated for LNAPL recovery efforts with these considerations in mind.

E.3 TECHNICAL AND POLICY DEVELOPMENT

Complete removal of LNAPL or removal to arbitrary remedial objectives such as less than 1/8 of an inch in monitoring wells is sometimes difficult to achieve. The Interstate Technology and Regulatory Council (ITRC) document, *Evaluating LNAPL Remedial Technologies for Achieving Projects Goals* (ITRC, December 2009) lays out a scientifically based framework for setting project goals, interim and final; the selection of technologies to achieve the identified goals; and the appropriate metrics to evaluate progress toward achieving project ends. The document reflects a growing consensus among regulators and practitioners that interpretation of the term "maximum extent practicable" should evaluate "practicable" to consider site-specific factors related to NAPL composition, mobility, risk, and technology limitations. A summary of this shift in attitude is stated as:

> *"This guidance advocates ending historic "poor" practices, some of which have become commonplace and have resulted from the 'recover LNAPL to the maximum extent practicable"*

requirements. For example, setting an arbitrary maximum allowable in-well apparent LNAPL thickness (e.g., LNAPL ≤ 1/8 inch) as a remedial objective ignore site conditions, LNAPL type, and subsurface characteristics and may have limited or no correlation with LNAPL mobility, recoverability, or dissolved-phase groundwater or vapor-phase soil gas concentrations."

For sites addressing free product remediation under the VRP or UECA-LUST Program, OER will continue to consider the intermediate and long-term objectives of "no noticeable sheen". In all cases these objectives shall remain for sites with LNAPL that are being remediated under the LUST Program. However, for VRP and UECA-LUST Program projects, a remediation goal that allows for measurable LNAPL to remain on-site, yet is protective of human health and the environment, may be considered on a site-specific basis when assessments provide sufficient and adequate information upon which to base such a decision. In addition to meeting risk-based criteria, it must be demonstrated to the satisfaction of the agency that all migrating LNAPL has been recovered, all reasonable recovery efforts have been evaluated, and that the requirements of the WV Groundwater Protection Act and the Voluntary Remediation and Redevelopment Rule are met. Note that these regulatory requirements may necessitate source removal or encapsulation of soils containing residual contaminants judged to pose a continuing long-term threat to dissolved-phase groundwater concentrations or vapor-phase soil concentrations.

E.4 INFORMATION REQUIREMENTS

Prior to considering closure goals that include measurable LNAPL remaining in monitoring wells, the LRS must ensure that a site has been thoroughly investigated and that sufficient data of adequate quality are collected and presented in a complete and systematic manner to support the desired remedial goals. This will generally consist of several tiers of information, including but not limited to, a Site Assessment, an LNAPL conceptual site model (LCSM), and a Remedial Action Work Plan (RAWP).

Site characterization is the first step in defining the nature and extent of LNAPL and in determining the magnitude of risk. The actual extent of assessment is site-specific. For example, delineation of LNAPL at wholesale facilities with bulk storage will require more thorough characterization than retail gasoline releases. To provide sufficient and adequate information the site characterization should provide reliable information that allows for realistic, data-supported estimates of:

1. Source(s) and migration pathways of LNAPL
2. Vertical and aerial dimensions of the LNAPL body, including change over time
3. An estimate of the initial and current mass and volume of the LNAPL body
4. Chemical composition (e.g., fraction GRO/DRO/ORO), concentrations of risk drivers such as benzene and naphthalene, and physical properties of the LNAPL material (e.g., density and viscosity)
5. Composition of the LNAPL-containing matrix, including residual LNAPL concentrations, soil/material types, bulk densities, porosity, etc.

6. Degree of residual LNAPL saturation in soils and residual saturation variance across the LNAPL body as determined through physical testing of soil cores and through total petroleum hydrocarbon analysis
7. Evidence that the LNAPL mass is diminishing over time through natural processes
8. Vapor concentrations above the LNAPL body
9. Aerial (horizontal) extent of dissolved LNAPL related chemicals
10. Dissolved LNAPL constituent concentrations in groundwater immediately downgradient of the LNAPL body to support Natural Source Zone Depletion (NSZD) through dissolution
11. Hydrogeologic characteristics of the site, including water table elevation and fluctuations, hydraulic gradient, hydraulic conductivity, communication with adjacent surface water, and other aquifer characteristics
12. Hydrogeologic analysis that establishes whether variations in LNAPL thickness are in response to groundwater fluctuations or due to confined conditions. LNAPL thicknesses are often exaggerated under confined conditions. Therefore, the Site Characterization Report (SCR) must provide adequate characterization to determine if confining layers are present.

The characterization of a site with LNAPL includes the development of an appropriate LNAPL conceptual site model (LCSM). According to ASTM E 2531-06 guidance, an LCSM "describes the physical and chemical state and setting of the three-dimensional LNAPL body from which estimates of flux, risk and remedial actions are determined." The LCSM commonly requires revision as site characterization becomes more complete, remedial pilot test data becomes available, remedial performance metrics are collected, or as site conditions change due to remediation and other site factors.

The level of detail required for a given LCSM is site-specific and based on the complexity of environmental conditions at each site and the overall LNAPL site management objectives. In certain situations, where the size of the LNAPL body is relatively small and a presumptive remedy such as soil excavation is adequate to satisfy the LNAPL remedial objectives, the LCSM may be limited, with a primary focus on LNAPL delineation or spatial distribution. In situations where complete removal of LNAPL is not feasible, the LCSM needs adequate detail, particularly in terms of hydrogeology and LNAPL spatial distribution and mobility. Information needed to develop a thorough LCSM typically includes, but is not limited to:

- **Delineation**: LNAPL does not necessarily form a "pancake" on the groundwater surface, but shares the pore space in the vadose zone, the capillary fringe, and/or beneath the water table within the smear zone. Different approaches or technologies can be used to identify LNAPL trapped in soils (e.g. Laser-Induced Florescence (LIF) in conjunction with core photography).

- **Sources and Pathways**: Geologic or manmade features such as fractures in bedrock or clay, and fill material adjacent to underground utilities may also contain LNAPL and may serve as pathways for vapor and dissolved phases. The movement and storage of LNAPL in these features needs to be considered as part of the characterization and their presence may significantly increase risk by accelerating potential migration to receptors.
- **Volume**: Where possible, the volume (or plausible volume range) of LNAPL within the subsurface should be realistically estimated to allow the development and selection of an appropriate recovery strategy as well as a basis for the risk evaluation. Historic records for the site should be reviewed to determine whether past releases may have contributed to the volume of LNAPL.
- **Age and Chemical/Physical Character**: LNAPL and groundwater can be analyzed to identify or verify the type of product as well as assess if the product poses a risk to receptors. As LNAPL weathers, the physical and chemical properties of the LNAPL change. Weathered LNAPL can be more viscous and dense, and therefore less mobile and less recoverable than unweathered LNAPL. LNAPL chemical properties can also assist in determining a probable date or time frame for the release. As LNAPL weathers, lighter fraction hydrocarbons tend to decrease when compared to heavier fractions. Knowing the amount of time the LNAPL has been present compared to the known impacts (or lack thereof) can provide valuable insight on whether continued recovery is advisable. This information is also valuable in supporting NSZD.
- **LNAPL Mobility**: LNAPL in porous media must exist at saturations greater than residual saturation to be mobile. It is the mobile portion of the LNAPL body that is typically recovered by LNAPL extraction and recovery technologies. However, the presence of mobile LNAPL in a well does not necessarily indicate that the LNAPL body is migrating. The potential for mobile LNAPL to migrate may depend on changing hydraulic or LNAPL gradients as well as precipitation and variations of groundwater elevation. Gauging or recovery data from drought and heavy precipitation events may provide mobility data.
- **LNAPL Recoverability/Transmissivity**: LNAPL Transmissivity (LNAPL T_n) is a useful quantitative metric for determining the recoverability of mobile free product. Since LNAPL T_n accounts for multiple LNAPL properties such as density, viscosity, and LNAPL saturation, LNAPL T_n can be more useful than just the measured thickness for determining free product recoverability (ASTM E2856, Section VII). However, LNAPL T_n can vary over time due to subsurface conditions such as groundwater fluctuations, corrective action implementation (reduced LNAPL saturation), or weathering of LNAPL.

LNAPL T_n tests should be performed to aid in determining the recoverability of the LNAPL. LNAPL T_n tests can also be completed over time to document the progress of recovery efforts. The ASTM Standard E2856 discusses several LNAPL T_n test methods and how to select the most appropriate method for site conditions. The number and location of tests will be dictated by aerial extent and heterogeneity of the LNAPL body.

E.5 CLOSURE REQUIREMENTS

Applicants who wish to propose a remedial end goal that includes measurable LNAPL remaining in monitoring wells must submit a Remedial Action Work Plan (RAWP) that supports the proposed remedial goals. A RAWP that proposes a remedial end goal that includes measurable LNAPL in monitoring wells will be reviewed by OER technical staff who possess specialized training and experience in the subject. The staff will also review any future reports associated with the site, such as on-going monitoring data, to ensure that closure goals continue to be met. To demonstrate that additional LNAPL recovery is no longer necessary, several "lines of evidence" must show that free product has been recovered to the "maximum extent practicable" and that the risks associated with the remaining LNAPL are at an acceptable level. The following primary and secondary criteria will be considered by OER in approving a remedial end goal that includes measurable LNAPL in monitoring wells.

Primary Criteria

1. Because it is likely that groundwater will continue to exhibit concentrations of LNAPL related contaminants that exceed risk-based levels, and because soil vapor concentrations may also continue to exist at levels which would pose an ongoing threat to receptors, the site must be addressed under the oversight of a program that permits the implementation of institutional controls as a remedy component (i.e., VRP or UECA-LUST Program).
2. An adequate network of groundwater monitoring wells must be in place that has been monitored over a sufficient period of time and at sufficient frequency (at least semiannually for a minimum of 4 years) to establish that the LNAPL body is not increasing in aerial extent and is not migrating. The appearance of an LNAPL related sheen on an adjacent surface water body, even if infrequent, will be considered as prima fascia evidence that LNAPL plume control has not been demonstrated.
3. Monitoring data collected at regular intervals over time from wells within the LNAPL plume that indicate a decrease in exhibited LNAPL thickness.
4. Monitoring data collected at regular intervals over time from wells within the dissolved contaminant groundwater plume that demonstrate a stable or decreasing aerial extent coupled with stable or decreasing LNAPL related contaminant concentrations.
5. Data from appropriate, effective, and efficiently operated recovery efforts that demonstrate a declining recovery trend over time that provides a credible indication that continued recovery would have minimal effect on the longevity of either the LNAPL body or the dissolved groundwater plume.
6. A demonstration that alternate recovery technologies would not significantly increase LNAPL recovery.
7. Qualitative evidence that Natural Source Zone Depletion through dissolution, biodegradation, and volatilization are comparable to, or exceed, the anticipated depletion rate via active recovery.

8. Transmissivity testing and analysis that indicate continued LNAPL recovery will be impractical. Analyses of test data from strategically located wells within the LNAPL plume must indicate that transmissivity values do not exceed 0.8 ft^2/day. Several locations will be necessary for larger plumes. Several tests in a single location may also be helpful to strengthen data quality and reduce variance.
9. The site meets the criteria to be eligible for natural attenuation to be a component of the remedy (Voluntary Remediation and Redevelopment Rule § 60-3-9.9).

Secondary Criteria

1. A comparison of soil data collected at various points in time that indicate a decrease in LNAPL saturation.
2. Compositional analyses of LNAPL samples collected at various points in time that demonstrate a reduction of the molar fraction of primary risk drivers (e.g., benzene, ethylbenzene, naphthalene, etc.).
3. In cases where soil vapor extraction has been conducted at the site, soil vapor recovery data that indicate a declining trend in the mass recovered per unit time.

The RAWP must also contain a full description of the institutional and engineering controls that will be applied to limit potential risks as necessary to achieve the selected remediation standard.

E.6 SUMMARY

WVDEP recognizes that situations exist in which LNAPL can justifiably remain at a site after closure and not pose an unacceptable risk to human health and the environment when the site is closed under the authority of the VRP or UECA-LUST Programs. However, it is necessary to provide a full understanding of the site-specific geological, hydrogeological, and receptor risk factors in a RAWP that includes measurable LNAPL remaining at a site. It is the responsibility of the program Applicant and their LRS to follow this guidance and the cited resources to provide a thorough site characterization that is supported by an adequate amount of high-quality data to generate a comprehensive SCR, LCSM, and RAWP. For sites enrolled in the VRP and UECA-LUST Program prior to inclusion of this LNAPL remediation option in program guidance, it may be necessary to provide an updated and possibly expanded site assessment, risk assessment, or RAWP to meet the standard. In some cases, previously collected data may need to be supplemented. New types of approaches and the gathering of additional lines of evidence may be required to ensure that site conditions have not changed since the original site characterization or RAWP were prepared. The evidence must be presented to OER in a manner that clearly supports a RAWP that includes discontinuance of LNAPL recovery.

E.7 REFERENCES

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APPENDIX F

Appendix F: Cover and Cap Guidance

F.1 INTRODUCTION

This guidance provides fundamental performance standards for cover and cap systems installed at VRP and UECA-LUST Program sites and should be followed to ensure that covers and caps used at these risk-based remediation sites in the future are reasonably consistent between sites and are effective in preventing direct contact exposure or surface water infiltration, as necessary.

The VRP and the UECA-LUST Program use risk-based cleanup standards that consider site-specific conditions and future land use to prevent unacceptable human and ecological risks, while encouraging the remediation and reuse of contaminated sites so that undeveloped land remains pristine. Remediation standards (De Minimis, Uniform, and Site-Specific) are used by the LRS to determine if a site represents an unacceptable risk. Various remedies, ranging from removal or treatment of contaminated media to activity and use limitations (AULs), are used alone or in combination to reduce risk and achieve the selected remediation standard. The UECA-LUST Program is a specific application of the risk-based remediation principles of the VRP, where Applicants remediate leaking underground storage tank sites to risk-based standards.

Based on the results of site characterization and risk assessment, the LRS selects a remedy or combination of remedies. The remedies are proposed and described in a Remedial Action Work Plan (RAWP) that is submitted to OER for review and comment. Where a cover or cap system is proposed to reduce risk or contaminant migration, details regarding the design, construction, and maintenance of these remedies must be submitted in the RAWP. The amount of information and supporting calculations that will be required to support the design of a cap or cover system will vary depending on the function of the system. For example, a simple soil cover that is intended to provide a 2-foot layer of clean soil between receptors and contaminated soil will require much less information than a cover system that will also function as a roadway, or a cap system that is intended to prevent surface water infiltration. The amount of information and design calculations required to support a proposed cap or cover are discussed in the subsequent sections.

After the cover or cap system has been installed, the construction process must be documented in a Remedial Action Completion Report (RACR). As discussed above, the amount of detail to be provided will depend on the complexity of the remedy, but in all cases, adequate information must be submitted to document that the material and installation requirements set forth in the design have been met. Documentation to be provided in the RACR should include as-built drawings that document the horizontal extent of the cover or cap, reports of all construction testing and inspection performed, and a description of any design variance or field modification that occurred.

Cap and cover systems are considered to be engineering controls for purposes of meeting a VRP remediation standard and are divided into 2 broad classes:

1. Direct Contact Cover System
   A systematic layering of material(s) that is specifically intended to prevent direct contact exposure to contaminated media that exceed a VRP remediation standard. Covers are commonly composed of soil, gravel, asphalt, concrete, or other similar materials that are suitable to act as a barrier to contact.

2. Low Permeability Cap System
   A systematic layering of materials that is specifically designed to prevent surface water infiltration into contaminated media that may result in leaching and migration of contaminants into an area that has not been previously impacted, or to prevent greater impact to media previously contaminated. Caps will always include a hydraulic barrier layer (natural or synthetic) that is specially designed to prevent water infiltration. Caps will sometimes also serve to prevent direct exposure to contaminated media, but not necessarily.

In general, contaminated media at VRP sites do not meet the definition of a solid or hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA), and, therefore, caps installed at VRP sites are not required to meet the prescriptive requirements of these regulatory programs. However, at VRP sites where another regulatory program has precedent, such as RCRA or the Toxic Substances Control Act (TSCA), the cap system design will be dictated by the requirements of that regulatory program. In these cases, cap systems designed and installed to meet those requirements are deemed to be acceptable to the VRP.

F.2 DIRECT CONTACT COVER SYSTEMS

A cover system must be designed, constructed, and maintained to prevent direct contact exposure to contaminated media for as long as the media remain contaminated above the applicable remediation standard (De Minimis, Uniform, or Site-Specific). Cover system designs should address site-specific factors, including, but not limited to:

- Current and potential future land use
- Surrounding land use and cover location (e.g., sites in or near unrestricted-use residential areas will require a more secure cover)
- Nature of the contaminants (concentration, volatility, toxicity, etc.)
- Quality, durability, and reliability of the cover system materials and construction

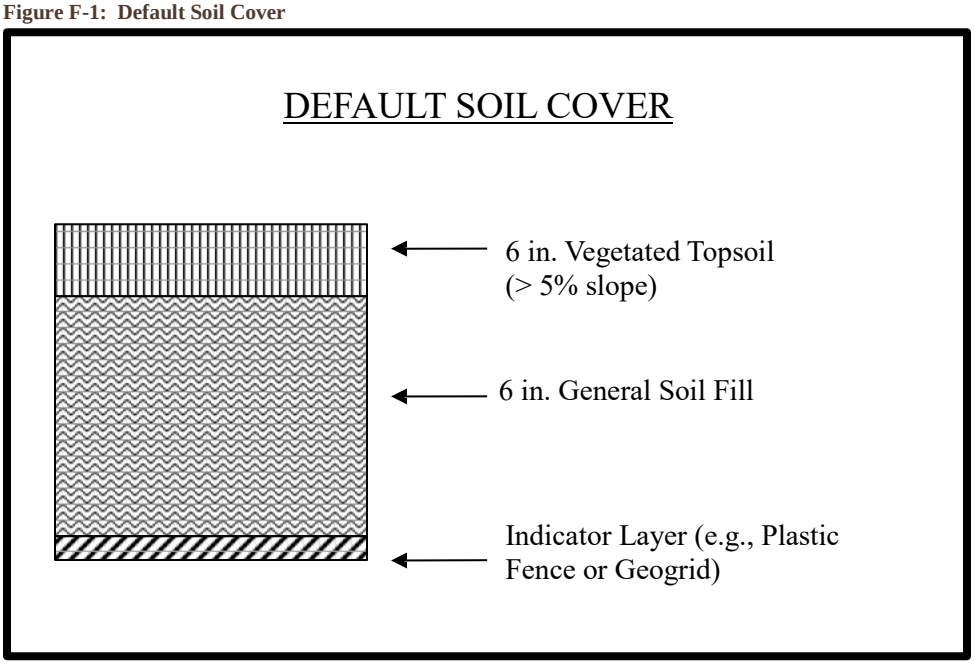
In all cases, where excavation of the soil underlying a cover system is prohibited or regulated, an indicator layer must be installed to notify persons that excavation below the indicator layer is controlled. The horizontal extent of a direct contact cover system must in all cases extend a minimum of 2 feet beyond the extent of the impacted media being protected from infiltration.

F.2.1 Soil Covers

A soil cover is typically the least expensive and simplest method of preventing direct contact exposure to underlying contaminated media. At a minimum, a 1-foot thickness of clean soil must be used to prevent direct contact. Soil covers must also be vegetated and maintained to prevent growth of deep-rooted vegetation, erosion, and deterioration over time. Therefore, the upper 6 inches of material must consist of soil that is capable of supporting vegetation, and an appropriate seeding mixture must be provided to establish a healthy stand of grass. The lower layer should not be over-compacted such that the water-retaining capability of the subsoil is significantly reduced.

The slope of a soil cover must not be steeper than 2:1 (H:V), but preferably no steeper than 3:1 to minimize the potential for slope instability. Soil covers placed on relatively steep slopes must be designed with adequate erosion control measures to prevent damage to the cover. This may include erosion control mats (jute, straw, coconut fiber, etc.) or may require rigid armor products (e.g., Armor Flex) on long or particularly steep slopes with a high potential for damage from run-off. Conversely, soil covers must be graded to be free-draining and prevent ponding. Therefore, a minimum slope of 5% should be maintained for vegetated soil surfaces. Figure F-1 depicts a default soil cover that meets the minimum performance standards.

Figure F-1: Default Soil Cover



The LRS must ensure that all material used in cover and cap systems does not contain contaminants from the site or an off-site source. Borrow material should always be obtained from undeveloped areas that have not been previously used for commercial, agricultural, or industrial purposes. If it is necessary to use material from an area that may contain contamination, the materials must be tested for potential contaminants prior to being used. Analytical parameters will depend on the soil source and previous use, but will likely include VOCs, SVOCs, and RCRA 8 metals, at a minimum. The LRS must consult with

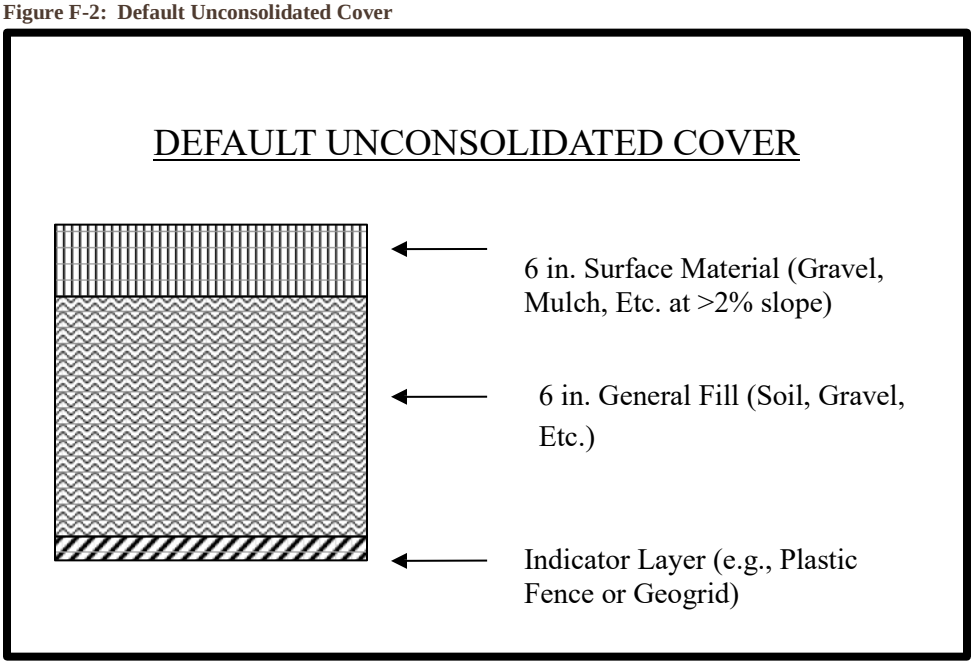
the OER Project Manager to determine the number of samples and analytical parameters necessary to properly evaluate potentially impacted materials, and this information must be included in the RAWP. All materials used for covers must meet De Minimis Standards appropriate for the site use or natural background levels.

F.2.2 Other Unconsolidated Covers

As an alternative to using soil to prevent direct contact with contaminated media, other materials may be used to partially or completely replace the soil. For example, a layer of aggregate (crushed stone or gravel) may be specified as the surface layer where limited vehicle traffic is anticipated to occur on the cover. Another possible scenario might be the use of rubber chips, wood chips, bark chips, or other organic mulch in situations where the final use includes landscaping, such as in a park or commercial development. Where alternate surface materials are proposed, vegetation is not required. However, a plan for inspection and maintenance will be required to ensure that the surface materials are not damaged by pedestrian or vehicular traffic or erosion. In each case, it is the responsibility of the LRS to demonstrate that the proposed cover material will prevent direct contact with the underlying contaminants and will continue to function effectively in the post-remediation scenario.

Where materials of differing particle sizes are proposed to be placed in layers, an appropriately designed separation layer (e.g., geotextile fabric) must be installed to prevent materials of differing particle size from mixing or disintegrating into each other. In all cases where unconsolidated materials are proposed to prevent direct contact exposure, the thickness of the material must be adequate to reliably prevent exposure and to minimize long-term maintenance. If a thinner direct contact exposure cover is necessary or desired, the LRS must propose another material type (e.g., pavement cover). Covers comprised of unconsolidated materials must be graded to be free-draining. A minimum slope of 2% should be maintained for gravel surfaces. Minimum slope for other surfaces should be designed on a case-by-case basis. Figure F-2 depicts an alternate unconsolidated cover that meets the minimum performance standards.

Figure F-2: Default Unconsolidated Cover



F.2.3 Pavement Covers

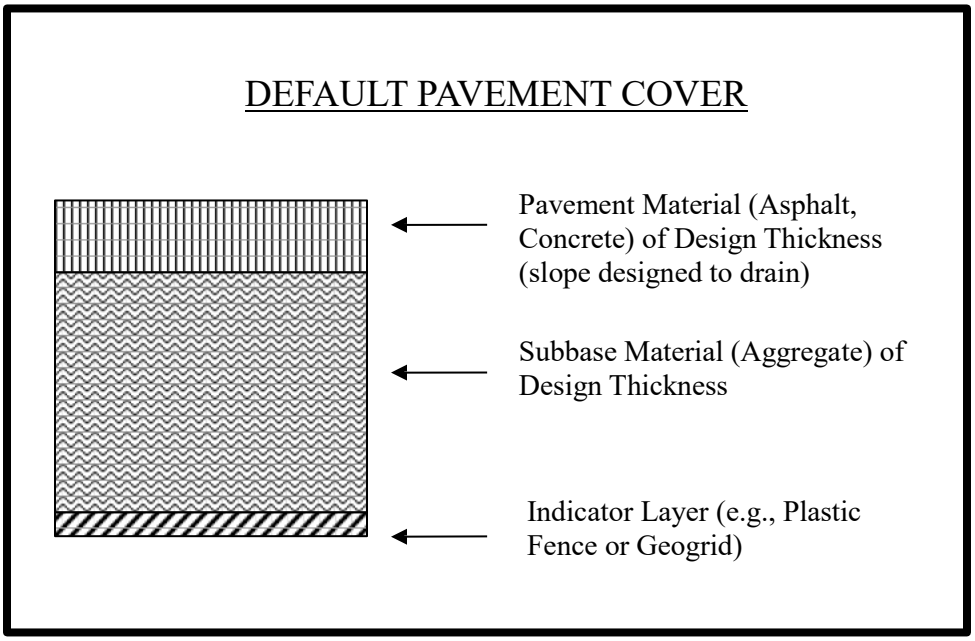
Pavement cover systems (concrete and asphalt) can prevent direct contact exposure to contaminated media while also providing site-related infrastructure, and, therefore, can often be an efficient remedy in commercial/industrial or recreational settings. However, damaged pavement systems can allow contaminated media to become exposed at the surface through settlement, cracking, freeze/thaw cycles, weathering, and other types of deterioration, unless these factors are adequately addressed through design, construction, and maintenance.

Pavement covers must be constructed over an appropriately prepared granular base course (generally compacted aggregate) to minimize freeze/thaw and provide the necessary support for the anticipated loads. Designs that minimize long-term maintenance should be used whenever possible. Pavement covers must be designed and constructed to ensure positive draining away from the cover and eliminate ponding. In all cases, the intended use of the covered area must be accounted for in the design. For example, traffic volume and vehicle loads must be considered, and the pavement design must meet commonly accepted requirements (e.g., WVDOT-DOH specification). These designs must be performed under the supervision of a Professional Engineer licensed in WV and must bear their professional seal.

Existing pavement covers in good condition which overlie contaminated media can be used in this application at sites where the impacted area is relatively small and exposure risks are relatively low, if information regarding the design and construction of the pavement system is provided in the RAWP. In all cases, an adequate inspection, maintenance, and repair program must be proposed and implemented to ensure that the pavement system continues to function as originally designed.

Granular layers (aggregates) used in pavement subbase systems must be separated from the underlying contaminated media with a geotextile layer to prevent migration of contaminated soil or water into the subbase. The geotextile must be designed to withstand anticipated loads and maintain its effectiveness over a long period of time to minimize the need for maintenance. Consideration should also be given in the design of granular subbase material potentially acting as a preferential flow path for infiltrating surface water or groundwater. In general, the use of a well-graded aggregate (i.e., "crusher run") is adequate to prevent infiltration and migration of surface water. Figure F-3 depicts a default pavement cover that meets the minimum performance standards.

Figure F-3: Default Pavement Cover



F.2.4 Buildings and Structures

An existing or new building or other concrete structure (e.g., pad, slab, sidewalk, etc.) may be used to prevent direct contact exposure to contaminated soils, provided the building slab or basement floor is adequate to meet the remediation standard and all structural design requirements. Additionally, roof runoff must be managed to minimize infiltration into contaminated soils.

Buildings and structures are typically used in concert with other cover systems such as pavement or soil to prevent exposure in commercial and industrial settings. Existing buildings with cracked slabs or basement floors, or walls in contact with contaminated soil, will generally not be acceptable covers unless the cracks can be reliably repaired and maintained. Buildings located on soils that are subject to settlement that could cause cracking in slab, floors, or walls do not meet the criteria for longevity and low-maintenance and are also unacceptable. If vapor migration may result in exposures above a remediation standard, this exposure must be addressed separately from the cover design through the use of a vapor barrier or sub-slab ventilation system.

F.2.5 Rail Trails

Rail trails are typically a special type of direct contact cover system. Rail trail covers are typically comprised of unconsolidated or pavement covers, but, in all cases, must be designed and constructed to withstand the permitted recreational use. For example, if a rail trail allows use by bicycles or horses, these surfaces must be more resilient than the surface installed at a rail trail that permits only foot traffic. In the latter case, a vegetated soil cover may be acceptable, whereas, in the former case, a gravel or pavement surface may be required along the trail alignment where traffic occurs. Rail trails that allow regular vehicles traffic (beyond inspection/maintenance by the trail manager) may require a pavement cover to prevent frequent maintenance.

Rail trail covers may include a combination of covers, because railroad corridors are often contaminated along the adjacent slopes and drainage features, as well as along the former railbed. For example, the high-traffic alignment along the former railbed may receive a more resistant cover while adjacent portions of the corridor would be covered by soil and vegetation.

F.3 LOW PERMEABILITY CAP SYSTEMS

Low permeability cover systems are required when the RAWP proposes to leave the source of groundwater contamination in place. The WV Groundwater Protection Act (W. Va. Code § 22-12, et seq.) requires that every reasonable effort be made to remove or mitigate the source of contamination that causes an exceedance of a groundwater standard. Therefore, to meet the requirements of the WV Groundwater Protection Act, it is necessary to install a low permeability cap system to mitigate the source by minimizing infiltration through the source. For purposes of the VRP, contaminated soils that are the result of typical site operations are not considered to be a source as defined by the WV Groundwater Protection Act. However, production/operation waste materials, such as spent foundry sand, wood treatment sludges, and other wastes that would typically be transported off-site for treatment or disposal are considered a source for purposes of the WV Groundwater Protection Act.

The design of a low permeability cap system must minimize the infiltration of surface water, precipitation, or snow melt through contaminated media to the maximum extent practicable. Therefore, a cap system must include a hydraulic barrier layer or multiple layers that reduce such infiltration. The design of these types of cover systems should address site-specific factors, including, but not limited to:

- Nature of contaminants (concentrations, solubility, mobility, toxicity, etc.).
- Depth of contamination. The deeper the contamination is, the less effective a hydraulic barrier may be, or the horizontal extent of the barrier may need to be expanded.
- Quality, durability, and reliability of the cover system materials and construction.

A cover system that meets the requirements for prevention of infiltration will likely be acceptable for prevention of direct contact. It should be evaluated under the guidelines in this guidance for the pathways being addressed.

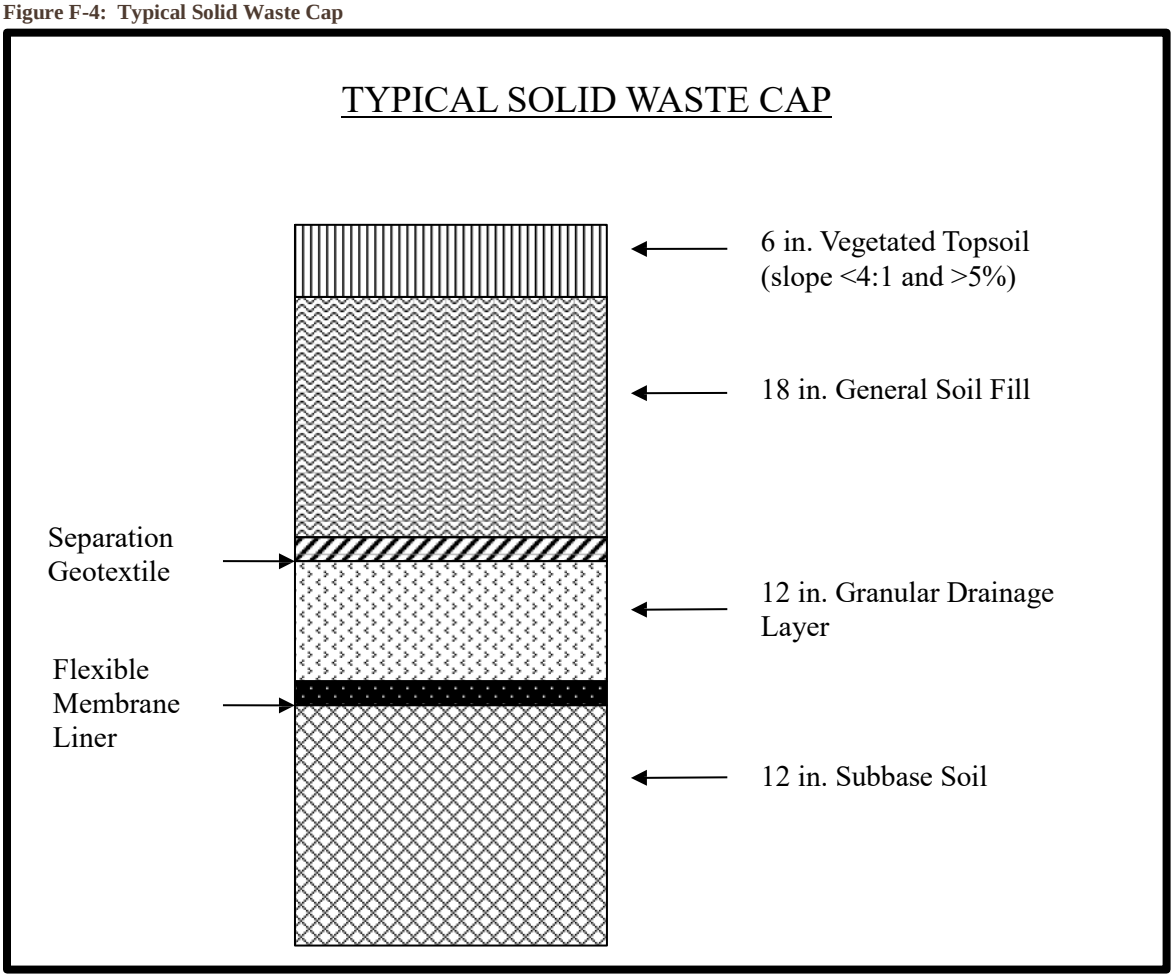
The slope of low-permeability cap systems must not be steeper than 4:1 (H:V) to minimize the potential for slope instability. Vegetative layers on relatively steep slopes must be designed with adequate erosion control measures to prevent damage to the cap. This may include erosion control mats (e.g., jute, straw, coconut fiber, etc.) or may require grid armor products (e.g., Armor Flex) on long or particularly steep slopes with a high potential for damage from run-off. Conversely, caps must be graded to be free-draining and prevent ponding. Therefore, a minimum slope of 5% should be maintained for vegetated caps.

The horizontal extent of a low permeability cap system must in all cases extended to a minimum of 5 feet beyond the extent of the impacted media being protected from infiltration. However, the LRS must consider the waste configuration, surface water patterns, and potential for infiltration along the waste margins when designing the horizontal extent of the cover. If may be necessary in some situations to extend the low permeability cap beyond the minimum 5-foot distance.

F.3.1 WV Solid Waste Cap

Generally, any cap which meets the regulatory standards for solid waste landfill covers outlined in the WV Solid Waste Management Rule (33SR1) is an acceptable design for use as a low permeability cap system at VRP and UECA-LUST Program sites. The gas collection layer required in solid waste cap systems would not typically be required at a VRP or UECA-LUST Program site unless putrescent materials are present, or this layer is to be used as a vapor collection system in situations where volatiles are present and vapor infiltration is a potential migration pathway to be addressed. Figure F-4 depicts a typical solid waste cap that meets the minimum performance standards.

Figure F-4: Typical Solid Waste Cap



F.3.2 Alternate Cap Designs

Where using the default solid waste cap system described in the WV Solid Waste Management Rule is impossible or impractical to implement, the LRS may propose an alternative design. Any alternative design must be completed and certified by a Professional Engineer licensed to practice in WV and must demonstrate that the cap system is adequate to limit surface water infiltration into in the contaminated media. Common alternative cap systems include the use of geosynthetic composite liners (GLC) as a hydraulic barrier and the use of geocomposite in lieu of a granular drainage layer. However, a significant research and development has occurred in the United States with regard to alternative cap systems since RCRA Subtitle D was implemented, and OER encourages the LRS to explore and propose other alternative cap systems. The LRS should provide a hydrologic balance model (HELP or equivalent) to demonstrate equivalent performance of the proposed cap system.

F.4 SPECIALIZED PAVEMENT DESIGNS

Specialized asphalt pavement mixes exist that have been shown to minimize infiltration to a much greater extent than standard pavement materials and may be considered as a significant infiltration prevention

cover system by themselves with the appropriate thickness of base material. If a specialized asphalt layer is selected as a hydraulic barrier, specialty designers and contractors may be needed in order to ensure that proper materials and construction techniques are utilized.

F.5 VOLATILE ORGANIC COMPOUND MIGRATION

The potential for vapor migration needs to be evaluated when VOCs are present at concentrations that result in exposures above the remediation standard. Covers and caps are not intended to address potential vapor impacts, which should be addressed using a vapor barrier or venting system. However, it is possible to incorporate these systems into a cover or cap system by providing active or passive venting below and/or adjacent to a cover to remove soil vapors and prevent vapor migration into or around a cover/cap system. Vapor control systems are beyond the scope of this guidance and will be reviewed and addressed on a case-by-case basis.

F.6 DESIGN AND CONSTRUCTION

F.6.1 Vegetation

Vegetated soil covers should maintain a uniform grass layer, with no bare spots or erosion. Deep rooted vegetation (i.e., trees, shrubs, etc.) that could tap into the underlying contaminants and bring them in the vegetation itself should be avoided at sites with high levels of metals to prevent the creation of a new potential exposure pathway. The default seed mixtures in Table F-1 and Table F-2 are acceptable for use in establishing vegetation; however, OER also encourages the use of native species as alternative seed mixtures on caps and covers to prevent the spread of noxious weeds. The LRS is encouraged to consult with the local Department of Agriculture Extension Service Agent to determine appropriate alternative seed mixtures.

Table F-1: Default Seed Mixture 1 (Southern States Meadow & Pasture Mix, or equivalent)

Vegetative Species	Rate/Acre
Orchard Grass	108 lbs.
Red Clover	45 lbs.
Climax Timothy	27 lbs.
Boost PRG	18 lbs.
Kentucky Bluegrass 85/80	18 lbs.
Ladino Clover	9 lbs.

Table F-2: Default Seed Mixture 2

Vegetative Species	Rate/Acre
Wheat or Rye	50 lbs.
Birdsfoot Trefoil	15 lbs.
KY 31 Fescue	15 lbs.
Orchard Grass	15 lbs.
Foxtail Millet	12 lbs.
Red Clover	10 lbs.
Redtop	3 lbs.
Weeping Lovegrass	2 lbs.

Soil amendments such as lime and fertilizer should be applied as appropriate for the cover soil, based on the results of laboratory or field tests.

F.6.2 Placement and Compaction

All fill materials must be placed in a manner that prevents damage to underlying layers due to material placement and loads from construction and equipment. The LRS must develop construction specifications to ensure that contractors place and compact all cover layers appropriately, based on the nature of the materials and their intended uses. Materials must be compacted (or placed loosely, in the case of vegetative layers) such that settlement is minimized and that the materials provide support as appropriate to the post-cover land use. Compaction specifications for pavement systems must be based on commonly accepted standards (e.g., WVDOT-DOH, AASHTO, etc.) and be developed by a Professional Engineer licensed to practice in WV.

F.6.3 Construction Documentation

Plans and designs for all cover/cap systems must be submitted as part of the RAWP. During the course of construction, the LRS must inspect the construction process and materials at a frequency that is adequate to ensure that the system is built as designed, and must submit documentation of the construction, including as-built drawings, photographs, test results, etc. in the RACR. If design changes are determined to be necessary during the course of construction (e.g., due to unanticipated field conditions), any variance from the design must be documented in writing and approved by OER.

F.6.4 Permits

Prior to construction, the LRS or the Applicant must ensure that all applicable permits for construction have been obtained. In most cases, storm water protection and erosion and sediment control plans will be required for all earth disturbance. The scope of required permits is beyond the scope of this guidance and must be determined by the LRS on a case-by-case basis in accordance with the applicable regulations.

F.7 INSPECTION AND MAINTENANCE

Caps and covers, like other engineering controls, require regular inspection, as well as occasional maintenance and repairs. The following sections describe performance standards for the inspection and maintenance of covers and caps.

F.7.1 Inspections

Any VRP or UECA-LUST Program site where an institutional or engineering control is required to achieve the remediation standard will require that these controls are documented in a Land Use Covenant (LUC). All LUCs executed under the authority of the VRP or UECA-LUST Program must include a provision requiring that the property owner conduct inspections at least once per year and submit an inspection form to WVDEP headquarters within 30 days of each inspection. In cases where a cover or cap is installed, the RAWP may also provide for additional inspections beyond the default annual frequency if that is appropriate to ensure that the remedy remains effective.

Inspections should take place a time of year when damage to the cover is easily detected. For example, inspections should not be conducted when snow is present or when grass/vegetation may obscure evidence of erosion or other damage. Similarly, inspections of pavement covers should not be conducted during a significant rain event when standing water may prevent an accurate and complete evaluation of pavement quality. However, the presence of ponded water following a rain event may indicate settlement of the underlying materials and the need for repair. Vegetated covers must be inspected for adequacy of growth, and portions of the cover where poor growth is present must be documented and addressed as part of the maintenance plan.

F.7.2 Maintenance

Cover and cap systems will require maintenance at different frequencies, depending on the final cover layer and the post-remediation use.

Vegetated systems will typically require mowing on a regular basis to prevent the introduction of deep-rooted woody vegetation and to maintain the health of the grass/turf. Generally, grass-covered covers must be mowed a minimum of two times per year. Portions of the cover where poor vegetative growth is present must be reseeded. If the type of vegetation is determined to be ineffective, a different seed mix may be specified, or soil amendments may be necessary. All woody vegetation (e.g., trees and shrubs) must be removed from the cover. Animal damage should also be repaired, and animals causing the damage should be controlled. Surface erosion should be refilled, regraded, and reseeded as necessary.

Systems consisting of alternate unconsolidated materials like organic mulch may require the addition of fresh material as the original material breaks down. Pavement systems will require sealing, patching, and/or replacement due to vehicle wear.

It is the responsibility of the LRS to design a maintenance regimen that is based on the materials used in the cover or cap system and post-remediation use. Details of the maintenance regimen and a provision for regular reporting must be included in the RAWP.

F.7.3 Repairs

Where an inspection indicates that a failure of the system has occurred or is imminent, the system must be repaired immediately to prevent a violation of the provisions of the LUC and possible revocation of the Certificate of Completion or No Further Action status. As with regular inspection and maintenance,

provisions for repair of the remedy must be designed by the LRS and included in the RAWP. Repairs may include filling and revegetation of areas where soil erosion has occurred, filling of potholes developed in gravel covers, replacement of geotextile layers, replacement of asphalt or concrete pavement, or other similar measures. In cases where it becomes apparent that the cover/cap system fails frequently or prematurely, it will be necessary to reopen the VRP or UECA-LUST Program Agreement and design an alternate or additional remedy that is adequate to maintain the required level of protection. It is the responsibility of the LRS to design a system that functions with minimal maintenance and repair.

As noted previously, storm water permits for construction should be obtained where required, based on the applicable regulations. Significant repairs to cover/cap systems that include the excavation or placement of soil may require that a permit be in place prior to beginning disturbance.

The property owner should notify WVDEP if cover damage is significant enough to potentially expose contaminated media. Post-repair sampling and analysis may be required in situations where cover damage is significant enough to potentially expose contaminated media. The need for sampling must be evaluated by the LRS and their recommendation reviewed by OER on a case-by-case basis.

F.7.4 Documentation and Reporting

The RAWP must include provisions for documenting and reporting inspections, maintenance, and repair of cover/cap systems on a regular basis. It is preferred that this be incorporated into the annual LUC inspection schedule, but, in cases where the type of cover/cap system or post-remediation use indicate otherwise, an alternate schedule must be provided in the RAWP.

APPENDIX G

Appendix G: Rail Trail Guidance

G.1 OVERVIEW OF RAIL TRAILS IN VRP

Due to significant interest from communities across the state, WVDEP has established this Rail Trail Guidance to expedite the development of rail trails via the VRP.

Decommissioned railways frequently have contamination from historic activities, such as the use of coal, diesel fuel, and herbicides. The most common contaminants are arsenic, lead, and various polycyclic aromatic hydrocarbons (PAHs). The remedies for these contaminants in a rail trail recreational setting are generally to cover the railbed where people will be recreating and to restrict the use of the property with a Land Use Covenant (LUC). Since the majority of decommissioned railways will have only these contaminants and the remedies are already known, WVDEP has developed this guidance to expedite the VRP process for properties meeting the criteria of standard rail trail sites.

G.2 QUALIFICATIONS FOR EXPEDITED VRP PROCESS

The expedited rail trail process is available to any VRP rail trail site if site assessments reveal that historic use of the site was as a railway—with no other industrial purposes, and the site only has the common rail trail contaminants of concern: arsenic, lead, and PAHs. However, a rail trail site must follow the traditional VRP process if any of the following conditions apply:

1. A Phase I ESA revealed historic industrial activities other than as a railbed.
2. Only a Phase I ESA was completed, and any other contaminants of potential concern (COPCs) besides arsenic, lead, and PAHs are identified, such as:
    - Chlorinated solvents due to maintenance activities
    - PCBs due to the presence of transformers
    - VOCs due to storage of petroleum products in underground storage tanks
    - Other contaminants caused by non-traditional railroad activity
3. Site assessment confirmed detections of any COPC other than arsenic, lead, and PAHs above the Residential, Soil, or Groundwater De Minimis Standards.

G.3 EXPEDITED VRP PROCESS FOR QUALIFYING RAIL TRAILS

Like all VRP sites, expedited rail trail sites must obtain the services of an LRS and follow the VRP process as outlined below and detailed in the Rule:

1. Pre-Application Site Assessment
2. VRP Application

3. Public Notification and Involvement
4. Voluntary Remediation Agreement (VRA)
5. Site Assessment Work Plan (SAWP) and Quality Assurance Project Plan (QAPP)
6. Site Assessment Report (SAR)
7. Risk Assessment
    a. Human Health
    b. Ecological
8. Remedial Action Work Plan (RAWP)
9. Remedy Implementation
10. Remedial Action Completion Report (*including LUCs, as needed*)
11. Final Report/Request for Certificate of Completion
12. Certificate of Completion

However, the Risk Assessment and RAWP may be expedited for qualifying rail trail properties by following the steps outlined below. By combining a simple De Minimis Risk Assessment with the RAWP, an Applicant can save time and money.

G.3.1 Expedited Rail Trail Risk Assessment

Any qualifying rail trail site should generally use the De Minimis Standards for the risk assessment process. Uniform Standards and Site-Specific Standards both require extensive site-specific information and more time-consuming (i.e., more expensive) risk assessment methods to calculate. However, rail trail sites may use either the Uniform Standard or Site-Specific Standard as they choose. The De Minimis Standards process generally compares on-site concentrations of COPCs to the De Minimis Standards in Table 60-3B of the Rule, which triggers the implementation of a remedy to sever any potentially complete pathways that present excessive risk.

The expedited rail trail risk assessment process includes the following steps:

1. Compare the maximum or upper 95% Upper Confidence Level (UCL) concentrations of COPCs in soils at the site to the Residential De Minimis Standards in Table 60-3B of the Rule (or the appropriate natural background concentrations) and either the default Migration to Groundwater screening levels, calculated screening levels, or measured screening levels developed using SPLP or TCLP methods as described in Appendix C.

    a. Any soil COPC with a maximum or 95% UCL concentration above the Residential De Minimis Standard, or appropriate natural background concentration, will be listed as a COC for soil.

    b. Any soil COPC with a maximum or 95% UCL concentration above the default, calculated, or measured Migration to Groundwater De Minimis screening level will be listed as a COC for groundwater and require groundwater sampling if none has been done previously. If groundwater samples have been collected, the COCs for groundwater will

be determined by comparing the maximum groundwater sample concentrations to the Groundwater De Minimis Standards, or the appropriate natural background concentrations, instead.

2. Conduct a De Minimis Ecological Screening Evaluation of the potential exposure pathways for ecological receptors. At a minimum, complete the ecological portion of the *Checklist to Determine Applicable Remediation Standards* provided in the *VRP Guidance Manual*, which includes a 5-step process:

   STEP 1: Determine whether a De Minims Ecological Screening Evaluation is appropriate for the site.

   STEP 2: Identify any readily apparent harm or exceedances of water quality standards.

   STEP 3: Identify contamination associated with ecological habitats.

   STEP 4: Characterize the potential ecological habitat.

   STEP 5: Identify any potential ecological receptors of concern.

   If the *Checklist to Determine Applicable Remediation Standards* reveals a potentially complete pathway presenting excessive risk for any ecological receptor, then conduct an Ecological Risk Assessment. The expedited rail trail risk assessment process can only proceed if the Ecological Risk Assessment determines acceptable risks to the ecological receptors.

Additional considerations regarding the expedited rail trail risk assessment include:

- The traditional VRP process must be followed if COPCs other than arsenic, lead, or PAH are detected in soil: (a) above the Residential De Minimis Standards for Soil (or natural background concentration); (b) above the default, calculated, or measured Migration to Groundwater screening level; or (c) if there is a potentially unacceptable risk to any ecological receptor.
- The expedited rail trail risk assessment process circumvents the need to calculate Uniform Standards or Site-Specific Standards, which should save a considerable amount of time and money. However, the Applicant always has the right to conduct either the Uniform Standards or Site-Specific Standards calculations, as necessary.
- If there are no COPCs that exceed any of their relevant De Minimis Standards, and there is no apparent risk to ecological receptors, then no further site assessment or remediation needs to occur.
- The De Minimis Standards may not be applied to any contaminant at a site where the contaminant is impacting surface water.

G.3.2 Expedited Rail Trail Remedial Action Work Plan

Sites that qualify for the expedited rail trail risk assessment will also qualify to expedite the Remedial Action Work Plan. Since the actions used to remediate the risks associated with rail trail sites are already well established, the Applicant can expedite the remedial process by combining the Expedited Rail Trail Risk Assessment and RAWP into one document. The RAWP should be included in the Expedited Rail trail Risk Assessment as an appendix. Note that combining these documents is not normally accepted by WVDEP for VRP sites using engineering controls, such as a cover or cap; however, WVDEP will allow this combination in the specific case of qualifying rail trails that use a pre-approved rail trail cover system (see the VRP *Cover and Cap Guidance*) due to the known contaminants, effectiveness of the remedy, and exposures.

The standard remedies necessary to address the risks associated with the site and thereby included in the RAWP are:

- Preventing contact with contaminated soils by using of one of the appropriate covers specified in the VRP *Cover and Cap Guidance* and approved by the OER Project Manager.
- Placing one or more of the following activity and use limitations (AULs) on the site by filing a Land Use Covenant:
    - Residential use of the property (specifying only trail or similar recreational activities allowed)
    - Use of groundwater on the site
    - Excavation, drilling, or penetration of the soils without meeting specific requirements
    - Any activity that may interfere with the groundwater monitoring well network, if applicable

Attachments

Attachment 1: Default Migration to Groundwater Screening Levels

Attachment 2: Checklist to Determine Applicable Remediation Standards

Attachment 3: VRP Decision Trees

Attachment 4: Figures and Tables Formatting Guidance

Attachment 5: Risk Assessment Report Format Guidance

Attachment 6: Site Assessment Work Plan (SAWP) Checklist

Attachment 7: Quality Assurance Project Plan (QAPP) Checklist

Attachment 8: Data Validation Report Checklist

Attachment 9: UECA-LUST Process Checklist

ATTACHMENT 1

Attachment 1: Default Migration to Groundwater Screening Levels

WVDEP has developed the default Migration to Groundwater screening levels to determine if groundwater assessment is necessary. Soil contaminant concentrations can be screened against these default values to determine if the contaminants may have leached into groundwater and created a contamination plume. These default values are naturally conservative. Therefore, Applicants are encouraged to either calculate site-specific Migration to Groundwater screening levels (see Appendix C for more details) or measure the leaching capability of the contaminants in site soils using the Synthetic Precipitation Leaching Procedure (SPLP).

ATTACHMENT 1

Contaminant	CAS No.	Migration to Groundwater[1] (mg/kg)
Acetaldehyde	75-07-0	5.2E-04
Acetochlor	34256-82-1	2.8E-01
Acetone	67-64-1	2.9E+00
Acetonitrile	75-05-8	2.6E-02
Acetophenone	98-86-2	5.8E-01
Acrolein	107-02-8	8.4E-06
Acrylamide	79-06-1	1.1E-05
Acrylonitrile	107-13-1	1.1E-05
Alachlor	15972-60-8	1.6E-03
Alar	1596-84-5	9.5E-04
Aldicarb	116-06-3	7.5E-04
Aldicarb sulfone	1646-88-4	4.4E-04
Aldrin	309-00-2	1.5E-04
Aluminum	7429-90-5	3.0E+04
Aniline	62-53-3	4.6E-03
Antimony and compounds	7440-36-0	3.5E-01
Arsenic	7440-38-2	2.9E-01
Assure	76578-14-8	1.9E+00
Atrazine	1912-24-9	2.0E-03
Azobenzene	103-33-3	9.3E-04
Barium and compounds	7440-39-3	8.2E+01
Baygon	114-26-1	2.5E-02
Baythroid	68359-37-5	3.1E+01
Bentazon	25057-89-0	1.2E-01
Benzaldehyde	100-52-7	4.1E-03
Benzene	71-43-2	2.6E-03
Benzidine	92-87-5	2.8E-07
Benzoic acid	65-85-0	1.5E+01
Benzyl alcohol	100-51-6	4.8E-01
Benzyl chloride	100-44-7	9.8E-05
Beryllium and compounds	7440-41-7	3.2E+00
1,1'-Biphenyl	92-52-4	8.7E-03
Bis(2-chloroethyl)ether	111-44-4	3.6E-06
Bis(2-chloroisopropyl)ether	108-60-1	1.3E-04
Bis(chloromethyl)ether	542-88-1	1.7E-08
Bis(2-ethylhexyl)phthalate (DEHP)	117-81-7	1.4E+00
Bromodichloromethane	75-27-4	3.6E-05
Bromoform (tribromomethane)	75-25-2	8.7E-04
Bromomethane	74-83-9	1.9E-03
Bromophos	2104-96-3	7.7E-02
1,3-Butadiene	106-99-0	9.9E-06
1-Butanol	71-36-3	1.1E-01
Butylate	2008-41-5	2.0E-01
n-Butylbenzene	104-51-8	3.2E+00

Contaminant	CAS No.	Migration to Groundwater[1] (mg/kg)
Butyl benzyl phthalate	85-68-7	2.4E-01
Cadmium and compounds	7440-43-9	3.8E-01
Caprolactam	105-60-2	2.5E+00
Carbaryl	63-25-2	1.7E+00
Carbon disulfide	75-15-0	2.4E-01
Carbon tetrachloride	56-23-5	1.9E-03
Carbosulfan	55285-14-8	1.2E+00
Chloranil	118-75-2	1.5E-04
Chlordane (Technical)	12789-03-6	2.7E-01
Chloroacetic acid	79-11-8	8.1E-03
4-Chloroaniline	106-47-8	1.6E-04
Chlorobenzene	108-90-7	6.8E-02
Chlorobenzilate	510-15-6	1.0E-03
p-Chlorobenzoic acid	74-11-3	1.3E-01
2-Chloro-1,3-butadiene	126-99-8	9.8E-06
1-Chlorobutane	109-69-3	8.1E-02
Chloroethane	75-00-3	5.9E+00
Chloroform	67-66-3	6.1E-05
Chloromethane	74-87-3	4.9E-02
4-Chloro-2-methylaniline	95-69-2	4.0E-04
beta-Chloronaphthalene	91-58-7	1.7E+00
o-Chloronitrobenzene	88-73-3	2.2E-04
p-Chloronitrobenzene	100-00-5	1.1E-03
2-Chlorophenol	95-57-8	2.6E-02
o-Chlorotoluene	95-49-8	8.8E-02
Chlorpyrifos-methyl	5598-13-0	5.4E-01
Chromium III	16065-83-1	4.0E+07
Chromium VI	18540-29-9	6.7E-04
Cobalt	7440-48-4	2.7E-01
Copper and compounds	7440-50-8	2.8E+01
Crotonaldehyde	123-73-9	1.7E-06
Cyanazine	21725-46-2	4.1E-05
Cyanide and compounds	74-90-8	2.0E+00
Cyanogen	460-19-5	
Cyanogen bromide	506-68-3	
Cyclohexane	110-82-7	1.3E+01
Cyclohexanone	108-94-1	3.4E-01
Cyhalothrin/Karate	68085-85-8	1.4E+01
Cypermethrin	52315-07-8	6.4E+01
Dacthal	1861-32-1	1.5E-01
Dalapon	75-99-0	4.1E-02
DDD	72-54-8	7.5E-03
DDE	72-55-9	1.1E-02
DDT	50-29-3	7.7E-02

Contaminant	CAS No.	Migration to Groundwater[1] (mg/kg)
Diazinon	333-41-5	6.5E-02
Dibenzofuran	132-64-9	1.5E-01
1,4-Dibromobenzene	106-37-6	4.5E-02
Dibromochloromethane	124-48-1	2.3E-04
1,2-Dibromo-3-chloropropane	96-12-8	8.7E-05
1,2-Dibromoethane	106-93-4	1.4E-05
Dibutyl phthalate	84-74-2	2.3E+00
Dicamba	1918-00-9	1.5E-01
1,2-Dichlorobenzene	95-50-1	5.8E-01
1,4-Dichlorobenzene	106-46-7	7.2E-02
3,3'-Dichlorobenzidine	91-94-1	8.5E-04
1,4-Dichloro-2-butene	764-41-0	6.6E-07
Dichlorodifluoromethane	75-71-8	3.0E-01
1,1-Dichloroethane	75-34-3	7.8E-04
1,2-Dichloroethane	107-06-2	1.4E-03
1,1-Dichloroethylene	75-35-4	2.5E-03
1,2-Dichloroethylene (cis)	156-59-2	2.1E-02
1,2-Dichloroethylene (trans)	156-60-5	3.1E-02
2,4-Dichlorophenol	120-83-2	2.3E-02
4-(2,4-Dichlorophenoxy)butyric Acid (2,4-DB)	94-82-6	4.2E-01
2,4-Dichlorophenoxyacetic Acid (2,4-D)	94-75-7	1.8E-02
1,2-Dichloropropane	78-87-5	1.7E-03
1,3-Dichloropropene	542-75-6	1.7E-04
2,3-Dichloropropanol	616-23-9	1.3E-02
Dichlorvos	62-73-7	8.1E-05
Dicyclopentadiene	77-73-6	2.2E-03
Dieldrin	60-57-1	2.9E-05
Diethylene glycol, monobutyl ether	112-34-5	1.3E-01
Diethylene glycol, monoethyl ether	111-90-0	2.4E-01
Di(2-ethylhexyl)adipate	103-23-1	2.9E+01
Diethyl phthalate	84-66-2	6.1E+00
Diethylstilbestrol	56-53-1	2.8E-05
Difenzoquat (Avenge)	43222-48-6	2.6E+02
1,1-Difluoroethane	75-37-6	2.8E+01
Diisopropyl methylphosphonate	1445-75-6	4.5E-01
3,3'-Dimethoxybenzidine	119-90-4	5.8E-05
N-N-Dimethylaniline	121-69-7	9.0E-04
2,4-Dimethylaniline	95-68-1	2.1E-04
2,4-Dimethylaniline hydrochloride	21436-96-4	1.2E-04
3,3'-Dimethylbenzidine	119-93-7	4.3E-05
2,4-Dimethylphenol	105-67-9	4.2E-01
2,6-Dimethylphenol	576-26-1	1.3E-02
3,4-Dimethylphenol	95-65-8	2.1E-02
4,6-Dinitro-o-cyclohexyl phenol	131-89-5	7.7E-01

Contaminant	CAS No.	Migration to Groundwater[1] (mg/kg)
1,2-Dinitrobenzene	528-29-0	1.8E-03
1,3-Dinitrobenzene	99-65-0	1.8E-03
1,4-Dinitrobenzene	100-25-4	1.8E-03
2,4-Dinitrophenol	51-28-5	4.4E-02
Dinitrotoluene (Technical Grade)	25321-14-6	1.4E-04
2,4-Dinitrotoluene	121-14-2	3.2E-04
2,6-Dinitrotoluene	606-20-2	6.7E-05
Dinoseb	88-85-7	6.1E-02
1,4-Dioxane	123-91-1	9.4E-05
Diphenylamine	122-39-4	2.3E+00
1,2-Diphenylhydrazine	122-66-7	2.5E-04
Diquat	85-00-7	3.7E-01
Disulfoton	298-04-4	9.4E-04
1,4-Dithiane	505-29-3	2.6E-02
Diuron	330-54-1	1.5E-02
Endosulfan	115-29-7	4.2E-01
Endothall	145-73-3	2.4E-02
Endrin	72-20-8	8.1E-02
Epichlorohydrin	106-89-8	4.5E-04
Ethion	563-12-2	8.5E-03
2-Ethoxyethanol	110-80-5	6.8E-02
Ethyl acetate	141-78-6	3.1E-02
Ethylbenzene	100-41-4	7.8E-01
Ethylene diamine	107-15-3	1.1E-01
Ethylene glycol	107-21-1	8.1E+00
Ethylene glycol, monobutyl ether	111-76-2	4.1E-01
Ethylene thiourea (ETU)	96-45-7	3.6E-04
Ethyl ether	60-29-7	2.4E-01
Ethyl methacrylate	97-63-2	1.5E-01
Fenamiphos	22224-92-6	4.3E-03
Fluometuron	2164-17-2	1.9E-01
Fluorine (Soluble Fluoride)	7782-41-4	6.0E+02
Fomesafen	72178-02-0	1.6E-01
Fonofos	944-22-9	4.7E-02
Formaldehyde	50-00-0	8.7E-05
Formic Acid	64-18-6	1.3E-04
Furan	110-00-9	2.0E-03
Furazolidone	67-45-8	3.9E-05
Furfural	98-01-1	8.1E-03
Glycidaldehyde	765-34-4	3.3E-04
Glyphosate	1071-83-6	3.1E+00
Heptachlor	76-44-8	3.3E-02
Heptachlor epoxide	1024-57-3	4.1E-03
Hexabromobenzene	87-82-1	6.2E-02

Contaminant	CAS No.	Migration to Groundwater[1] (mg/kg)
Hexachlorobenzene	118-74-1	1.3E-02
Hexachlorobutadiene	87-68-3	2.7E-04
HCH (alpha)	319-84-6	4.2E-05
HCH (beta)	319-85-7	1.5E-04
HCH (gamma) Lindane	58-89-9	1.2E-03
HCH-technical	608-73-1	1.5E-04
Hexachlorocyclopentadiene	77-47-4	1.5E-01
Hexachlorodibenzo-p-dioxin mixture (HxCDD)	Various	1.7E-05
Hexachloroethane	67-72-1	2.0E-04
Hexachlorophene	70-30-4	8.1E+00
1,6-Hexamethylene diisocyanate	822-06-0	2.1E-04
n-Hexane	110-54-3	1.0E+01
Hexazinone	51235-04-2	2.9E-01
HMX	2691-41-0	1.3E+00
Hydrazine	302-01-2	2.2E-07
Hydrogen sulfide	7783-06-4	
p-Hydroquinone	123-31-9	8.8E-04
Iron	7439-89-6	3.5E+02
Isobutanol	78-83-1	3.4E-01
Isophorone	78-59-1	2.6E-02
Isopropalin	33820-53-0	6.7E-01
Isopropylbenzene (Cumene)	98-82-8	7.4E-01
Isopropyl methyl phosphonic acid	1832-54-8	4.3E-01
Lead*	7439-92-1	1.4E+01
Lead (tetraethyl)	78-00-2	4.7E-06
Lithium	7439-93-2	1.2E+01
Malathion	121-75-5	1.0E-01
Maleic anhydride	108-31-6	3.8E-01
Manganese (non-food)	7439-96-5	2.8E+01
Mephosfolan	950-10-7	2.6E-03
Mepiquat	24307-26-4	2.0E-01
Mercury (elemental and inorganic)	7439-97-6	1.0E-01
Mercury (methyl)	22967-92-6	1.4E+01
Methacrylonitrile	126-98-7	4.3E-04
Methanol	67-56-1	4.1E+00
Methidathion	950-37-8	7.0E-03
Methoxychlor	72-43-5	2.2E+00
Methyl acetate	79-20-9	1.1E+00
Methyl acrylate	96-33-3	8.9E-03
Methyl Tertiary Butyl Ether (MTBE)	1634-04-4	3.2E-03
2-Methylaniline (o-toluidine)	95-53-4	2.0E-03
2-Methyl-4-chlorophenoxyacetic acid	94-74-6	2.0E-03
4-(2-Methyl-4-chlorophenoxy) butyric acid	94-81-5	2.6E-02
2-(2-Methyl-4-chlorophenoxy) propionic acid	93-65-2	4.6E-03

Contaminant	CAS No.	Migration to Groundwater[1] (mg/kg)
4,4'-Methylenebisbenzeneamine	101-77-9	2.1E-04
4,4'-Methylene bis(2-chloroaniline)	101-14-4	1.8E-03
4,4'-Methylene bis(N,N'-dimethyl)aniline	101-61-1	2.9E-03
Methylene bromide	74-95-3	2.0E-03
Methylene chloride	75-09-2	1.3E-03
Methylenediphenyl diisocyanate	101-68-8	
Methyl ethyl ketone	78-93-3	1.2E+00
Methyl isobutyl ketone	108-10-1	2.8E-01
Methyl methacrylate	80-62-6	3.0E-01
2-Methyl-5-nitroaniline	99-55-8	4.6E-03
Methyl parathion	298-00-0	7.4E-03
2-Methylphenol	95-48-7	7.5E-01
3-Methylphenol (Cresol)	108-39-4	7.4E-01
4-Methylphenol	106-44-5	1.5E+00
Methyl styrene (mixture)	25013-15-4	3.8E-02
Methyl styrene (alpha)	98-83-9	1.2E+00
Metolaclor (Dual)	51218-45-2	3.2E+00
Metribuzin	21087-64-9	1.5E-01
Mirex	2385-85-5	6.3E-04
Molybdenum	7439-98-7	2.0E+00
Monochloramine	10599-90-3	
Naled	300-76-5	4.9E-03
Nickel and compounds	7440-02-0	2.6E+01
Nitrate	14797-55-8	
Nitrite	14797-65-0	
2-Nitroaniline	88-74-4	8.0E-02
Nitrobenzene	98-95-3	9.2E-05
Nitrofurantoin	67-20-9	6.1E-01
Nitrofurazone	59-87-0	5.4E-05
Nitroglycerin	55-63-0	8.5E-04
2-Nitropropane	79-46-9	5.4E-07
N-Nitrosodi-n-butylamine	924-16-3	5.5E-06
N-Nitrosodiethanolamine	1116-54-7	5.6E-06
N-Nitrosodiethylamine	55-18-5	6.0E-08
N-Nitrosodimethylamine	62-75-9	2.7E-08
N-Nitrosodiphenylamine	86-30-6	6.7E-02
N-Nitroso di-n-propylamine	621-64-7	8.1E-06
N-Nitroso-N-methylethylamine	10595-95-6	2.0E-07
N-Nitrosopyrrolidine	930-55-2	1.4E-05
m-Nitrotoluene	99-08-1	1.6E-03
o-Nitrotoluene	88-72-2	3.0E-04
p-Nitrotoluene	99-99-0	4.0E-03
NuStar	85509-19-9	5.1E+00
Oryzalin	19044-88-3	1.5E-02

Contaminant	CAS No.	Migration to Groundwater[1] (mg/kg)
Oxadiazon	19666-30-9	4.8E-01
Oxamyl	23135-22-0	4.4E-02
Oxyfluorfen	42874-03-3	4.3E-02
Paraquat dichloride	1910-42-5	1.2E+00
Parathion	56-38-2	4.3E-01
Pentachlorobenzene	608-93-5	1.6E-02
Pentachloronitrobenzene	82-68-8	1.5E-03
Pentachlorophenol	87-86-5	1.4E-03
Perchlorate and perchlorate salts	Various	
Permethrin	52645-53-1	2.4E+02
Phenol	108-95-2	3.3E+00
m-Phenylenediamine	108-45-2	3.2E-02
p-Phenylenediamine	106-50-3	5.4E-03
2-Phenylphenol	90-43-7	4.2E-01
Phosphine	7803-51-2	
Phosphorus (white)	7723-14-0	1.5E-03
p-Phthalic acid	100-21-0	6.8E+00
Phthalic anhydride	85-44-9	8.5E+00
Polybrominated biphenyls	59536-65-1	
Polychlorinated biphenyls (PCBs)	1336-36-3	7.8E-02
Aroclor 1016	12674-11-2	2.1E-02
Aroclor 1221	11104-28-2	1.3E-04
Aroclor 1232	11141-16-5	1.3E-04
Aroclor 1242	53469-21-9	1.2E-03
Aroclor 1248	12672-29-6	1.2E-03
Aroclor 1254	11097-69-1	2.1E-03
Aroclor 1260	11096-82-5	5.5E-03
Polycyclic Aromatic Hydrocarbons (PAHs)		
Acenaphthene	83-32-9	2.5E+00
Acenaphthylene	208-96-8	2.4E+00
Anthracene	120-12-7	5.8E+01
Benz[a]anthracene	56-55-3	1.1E-02
Benzo[b]fluoranthene	205-99-2	3.0E-01
Benzo[k]fluoranthene	207-08-9	2.9E+00
Benzo[g,h,i]perylene	191-24-2	2.3E+03
Benzo[a]pyrene	50-32-8	2.3E-01
Chrysene	218-01-9	9.1E+00
Dibenz[a,h]anthracene	53-70-3	9.6E-02
Fluoranthene	206-44-0	8.9E+01
Fluorene	86-73-7	2.7E+00
Indeno[1,2,3-cd]pyrene	193-39-5	9.8E-01
1-Methylnaphthalene	90-12-0	6.0E-03
2-Methylnaphthalene	91-57-6	1.9E-01
Naphthalene	91-20-3	5.4E-04

Contaminant	CAS No.	Migration to Groundwater[1] (mg/kg)
Phenanthrene	85-01-8	5.9E+01
Pyrene	129-00-0	8.6E+00
Prometon	1610-18-0	1.2E-01
Prometryn	7287-19-6	9.0E-01
Propachlor	1918-16-7	1.5E-01
Propanil	709-98-8	4.5E-02
Propargite	2312-35-8	1.2E-02
n-Propylbenzene	103-65-1	1.2E+00
Propylene glycol	57-55-6	8.1E+01
Propylene glycol, monoethyl ether	1569-02-4	2.8E+00
Propylene glycol, monomethyl ether	107-98-2	6.5E-01
Pursuit	81335-77-5	4.1E+01
Pyridine	110-86-1	1.8E-03
Quinoline	91-22-5	7.8E-05
RDX (Cyclonite)	121-82-4	2.7E-04
Resmethrin	10453-86-8	4.2E+01
Ronnel	299-84-3	1.8E+00
Rotenone	83-79-4	3.2E+01
Selenious Acid	7783-00-8	
Selenium	7782-49-2	2.6E-01
Silver and compounds	7440-22-4	8.0E-01
Simazine	122-34-9	2.0E-03
Sodium azide	26628-22-8	
Sodium diethyldithiocarbamate	148-18-5	1.8E-04
Strontium, stable	7440-24-6	4.2E+02
Strychnine	57-24-9	6.5E-02
Styrene	100-42-5	1.1E-01
tert-butanol	75-65-0	7.3E-02
2,3,7,8-Tetrachlorodibenzodioxin (TCDD/dioxin)	1746-01-6	1.5E-05
1,2,4,5-Tetrachlorobenzene	95-94-3	4.5E-03
1,1,1,2-Tetrachloroethane	630-20-6	2.2E-04
1,1,2,2-Tetrachloroethane	79-34-5	3.0E-05
Tetrachloroethylene (PCE)	127-18-4	2.3E-03
2,3,4,6-Tetrachlorophenol	58-90-2	1.5E+00
p,a,a,a-Tetrachlorotoluene	5216-25-1	1.9E-06
Tetrahydrofuran	109-99-9	7.5E-01
Thallium and compounds	7440-28-0	1.4E-01
Thiobencarb	28249-77-6	5.5E-01
Thiocyanates	Various	
Tin and compounds	7440-31-5	3.0E+03
Toluene	108-88-3	6.9E-01
Toluene-2,4-diamine	95-80-7	6.3E-06
Toluene-2,5-diamine	95-70-5	1.3E-04
Toluene-2,6-diamine	823-40-5	1.9E-01

Contaminant	CAS No.	Migration to Groundwater[1] (mg/kg)
p-Toluidine	106-49-0	1.1E-03
Toxaphene	8001-35-2	4.6E-01
1,2,4-Tribromobenzene	615-54-3	2.9E-02
Tributyltin oxide (TBTO)	56-35-9	2.9E+02
2,4,6-Trichloroaniline	634-93-5	3.6E-03
1,2,4-Trichlorobenzene	120-82-1	2.0E-01
1,1,1-Trichloroethane	71-55-6	7.0E-02
1,1,2-Trichloroethane	79-00-5	1.6E-03
Trichloroethylene (TCE)	79-01-6	1.8E-03
Trichlorofluoromethane	75-69-4	7.3E-01
2,4,5-Trichlorophenol	95-95-4	4.4E+00
2,4,6-Trichlorophenol	88-06-2	4.0E-03
2,4,5-Trichlorophenoxyacetic Acid	93-76-5	6.8E-02
2-(2,4,5-Trichlorophenoxy) propionic acid	93-72-1	2.8E-02
1,1,2-Trichloropropane	598-77-6	1.0E-02
1,2,3-Trichloropropane	96-18-4	3.2E-07
1,2,3-Trichloropropene	96-19-5	3.1E-04
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	76-13-1	2.6E+01
1,2,4-Trimethylbenzene	95-63-6	8.1E-02
1,3,5-Trimethylbenzene	108-67-8	8.7E-02
Trimethyl phosphate	512-56-1	8.6E-04
1,3,5-Trinitrobenzene	99-35-4	2.1E+00
Trinitrophenylmethylnitramine (Tetryl)	479-45-8	3.7E-01
2,4,6-Trinitrotoluene	118-96-7	1.5E-02
Vanadium and compounds	7440-62-2	1.5E+02
Vinclozolin	50471-44-8	1.6E-02
Vinyl acetate	108-05-4	8.7E-02
Vinyl bromide	593-60-2	5.1E-05
Vinyl chloride	75-01-4	6.9E-04
Warfarin	81-81-2	5.9E-03
Xylenes	1330-20-7	9.9E+00
Zinc and Compounds	7440-66-6	3.7E+02
Zinc phosphide	1314-84-7	
Zineb	12122-67-7	2.9E+00

Notes:
[1]The migration from soil to groundwater values shall be applied unless it is shown to the satisfaction of the Secretary that migration of soil contaminants to groundwater will not result in an exceedance of the De Minimis Groundwater Standards via site-specific migration to groundwater calculations or by direct measurement using the Synthetic Precipitation Leaching Procedure.

ATTACHMENT 2

Attachment 2: Checklist to Determine Applicable Remediation Standards

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The Checklist to Determine Applicable Remediation Standards must be completed for each VRP site and attached to the Risk Assessment Report. Part 1 (Ecological Standards) is used to determine the degree to which ecological risks need to be addressed. Part 2 (Human Health Standards) is used to determine if a site should use De Minimis, Uniform, or Site-Specific risk assessment to progress the site in the VRP.

Checklist to Determine Applicable Remediation Standards

Part 1: Ecological Standards

STEP 1: Determine Whether a De Minimis Ecological Screening Evaluation is Appropriate for the Site		
1.1	Are there any undeveloped terrestrial areas on or adjacent to the site (e.g., areas that are not under intensive landscape or agricultural control)?	☐ Yes ☐ No
1.2	Are there any potential wetlands (including vernal pools) on or adjacent to the site?	☐ Yes ☐ No
1.3	Are there any surface water bodies (i.e., lotic or lentic habitat) on or adjacent to the site?	☐ Yes ☐ No
1.4	Are there any terrestrial, wetland, or aquatic habitats off-site, but situated downstream, downwind, or downgradient from the site that may be affected by site-related stressors?	☐ Yes ☐ No
1.5	Are there any projected land uses for the site that would result in undeveloped areas, wetland habitat, lotic habitat, or lentic habitat?	☐ Yes ☐ No
If "Yes" to any: A complete exposure pathway may exist for potential ecological receptors of concern. Proceed to Step 2. *If "No" to all: No further ecological evaluation is required. File this completed form with the Risk Assessment Report.*		

STEP 2: Identify any Readily Apparent Harm or Exceedances of Surface Water Quality Standards		
2.1	Have there been any incidents where harm to wildlife attributable to contaminants originating from the site has been readily apparent?	☐ Yes ☐ No
	If "Yes": Proceed to Question 2.2. *If "No": Skip to Question 2.3.*	
2.2	Has the cause of such harm been eliminated?	☐ Yes ☐ No
	If "Yes": Briefly describe the action taken and complete the rest of the checklist. *If "No": Proceed directly to the remedy evaluation or, alternately, proceed with a determination of a Uniform or Site-Specific Ecological Standard, as described in the VRP Guidance Manual, prior to implementation of the remedy. File this form with the Risk Assessment Report.*	
	Action Taken:	
2.3	Is the site contributing to exceedances of surface water quality standards established for the protection of aquatic life (see W. Va. Legislative Rule 47CSR2)?	☐ Yes ☐ No
	If "Yes": Proceed directly to the remedy evaluation or, alternately, proceed with a determination of a Uniform or Site-Specific Ecological Standard, as described in the VRP Guidance Manual, prior to implementation of the remedy. *If "No": Proceed to Step 3.*	

STEP 3: Identify Contamination Associated with Ecological Habitats		
3.1	Have the environmental media (e.g., soil, surface water, sediment, biota) associated with the ecological habitat(s) identified in Questions 1.2 through 1.5 been sampled and analyzed with regard to potential site-related contaminants of concern?	☐ Yes ☐ No
	If "Yes": Proceed to Question 3.2. *If "No": Skip to Step 4.*	
3.2	Have any site-related contaminants been detected above natural background concentrations in environmental media collected from terrestrial habitat?	☐ Yes ☐ No ☐ Unknown ☐ n/a
3.3	Have any site-related contaminants been detected above natural background concentrations in environmental media collected from wetland or aquatic habitats (lotic or lentic habitats)?	☐ Yes ☐ No ☐ Unknown ☐ n/a
	If "Yes" or "Unknown" to 3.2 and/or 3.3: Proceed to Question 3.4. *If "No" or "n/a" to both 3.2 and 3.3: Skip to Question 3.6.*	
3.4	Are site-related contaminants presenting an ecological risk over and above "local" condition?	☐ Yes ☐ No ☐ Unknown
	If "Yes": Skip to Step 4. *If "No" or "Unknown": Proceed to Question 3.5.*	
3.5	Have site-related releases of contaminants been stopped?	☐ Yes ☐ No
	If "Yes": Proceed to Question 3.6. *If "No": Skip to Part 4.*	
3.6	Are site-related contaminants currently or likely to be migrating to aquatic habitat (e.g., lotic, lentic, or wetland habitat)?	☐ Yes ☐ No ☐ n/a
	If "Yes": Proceed to Step 4. *If "No" or "n/a": No further ecological evaluation is required. File this completed form with the Risk Assessment Report.*	

STEP 4: Characterize the Potential Ecological Habitat		
4.1	Describe the general land use in the immediate vicinity of the site.	
	☐ Commercial/Industrial ☐ Residential ☐ Rural/Agricultural ☐ Rural/Undeveloped ☐ Urban ☐ Other:	
4.2	For all affected areas that fulfill the descriptions in Step 1, answer the following and attach a site map identifying the potential ecological habitat.	
	4.2.1 Outline characteristics for potential terrestrial habitats.	
	Location:	
	Contiguous Area:	
	General Topography:	
	Primary Soil Type:	
	Predominant Vegetation Species:	
	4.2.2 Outline characteristics for potential wetland habitats (e.g., vernal pools, marshes, etc.).	
	Location:	
	Contiguous Area:	
	General Topography:	
	Primary Soil Type:	
	Predominant Vegetation Species:	
	4.2.3 Outline characteristics for potential lotic habitats (e.g., flowing water habitat such as rivers and streams).	
	Location:	
	Typical Width and Depth:	
	Typical Flow Rate:	
	Typical Gradient (m/km):	
	Type of River/Creek Bottom:	
	Types of Aquatic Vegetation Present:	
	Topography of the Riparian Zone:	
	Predominant Riparian Vegetation:	
	Human Utilization of Lotic Habitat:	
	Local Conditions:	
	4.2.4 Outline characteristics for potential lentic habitats (e.g., standing water habitats such as lakes and ponds).	
	Location:	
	Is the lentic habitat…?	☐ Natural ☐ Man-made
	Area of Lentic Habitat	
	Typical and Maximum Depth:	
	Description of Sources & Drainage:	
	Predominant Aquatic Vegetation:	
	Topography of Littoral Zone:	
	Predominant Littoral Zone Vegetation:	
	Human Utilization of Lentic Habitat:	

	Local Conditions:	
4.3	Indicate if the site contains or is adjacent to any of the following types of valued terrestrial habitats:	
	☐ Climax Community (e.g., old growth forest) ☐ Federal Wilderness Area (designated or administratively proposed) ☐ National or State Forest ☐ National or State Park ☐ National or State Wildlife Refuge ☐ National Preserve Area ☐ State designated natural area ☐ Federal land designated for protection of natural ecosystems ☐ Federal or State land designated for wildlife or game management ☐ Area utilized for breeding by large or dense aggregations of wildlife ☐ Feeding, breeding, nesting, cover, or wintering habitat for migratory birds ☐ Area important to the maintenance of unique biotic communities (e.g., high proportion of endemic species) *Threatened or Endangered Species* ☐ Critical habitat for federally designated threatened or endangered species ☐ Habitat known to be used or potentially used by Federal or State designated threatened or endangered species, or species in the State Wildlife Action Plan	
4.4	Indicate if the site contains or is adjacent to any of the following types of valued wetlands:	
	☐ Area important to the maintenance of unique biotic communities (e.g., high proportion of endemic species) ☐ Area utilized for breeding by large or dense aggregations of wildlife ☐ Spawning or nursery areas critical to the maintenance of fish/shellfish species ☐ Feeding, breeding, nesting, cover, or wintering habitat for migratory waterfowl or other aquatic birds ☐ Area important to the maintenance of unique biotic communities (e.g., high proportion of endemic species) *Threatened or Endangered Species* ☐ Critical habitat for federally designated threatened or endangered species ☐ Habitat known to be used or potentially used by Federal or State designated threatened or endangered species, or species in the State Wildlife Action Plan	
4.5	Indicate if the site is within or adjacent to any of the following valued aquatic habitats:	
	☐ Federal or State Fish Hatchery ☐ Federal or State designated Scenic or Wild River ☐ National River Reach designated as recreational ☐ Critical areas identified under the Clean Lakes Program ☐ Trout-stocked streams or wild trout streams with verified trout production ☐ Spawning or nursery areas critical the maintenance of fish/shellfish species ☐ Feeding, breeding, nesting, cover, or wintering habitat for migratory waterfowl or other aquatic birds ☐ Area important to the maintenance of unique biotic communities (e.g., high proportion of endemic species) *Threatened or Endangered Species* ☐ Critical habitat for federally designated threatened or endangered species ☐ Habitat known to be used or potentially used by Federal or State designated threatened or endangered species, or species in the State Wildlife Action Plan	
4.6	Have valued terrestrial, wetland, or aquatic habitats been identified within or adjacent to this site? *(A list of agencies that can provide information that should assist in determining whether the site is located within or adjacent to the areas listed in 4.3, 4.4, and 4.5 is provided at the end of this checklist.)*	☐ Yes ☐ No

STEP 5: Identify Any Potential Ecological Receptors of Concern		
5.1	Threatened and Endangered Species Were any potential habitats within or adjacent to the site identified as critical habitat for federally designated threatened or endangered species listed in 50CFS17.95 or 17.96, or areas known to be used by federal or state designated threatened or endangered species?	☐ Yes ☐ No
	If "Yes", indicate which species*: *Amphibians* ☐ Cheat Mountain salamander (Plethodon nettingi) *Birds* ☐ Bald eagle (Haliaeetus leucocephalus) *Clams* ☐ Clubshell (Pleurobema clava) ☐ Fanshell (Cyprogenia stegaria) ☐ James spinymussel (Pleurobeam collina) ☐ Northern riffleshell (Epioblasma torulosa rangiana) ☐ Pink mucket pearlymussel (Lampsilis abrupta) ☐ Tubercled blossom pearlymussel (Epioblasma torulosa torulosa) *Flowering Plants* ☐ Harperella (Ptilimnium nodosum) ☐ Northeastern bulrush (Scirpus ancistrochaetus) ☐ Running buffalo cover (Trifolium stoloniferum) ☐ Shale barren rock cress (Arabis perstellata) ☐ Small whorled pogonia (Isotria medeoloides) ☐ Virginia spiraea (Spiraea virginiana) *Mammals* ☐ Eastern cougar (Felis concolor couguar) ☐ Gray bat (Myotis grisescens) ☐ Indiana bat (Myotis sodalis) ☐ Virginia big-eared bat (Corynorhinus towsendii virgniaus) ☐ Virginia northern flying squirrel (Glaucomys sabrinus fuscus) *Snails* ☐ Flat-spired three-toothed land snail (Triodopsis platysayoides)	
5.2	Local Populations Providing Important Natural or Economic Resources, Functions, and Values Were any valued terrestrial, wetland, or aquatic habitats listed in 4.3, 4.4, or 4.5 identified within or adjacent to the site?	☐ Yes ☐ No
If "Yes" to 5.1 and/or 5.2 and/or surface water bodies are not in compliance with applicable water quality standards: The site does not pass the De Minimis ecological risk screening, since a complete exposure pathway may exist for potential ecological receptors of concern. Further evaluation of the site is required using either the Uniform Ecological Standard or the Site-Specific Ecological Standard. *If "No" to 5.1 and 5.2 and surface water bodes are in compliance with applicable water quality standards: No further ecological evaluation is required. File this completed form with the Risk Assessment Report.*		

*The list contains those federally designated threatened and endangered species that are indigenous to WV. WVDNR, Wildlife Resources Section should be consulted to ensure the list is correct. WV has not established a list of state designated threatened or endangered species; however, the WVDNR has developed a "Species of Greatest Conservation Need" list in the State Wildlife Action Plan. Species listed in the in the State Wildlife Action Plan should also be considered in any Ecological Risk Assessment.

ATTACHMENT 2

Federal and State Agencies for Ecological Review Consultation

U.S. Department of Agricultural – Natural Resources and Conservation Service
1550 Earl L. Core Road, Suite 200
Morgantown, WV 26505
304-284-7540
https://www.nrcs.usda.gov/wps/portal/nrcs/site/wv/home

U.S. Fish and Wildlife Service – WV Field Office
Ecological Services
90 Vance Drive
Elkins, WV 26241
304-636-6586
https://www.fws.gov/northeast/ecologicalservices/index.html

WV Division of Forestry
7 Players Club Drive
Charleston, WV 25311
304-558-2788
https://wvforestry.com/

WV Division of Natural Resources
Building 74
324 Fourth Avenue
South Charleston, WV 25303
304-558-2754
http://www.wvdnr.gov/

WV Division of Natural Resources – Wildlife Resources Section
Building 74
324 Fourth Avenue
South Charleston, WV 25303
304-558-2771
http://www.wvdnr.gov/

Checklist to Determine Applicable Remediation Standards

Part 2: Human Health Standards

STEP 1: Determine Whether the De Minimis Standard is Appropriate for the Site

The De Minimis Standard applies to contaminants for which the primary exposure routes will be ingestion, dermal contact, and/or inhalation of soil or groundwater. For soil, the De Minimis Standard is either the risk-based concentration (RBC) (Table 60-3B of the Rule) or the natural background level of the contaminant, whichever is higher. The potential for vapor intrusion also needs to be screened by comparing site groundwater, soil gas, or indoor air concentrations to the relevant RBC in the USEPA Vapor Intrusion Screening Levels (VISL).

Evaluating a site based on the De Minimis Standard consists of aggregating site data and comparing either maximum concentrations detected, or the 95% upper confidence limit (UCL) concentration, known as the exposure point concentration (EPC), to establish RBCs. If site EPCs do not exceed the RBC or site-specific background, then no further evaluation or remediation of the site is required. Similarly, if the site EPCs do exceed the RBC or site-specific background but presumptive remedies can be shown to sever the potential exposure route, then no further evaluation is needed, and the Applicant can proceed to implementing the presumptive remedies. (Completing Worksheet 4-1 at the end of this checklist may aid in this process.)

The De Minimis approach is limited to particular compounds and is appropriate only for residential or industrial exposure scenarios. Below are several questions that will help to determine whether a site may be evaluated under the De Minimis Standard.

1.1	Have media representing all potentially complete pathways in the conceptual site model been sampled?	☐ Yes ☐ No
1.2	Are there fewer than 10 chemicals present at the site?	☐ Yes ☐ No
1.3	If any concentration of chemicals of potential concern exceed the RBC, are there presumptive remedies that can sever the exposure pathways and that are acceptable to the Applicant and impacted off-site property owners?	☐ Yes ☐ No
1.4	Is the future use of the site expected to only be residential and/or industrial?	☐ Yes ☐ No
1.5	Does Part 1 (Ecological Standards) of this checklist indicate that there are no ecological receptors of concern at the site (e.g., wetlands or endangered species)?	☐ Yes ☐ No

If "Yes" to all: The De Minimis Standard is likely appropriate for the site.
If "No" to any: The De Minimis Standard may not be appropriate for the site, and more site-specific characterization may be needed; however, the Applicant may consult with WVVDEP to confirm the determination.
If "No" to all: The De Minimis Standard is not appropriate for the site. The Uniform Standard or Site-Specific Standard should be considered instead.

STEP 2: Determine Whether the Uniform Standard is Appropriate for the Site

The Uniform Standard is based on the use of WVDEP-approved methodologies to calculate remediation standards. Advantages to using the Uniform Standard include the fact that this methodology can be used to determine remediation standards for some contaminants and receptors not included under the De Minimis Standards or De Minimis Risk Assessment process (e.g., recreators and construction workers), and that, with adequate documentation, site-specific information can be incorporated into the calculations. The disadvantages of the approach defined under the Uniform Standard are that exposure scenarios and potential exposure pathways included in these calculations are limited to those available in the USEPA Regional Screening Levels methodology.

Note that if site-specific modeling will be used in determining EPCs for media at a site, a site-specific risk assessment should be used.

2.1	Is future use of the site potentially other than residential or industrial use?	☐ Yes ☐ No
2.2	Do potentially impacted sediments exist at the site that you feel should not be held to residential or industrial soil cleanup standards?	☐ Yes ☐ No
2.3	Do home vegetable gardens potentially exist in the vicinity of the site, and is homegrown produce potentially impacted by site-related chemicals?	☐ Yes ☐ No
2.4	Are there any dairy farms or livestock grazing areas within the area of impact of the site?	☐ Yes ☐ No
2.5	Is impacted groundwater or surface water used for irrigation or any use other than drinking water?	☐ Yes ☐ No
2.6	Are construction/utility workers potentially exposed to contaminated groundwater in a trench?	☐ Yes ☐ No

If "Yes" to any: There are potential pathways for human exposure to site-related chemicals that are not addressed in the methodology provided for determining a Uniform Standard. Therefore, a Site-Specific Standard is more appropriate for the site.
If "No" to all: The Uniform Standard is likely appropriate for the site.

Worksheet 4-1

If EPCs for all site contaminants are less than the corresponding RBC values, no remediation is required.
If the site EPC values exceed the RBC values, additional assessment or remediation of the site is required.

Worksheet 4-1: Compare Site Data to Chemical Specific De Minimis RBC Values					
Soil (mg/kg)	Contaminant	Max Concentration	UCL	RBCs Residential	RBCs Industrial
Groundwater µg/L	Contaminant	Max Concentration	UCL	RBCs Groundwater	RBCs VISL
Soil Vapor µg/m^3	Contaminant	Max Concentration	UCL	RBCs Residential	RBCs Industrial

UCL = 95% Upper Confidence Level
RBC = Risk Based Concentrations provided in Table 60-3B of the Rule and in the USEPA Vapor Intrusion Screening Levels (VISL)

ATTACHMENT 3

Attachment 3: VRP Decision Trees

This set of VRP Decision Trees is a tool to guide the assessment and remediation of a site through the program. Example scenarios are provided for general risk assessment within the VRP; however, most of the decision trees are specific to a certain medium or pathway of exposure, such as groundwater, soils, surface water, sediment, and vapor intrusion.

ATTACHMENT 3

VRP Decision Tree: Risk Assessment Scenarios

SCENARIO 1		
1.1	All COPCs are below screening criteria (e.g., De Minimis Standards, EPA Vapor Intrusion Screening Levels, and USEPA Region 3 Biological Technical Assistance Group Ecological Benchmarks), meaning that there are no COCs.	☐ True ☐ False
1.2	There are no complete pathways in the CSM for both human and ecological receptors due to existing or presumptive remedies.	☐ True ☐ False
If 1.1 is true: A De Minimis Risk Assessment Report can be included in the Site Assessment Report. *If 1.2 is true:* A De Minimis Risk Assessment Report may be combined with the Remediation Action Work Plan if presumptive remedies need to be implemented. Either of these combined reports/work plans may require a Modification of the Voluntary Remediation Agreement to include them in one document. After De Minimis Risk Assessment is complete, proceed toward the Final Report and apply for a Certificate of Completion.		

SCENARIO 2		
2.1	There are COCs and complete exposure pathways, but a Uniform or Site-Specific Baseline Risk Assessment shows the risks associated with current site conditions are acceptable and no remediation is necessary.	☐ True ☐ False
If true: Proceed toward the Final Report and apply for a Certification of Completion		

SCENARIO 3		
3.1	There are COCs and complete exposure pathways, and a Uniform or Site-Specific Baseline Risk Assessment shows the risks are unacceptable under current site conditions. However, the risks can be made acceptable with the implementation of remedies. Remedies may be limited (such as hot spot removal, institutional controls, and/or engineering controls) or more extensive (requiring active remediation strategies).	☐ True ☐ False
If true: Submit a Baseline Risk Assessment (either Uniform or Site-Specific) to estimate risks under current conditions, followed by a Remediation Action Work Plan, and a residual risk assessment to estimate risks after implementation of remediation and/or controls. The residual risk assessment may be De Minimis if either of the criteria in Scenario 1 are met. Alternately, the residual risk assessment may be Uniform or Site-Specific if the criteria in Scenario 1 are not met. Once the residual risk assessment shows that the risks are acceptable for all receptors and exposure pathways, proceed toward the Final Report and apply for a Certificate of Completion.		

VRP Decision Tree: Groundwater Screening

Screening Notes

All sources of contamination must be remediated or controlled to prevent further contamination of groundwater and other media.

- Samples must have been analyzed for either the list of all COPCs as determined in a Phase I or Phase II ESA or by the list of COPCs that exceeded the default, calculated, or measured Migration to Groundwater screening levels in soils. Note that if none of the COPCs exceed the default, calculated, or measured Migration to Groundwater screening levels, then there is no further need for groundwater assessment or screening (see Section 3.6.2 for details).
- Detection limits must be less than or equal to screening levels whenever possible.
- Compare the maximum detected concentration or Upper 95% Confidence Level to the De Minimis Groundwater level.
- The De Minimis groundwater screening process does not include the vapor intrusion into buildings exposure pathway; therefore, even if volatile organics pass De Minimis groundwater screening levels, it is necessary to evaluate risks associated with volatiles if vapor instruction pathways are viable under the CSM, unless vapor intrusion is being assessed via the soil gas medium.
- The De Minimis groundwater screening process does not include exposures to excavation workers in trenches. WVDEP assumes excavation workers may dig trenches up to 10 feet deep and their exposures should include direct contact with soil through the ingestion, dermal, and inhalation pathways, and contact with groundwater through the dermal and inhalation pathways using the VADEQ Trench Model, which is available in the Virginia United Risk Assessment Model (VURAM), or via a site-specific risk assessment.
- The De Minimis groundwater screening process does not include the migration into surface water pathway. This pathway must be evaluated separately if it is viable under the CSM. Recharge of groundwater into surface water must be considered under current conditions by analyzing the surface water for COPCs in the groundwater, and under potential future conditions by comparing groundwater COPC concentrations to surface water quality standards (SWQS) or Benchmarks, if SWQS are not available. If SWQS or Benchmarks are exceeded in groundwater, then site-specific conditions may be considered following the procedures in Appendix B (such as geologic or hydrogeologic conditions, equilibrium between groundwater and surface water, dilution factors, and overall degradation of the surface water), or groundwater modeling may be necessary. Under no circumstances may contaminated groundwater be allowed to cause exceedances of SWQS. Consultation with WVDEP is strongly suggested in this situation.

Natural Attenuation as a Remedial Action

A remediation plan based on upon natural processes of degradation and attenuation of contaminants may be requested. Requests must include a description of site-specific conditions, including:

- Written documentation of projected groundwater use in the contaminated area, based on current state or local government planning efforts
- Technical basis for the request
- Any other information requested by WVDPE to thoroughly evaluate the request.

The requestor must also demonstrate all of the following:

- The contaminant has the capacity to degrade or attenuate under the site-specific conditions.
- The contaminant area, such as a groundwater plume or soil volume, is not increasing in size, or because of natural attenuation processes, that the rate of contaminant degradation is demonstrably more rapid than the rate of contaminant migration; and that all sources of contamination and free product have been controlled or removed where practicable.
- The time and direction of contaminant travel can be predicted with reasonable certainty.
- The contaminant migration will not result in any violation of applicable groundwater standards at any existing or reasonably foreseeable receptor.
- If the contaminant has migrated onto adjacent properties, demonstration of one of the following.
    - Such properties are served by an existing public water supply system dependent on surface water or hydraulically isolated groundwater.
    - The owners of such properties have consented in writing to allow contamination migration onto their property.
- If the contaminant plume is expected to intercept surface waters, the groundwater discharge beyond the sediment/water interface will not possess contaminant concentrations that would result in violations of standards for surface waters contained in W. Va. Legislative Rule 47CSR2.
- The requestor will put in place a groundwater monitoring program sufficient to track the degradation and attenuation of contaminants and contaminant by-products within and downgradient of the plume and to detect contaminants and contaminant by-products prior to their reaching any existing or reasonably foreseeable receptor. Such monitoring program shall provide for placing one or more monitoring wells at least one year's time of travel upgradient of the receptor, and at least one monitoring well shall be placed a location(s) no farther away from the leading edge of the contaminated groundwater at the site than such contamination is likely to travel in 5 years. The Applicant may satisfy the requirement for groundwater monitoring upon successful completion of all the following, as determined by WVDEP:
    - Installation of an adequate number of appropriately located groundwater monitoring wells.
    - Collection of a minimum of 4 years of semiannual groundwater monitoring data for site-related contaminants to demonstrate the site meets conditions as specified in the second bullet of the required groundwater demonstrations above.
    - Use of an attenuation model approved by WVDEP and calibrated using the aforementioned data. The model must be capable of reliably estimating the extent of contaminant impacts to groundwater.
- All necessary access agreements needed to monitor groundwater quality have been or can be obtained.

The proposed correction action plan would be consistent with all other environmental laws.

ATTACHMENT 3

SECTION A: Initial Screening		
A1	Do on-site groundwater chemical concentrations or modeled future concentrations of the contaminant and related breakdown products exceed Groundwater De Minimis levels?	☐ Yes ☐ No
A2	Do off-site groundwater chemical concentrations or modeled future concentrations of the contaminant and related breakdown products exceed Groundwater De Minimis levels?	☐ Yes ☐ No
A3	Do on-site or off-site groundwater chemical concentrations exceed USEPA Vapor Intrusion Screening Levels (VISL) for residential receptors (assuming risk threshold of 1E-06 and hazard index of 1.0)?	☐ Yes ☐ No
A4	Are on-site or off-site groundwater elevations less than 10 feet below ground level?	☐ Yes ☐ No
If "Yes" to either A1 or A2: Proceed to Section B. *If "Yes" to A3: Skip to Section C.* *If "Yes" to A4: Skip to Section D.* *If "No" to all: Contaminant passes De Minimis groundwater screening. However, the groundwater to surface water pathway may still require assessment depending on site conditions.*		
SECTION B: Residential or Commercial/Industrial Direct Contact with Groundwater		
B1	Do groundwater data and/or modeling results indicate exceedances of Groundwater De Minimis levels at the property boundary or reasonably anticipated receptor within nearest migrating distance at any point in time?	☐ Yes ☐ No
If "Yes": Proceed with one of the following actions. • *Determine Uniform or Site-Specific Standards for either on-site or off-site groundwater portions of the plume, or both.* • *Select a remedial action for either on-site or off-site groundwater portions of the plume, or both, and submit a Remedial Action Plan.* • *Restrict on-site groundwater use with an LUC and demonstrate that off-site properties are served by an existing public water supply dependent on surface waters or hydraulically isolated groundwater. Obtain written consent from the off-site property owners to allow contaminant migration onto their property. In addition, implement monitored natural attenuation with WVDEP consultation.* *If "No": Proceed with one of the following actions.* • *Determine Uniform or Site-Specific Standards for on-site groundwater.* • *Select a remedial action for on-site groundwater and submit a Remedial Action Work Plan.* • *Restrict on-site groundwater use with an LUC. In addition, implement monitored natural attenuation with WVDEP consultation.*		
SECTION C: Vapor Intrusion		
C1. On-Site Vapor Intrusion		
C1-a	Do on-site groundwater chemical concentrations or modeled future concentrations of the contaminant and related breakdown products exceed residential VISL benchmarks?	☐ Yes ☐ No
	If "Yes": Proceed to Question C1-b. *If "No": Contaminant passes De Minimis groundwater screening, and no further action is required for potential of on-site vapor intrusion.*	
C1-b	Is the property currently used for residential purpose, or could it be in the future?	☐ Yes ☐ No
	If "Yes": Proceed with one of the following actions. • *Determine Uniform or Site-Specific Standards for vapor intrusion into residences due to contaminated on-site groundwater.* • *Select a remedial action for vapor intrusion due to contaminated on-site groundwater and submit a Remedial Action Work Plan.*	

	• *Restrict residential use of site with an LUC and screen the groundwater for commercial uses.* • *Sample on-site soil gas as the next line of evidence for potential vapor intrusion and screen soil gas concentrations against VISL soil gas values (see Vapor Intrusion Decision Tree).* *If "No": Proceed to Question C1-c.*	
C1-c	Do on-site groundwater chemical concentrations or modeled future concentrations of the contaminant and related breakdown products exceed commercial VISL benchmarks (assuming risk threshold of 1E-05 and hazard index of 1.0)?	☐ Yes ☐ No
	If "Yes": Proceed with one of the following actions. • *Determine Uniform or Site-Specific Standards for vapor intrusion into a commercial/industrial building due to contaminated on-site groundwater.* • *Select a remedial action for vapor intrusion due to contaminated on-site groundwater and submit a Remedial Action Work Plan.* • *Sample on-site soil gas as the next line of evidence for potential vapor intrusion and screen soil gas concentrations against VISL soil gas values (see Vapor Intrusion Decision Tree).* *If "No": Contaminant passes De Minimis groundwater screening for a commercial/industrial setting, and no further action is required for potential of vapor intrusion as long as the property does not change, which may require an LUC restricting residential use of the on-site property.*	
C2. Off-Site Vapor Intrusion		
C2-a	Do off-site groundwater chemical concentrations or modeled future concentrations of the contaminant and related breakdown products exceed residential VISL benchmarks?	☐ Yes ☐ No
	If "Yes": Proceed to Question C2-b. *If "No": Contaminant passes De Minimis groundwater screening, and no further action is required for potential of off-site vapor intrusion.*	
C2-b	Is the off-site property currently used for residential purposes, or could it be in the future?	☐ Yes ☐ No
	If "Yes": Proceed with one of the following actions. • *Determine Uniform or Site-Specific Standards for vapor intrusion into residences due to contaminated off-site groundwater.* • *Select a remedial action for vapor intrusion due to contaminated off-site groundwater and submit a Remedial Action Work Plan.* • *Obtain written consent from off-site property owner to allow contaminant migration onto their property, assuming off-site property is served by a public water supply dependent on surface water or hydraulically isolated groundwater.* • *Have off-site property owner restrict residential use of site and evaluate the potential of vapor intrusion for a commercial/industrial site.* • *Sample off-site soil gas as the next line of evidence for potential vapor intrusion and screen soil gas concentrations against VISL soil gas values (see Vapor Intrusion Decision Tree).* *If "No": Proceed to Question C2-c.*	
C2-c	Do off-site groundwater chemical concentrations or modeled future concentrations of the contaminant and related breakdown products exceed commercial VISL benchmarks (assuming risk threshold of 1E-05 and hazard index of 1.0)?	☐ Yes ☐ No
	If "Yes": Proceed with one of the following actions. • *Determine Uniform or Site-Specific Standards for vapor intrusion into a commercial/industrial building due to contaminated off-site groundwater.* • *Select a remedial action for vapor intrusion due to contaminated off-site groundwater and submit a Remedial Action Work Plan.*	

	• *Sample off-site soil gas as the next line of evidence for potential vapor intrusion and screen soil gas concentrations against VISL soil gas values (see Vapor Intrusion Decision Tree).* *If "No": Contaminant passes De Minimis groundwater screening for a commercial/industrial setting, and no further action is required for potential of vapor intrusion as long as the property use does not change, which may require restricting residential use of the off-site property.*	
SECTION D: Excavation Workers in a Trench		
D1	Do on-site groundwater chemical concentrations or modeled future concentrations of the contaminant and related breakdown products exceed Groundwater De Minimis levels?	☐ Yes ☐ No
	If "Yes": Proceed with one of the following actions. • *Determine Uniform or Site-Specific Standards for risks to excavation workers exposed to contamination in a trench using the VADEQ Trench Model.* • *Select a remedial action to protect excavation workers in a trench and submit a Remedial Action Work Plan.* • *Restrict excavation on the site using an LUC.* *If "No": Contaminant passes De Minimis groundwater screening for potential on-site exposure to excavation workers.*	
D2	Do off-site groundwater chemical concentrations or modeled future concentrations of the contaminant and related breakdown products exceed Groundwater De Minimis levels?	☐ Yes ☐ No
	If "Yes": Proceed with one of the following actions. • *Determine Uniform or Site-Specific Standards for risks to excavation workers exposed to contamination in a trench using the VADEQ Trench Model.* • *Select a remedial action to protect excavation workers in a trench and submit a Remedial Action Work Plan.* • *Have off-site property owner restrict excavation on their property with an LUC on the off-site property.* *If "No": Contaminant passes De Minimis groundwater screening for potential off-site exposure to excavation workers.*	

ATTACHMENT 3

VRP Decision Tree: Soil Screening

Screening Notes

Start with Section A for inorganics and Section B for organics.

- Detection limits must be less than or equal to screening levels whenever possible.
- For comparison, use maximum detected concentration or Upper 95% Confidence Level.
- The De Minimis soil screening process does not include the vapor intrusion into buildings exposure pathways. Neither USEPA nor WVDEP allow screening for vapor intrusion using soil concentrations. Therefore, even if volatile organics pass De Minimis soil screening levels, it may be necessary to evaluate vapor intrusion risks associated with volatiles via groundwater or soil gas media.

ATTACHMENT 3

SECTION A: Background for Inorganics		
A1	Does concentration of inorganic exceed background concentration? NOTE: Background levels can be the highest of (a) natural site-specific; (b) natural statewide; or (c) site-specific anthropogenic.	☐ Yes ☐ No
If "Yes": Proceed to Section B. *If "No": Contaminant passes soil screening for residential land use.*		
SECTION B: De Minimis Levels		
B1	Was groundwater sampled for the same COPCs as the soils at the site?	☐ Yes ☐ No
	If "Yes": Skip to Question B3. *If "No": Proceed to Question B2.*	
B2	Did any COPCs that were not sampled in groundwater exceed the default, calculated, or measured Migration to Groundwater screening level for soils?	☐ Yes ☐ No
	If "Yes": Sample groundwater for COPC that exceeded Migration to Groundwater screening levels and follow the Groundwater Screening Decision Tree. *If "No": Proceed to Question B3.*	
B3	Does the concentration exceed Residential Soil De Minimis level?	☐ Yes ☐ No
	If "Yes": Proceed to Question B4. *If "No": Contaminant passes soil screening for residential land use.*	
B4	Is the property currently used for residential purposes other than recreation, or could it be in the future?	☐ Yes ☐ No
	If "Yes": Proceed with one of the following actions. • *Determine Uniform or Site-Specific Standards.* • *Select a remedial action that is protective of residential uses and submit a Remedial Action Work Plan.* • *Restrict residential use of the property with an LUC, which will require the property owner's written consent.* *If "No": Proceed to Question B5.*	
B5	Is the property planned to be used for recreational purposes in the near future?	☐ Yes ☐ No
	If "Yes": Proceed with Site-Specific Standards using the Recreational Exposure Factors in Appendix C and determine if a remedial action is necessary to protect recreators at the site. *If "No": Proceed to Question B6.*	
B6	Is the property planned to be used for recreational purposes in the near future?	☐ Yes ☐ No
	If "Yes": Proceed with one of the following options. • *Determine Uniform or Site-Specific Standards.* • *Select a remedial action that is protective of commercial/industrial uses and submit a Remedial Action Work Plan. This will require an LUC restricting residential use.* *If "No": Contaminant passes industrial soil screening; however, an LUC must be implemented restricting residential use.*	

VRP Decision Tree: Surface Water Screening

Screening Notes

- Surface water should be analyzed for COPCs in soils, groundwater, and sediment.
- Detection limits must be less than or equal to screening levels whenever possible.
- For comparison, use maximum detected concentration or Upper 95% Confidence Level.
- WV Surface Water Standards do not allow for comparison to natural or anthropogenic background; however, WVDEP may evaluate surface water degradation at its discretion.
- The lowest Surface Water Standard is used for screening comparisons, which is usually the value in the column for the "Protection of Human Health" for drinking water and fish ingestion; however, the columns under "Protection of Aquatic Life" should be discussed in the Ecological Risk Assessment.
- Under no circumstances is a site allowed to exceed the applicable surface water quality standards as established in W. Va. Legislative Rule 47CSR2 (Requirements Governing Water Quality Standards).

Surface Water		
1	Does a WV Surface Water Standard exist for the contaminant detected?	☐ Yes ☐ No
	If "Yes": Skip to Question #3. *If "No": Develop benchmarks for relevant ecological and human receptors applicable to the Conceptual Site Model, use the lowest of these benchmarks as your site-specific benchmark, and then proceed to Question #2.* Ecological Receptors: • *Ascertain a Federal Water Quality Standard (e.g., USEPA Region 3 BTAG, USEPA Region 4 ERASG, or NOAA Screening Quick Reference Tables).* • *Develop a Uniform Ecological benchmark according to the VRP Guidance Manual.* Human Receptors: • *Ascertain a benchmark already developed from another state.* • *Ascertain a benchmark already developed from scientific literature.* • *Develop a Uniform Human Health benchmark according to the VRP Guidance Manual (e.g., recreational standard due to incidental ingestion, dermal contact, and/or inhalation of contaminants in surface water).*	
2	Does concentration exceed benchmark?	☐ Yes ☐ No
	If "Yes": Proceed with one of the following actions. • *Determine Uniform or Site-Specific Standards for human and ecological receptors.* • *Select a remedial action that is protective of human and ecological receptors and submit a Remedial Action Work Plan.* *If "No": Contaminant passes surface water screening.*	
3	Does concentration exceed lowest WV Surface Water Standard?	☐ Yes ☐ No
	If "Yes": Select a remedial action that is protective of human and ecological receptors and submit a Remedial Action Work Plan. *If "No": Contaminant passes surface water screening.*	

VRP Decision Tree: Sediment Screening

Screening Notes

Start with Section A for inorganics and Section B for organics.

- Sediment should be analyzed for COPCs in soils, groundwater, and surface water.
- Detection limits must be less than or equal to screening levels whenever possible.
- For comparison, use maximum detected concentration or Upper 95% Confidence Level.
- Sediment concentrations should be screened for ecological receptors. Human receptors to sediment exposures may be screened using the Residential and Industrial De Minimis Standards.

SECTION A: Background for Inorganics		
A1	Does concentration of inorganic exceed background concentration? NOTE: Background levels can be: (a) natural site-specific sediment; (b) natural statewide sediment; (c) natural site-specific soil; (d) natural statewide soil; or (e) site-specific anthropogenic sediment.	☐ Yes ☐ No
If "Yes": Proceed to Section B. *If "No": Contaminant passes sediment screening.*		
SECTION B: Sediment Benchmarks		
B1	Does concentration exceed sediment benchmark for ecological receptors? NOTE: No WV De Minimis levels exist specifically for sediments. Human receptors should have sediment concentrations screened against the WV De Minimis soil standards for residential and industrial receptors. However, recreational receptors can have Uniform Standards developed using the Recreational Exposure Factors in Appendix C. Ecological benchmark criteria can come from: (a) benchmark already developed from another state or federal agency (e.g., USEPA Region 3 BTAG, USEPA Region 4 ERASG, or NOAA Screening Quick Reference Tables); (b) a benchmark already developed from scientific literature; or (c) a Uniform Ecological benchmark developed according to the *VRP Guidance Manual*.	☐ Yes ☐ No
If "Yes": Proceed with one of the following actions. • *Determine Uniform or Site-Specific Standards for the relevant human and ecological receptors.* • *Select a remedial action that is protective of the receptors and submit a Remedial Action Work Plan.* *If "No": Contaminant passes sediment screening.*		

VRP Decision Tree: Vapor Intrusion Screening

Screening Notes

If groundwater samples have been analyzed for VOCs and SVOCs, start with Section A.

If sub-slab or near source soil gas samples have been analyzed, start with Section B.

If indoor air samples have been analyzed, start with Section C.

- Screening samples must have been analyzed for the list of all VOCs and applicable SVOCs (i.e., benzo(a)anthracene and naphthalene) that are COPCs as determined in Phase I or Phase II ESAs.
- Detection limits must be less than or equal to screening levels whenever possible.
- Compare the maximum detected concentration or Upper 95% Confidence Level to the relevant EPA Vapor Intrusion Screening Level (VISL) for groundwater, soil gas, or indoor air. Note that the potential for vapor intrusion cannot be assessed using soil samples.
- The VISL screening process does not include exposures to excavation workers in trenches. WVDEP assumes excavation workers may dig trenches up to 10 feet deep. Excavation worker exposures should include direct contact with soil through the ingestion, dermal, and inhalation pathways, and contact with groundwater through the dermal and inhalation pathways using the VADEQ Trench Model.
- The VISL Calculator allows for residential and commercial exposure scenarios, different risk and hazard index thresholds, and different groundwater temperatures.
    - Residential VISL thresholds should be:
        - Risk = 1E-06
        - HI =1.0.
    - Commercial VISL thresholds should be:
        - Risk = 1E-05
        - HI = 1.0
    - The default groundwater temperature for WV should be 13°C, but site-specific groundwater temperatures are recommended.
- It is recommended that groundwater samples be screened for vapor intrusion before proceeding to collect sub-slab or near source soil gas samples. Similarly, it is recommended that sub-slab or near source soil gas be screened for vapor intrusion before proceeding to collect indoor air samples. Due to the likelihood of confounding sources of vapors, collecting indoor air samples may not be necessary.

ATTACHMENT 3

SECTION A: Vapor Intrusion via Groundwater		
A1. On-Site Vapor Intrusion		
A1-a	Do on-site groundwater chemical concentrations or modeled future concentrations of the contaminant and related breakdown products exceed residential VISL benchmarks?	☐ Yes ☐ No
	If "Yes": Proceed to Question A1-b. *If "No": Contaminant passes De Minimis vapor intrusion screening, and no further action is required for the potential of on-site vapor intrusion.*	
A1-b	Is the property currently used for residential purposes, or could it be in the future?	☐ Yes ☐ No
	If "Yes": Proceed with one of the following actions. • *Determine Uniform or Site-Specific Standards for vapor intrusion into residences due to contaminated on-site groundwater.* • *Select a remedial action for vapor intrusion due to contaminated on-site groundwater and submit a Remedial Action Work Plan.* • *Restrict residential use of site with an LUC and screen groundwater for commercial uses.* • *Sample on-site sub-slab or near source soil gas as the next line of evidence for potential vapor intrusion and proceed to Section B for further screening.* *If "No": Proceed to Question A1-c.*	
A1-c	Do on-site groundwater chemical concentrations or modeled future concentrations of the contaminant and related breakdown products exceed commercial VISL benchmarks?	☐ Yes ☐ No
	If "Yes": Proceed with one of the following actions. • *Determine Uniform or Site-Specific Standards for vapor intrusion into a commercial/industrial building due to contaminated on-site groundwater.* • *Select a remedial action for vapor intrusion due to contaminated on-site groundwater and submit a Remedial Action Work Plan.* • *Sample on-site sub-slab or near source soil gas as the next line of evidence for potential vapor intrusion and proceed to Section B for further screening.* *If "No": Contaminant passes De Minimis vapor intrusion screening for a commercia/industrial setting, and no further action is required for the potential of vapor intrusion as long as the property use does not change, which may require an LUC restricting residential use of the property.*	
A2. Off-Site Vapor Intrusion		
A2-a	Do off-site groundwater chemical concentrations or modeled future concentrations of the contaminant and related breakdown products exceed residential VISL benchmarks?	☐ Yes ☐ No
	If "Yes": Proceed to Question A2-b. *If "No": Contaminant passes De Minimis vapor intrusion screening, and no further action is required for the potential of off-site vapor intrusion.*	
A2-b	Is the off-site property currently used for residential purposes, or could it be in the future?	☐ Yes ☐ No
	If "Yes": Proceed with one of the following actions. • *Determine Uniform or Site-Specific Standards for vapor intrusion into residences due to contaminated off-site groundwater.* • *Select a remedial action for vapor intrusion due to contaminated off-site groundwater and submit a Remedial Action Work Plan.* • *Obtain written consent from off-site property owner to allow contaminant migration onto their property.* • *Have off-site property owner restrict residential use of site and evaluate the potential of vapor intrusion for a commercial/industrial site.*	

	• *Sample off-site sub-slab or near source soil gas as the next line of evidence for potential vapor intrusion and proceed to Section B for further screening.* *If "No": Proceed to Question A2-c.*	
A2-c	Do off-site groundwater chemical concentrations or modeled future concentrations of the contaminant and related breakdown products exceed commercial VISL benchmarks?	☐ Yes ☐ No
	If "Yes": Proceed with one of the following actions. • *Determine Uniform or Site-Specific Standards for vapor intrusion into a commercial/industrial building due to contaminated off-site groundwater.* • *Select a remedial action for vapor intrusion due to contaminated off-site groundwater and submit a Remedial Action Work Plan.* • *Sample off-site sub-slab or near source soil gas as the next line of evidence for potential vapor intrusion and proceed to Section B for further screening.* *If "No": Contaminant passes De Minimis vapor intrusion screening for a commercia/industrial setting, and no further action is required for the potential of vapor intrusion as long as the property use does not change, which may require an LUC restricting residential use of the off-site property.*	
SECTION B: Vapor Intrusion via Sub-Slab or Near Source Soil Gas		
B1. On-Site Vapor Intrusion		
B1-a	Do on-site sub-slab or near source soil gas chemical concentrations of the contaminant exceed residential VISL benchmarks?	☐ Yes ☐ No
	If "Yes": Proceed to Question B1-b. *If "No": Contaminant passes De Minimis vapor intrusion screening, and no further action is required for the potential of on-site vapor intrusion.*	
B1-b	Is the property currently used for residential purposes, or could it be in the future?	☐ Yes ☐ No
	If "Yes": Proceed with one of the following actions. • *Determine Uniform or Site-Specific Standards for vapor intrusion into residences due to contaminated on-site soil gas.* • *Select a remedial action for vapor intrusion due to contaminated on-site soil gas and submit a Remedial Action Work Plan.* • *Restrict residential use of site with an LUC and screen soil gas for commercial uses.* • *Sample on-site indoor air as the next line of evidence for potential vapor intrusion and proceed to Section C for further screening.* *If "No": Proceed to Question B1-c.*	
B1-c	Do on-site sub-slab or near source soil gas chemical concentrations of the contaminant exceed commercial VISL benchmarks?	☐ Yes ☐ No
	If "Yes": Proceed with one of the following actions. • *Determine Uniform or Site-Specific Standards for vapor intrusion into a commercial/industrial building due to contaminated on-site soil gas.* • *Select a remedial action for vapor intrusion due to contaminated on-site soil gas and submit a Remedial Action Work Plan.* • *Sample on-site indoor air as the next line of evidence for potential vapor intrusion and proceed to Section C for further screening.* *If "No": Contaminant passes De Minimis vapor intrusion screening for a commercial/industrial setting, and no further action is required for the potential of vapor intrusion as long as the property use does not change, which may require an LUC restricting residential use of the property.*	

B2. Off-Site Vapor Intrusion		
B2-a	Do off-site sub-slab or near source soil gas chemical concentrations of the contaminant exceed residential VISL benchmarks?	☐ Yes ☐ No
	If "Yes": Proceed to Question B2-b. *If "No": Contaminant passes De Minimis vapor intrusion screening, and no further action is required for the potential of off-site vapor intrusion.*	
B2-b	Is the off-site property currently used for residential purposes, or could it be in the future?	☐ Yes ☐ No
	If "Yes": Proceed with one of the following actions. • *Determine Uniform or Site-Specific Standards for vapor intrusion into residences due to contaminated off-site soil gas.* • *Select a remedial action for vapor intrusion due to contaminated off-site soil gas and submit a Remedial Action Work Plan.* • *Obtain written consent from off-site property owner to allow contaminant migration onto their property.* • *Have off-site property owner restrict residential use of site and evaluate the potential for vapor intrusion of a commercial/industrial site.* • *Sample off-site indoor air as the next line of evidence for potential vapor intrusion and proceed to Section C for further screening.* *If "No": Proceed to Question B2-c.*	
B2-c	Do off-site sub-slab or near source soil gas chemical concentrations of the contaminant exceed commercial VISL benchmarks?	☐ Yes ☐ No
	If "Yes": Proceed with one of the following actions. • *Determine Uniform or Site-Specific Standards for vapor intrusion into a commercial/industrial building due to contaminated off-site soil gas.* • *Select a remedial action for vapor intrusion due to contaminated off-site soil gas and submit a Remedial Action Work Plan.* • *Sample off-site indoor air as the next line of evidence for potential vapor intrusion and proceed to Section C for further screening.* *If "No": Contaminant passes De Minimis vapor intrusion screening for a commercial/industrial setting, and no further action is required for the potential of vapor intrusion as long as the property use does not change, which may require an LUC restricting residential use of the off-site property.*	
SECTION C: Vapor Intrusion via Indoor Air		
C1. On-Site Vapor Intrusion		
C1-a	Do on-site indoor air chemical concentrations of the contaminant exceed residential VISL benchmarks?	☐ Yes ☐ No
	If "Yes": Proceed to Question C1-b. *If "No": Contaminant passes De Minimis vapor intrusion screening, and no further action is required for the potential of on-site vapor intrusion. However, future buildings will need to be assessed by screening sub-slab or near source soil gases in Section B or requiring vapor mitigation on all new buildings via an LUC.*	
C1-b	Is the property currently used for residential purposes, or could it be in the future?	☐ Yes ☐ No
	If "Yes": Proceed with one of the following actions. • *Determine Uniform or Site-Specific Standards for vapor intrusion into residences due to contaminated indoor air.* • *Select a remedial action for vapor intrusion due to contaminated indoor air and submit a Remedial Action Work Plan.*	

	• *Restrict residential use of site with an LUC and screen indoor air for commercial uses.* *If "No": Proceed to Question C1-c.*	
C1-c	Do on-site indoor air chemical concentrations of the contaminant exceed commercial VISL benchmarks?	☐ Yes ☐ No
	If "Yes": Proceed with one of the following actions. • *Determine Uniform or Site-Specific Standards for vapor intrusion into a commercial/industrial building due to contaminated indoor air.* • *Select a remedial action for vapor intrusion due to contaminated indoor air and submit a Remedial Action Work Plan.* *If "No": Contaminant passes De Minimis vapor intrusion screening for a commercial/industrial setting, and no further action is required for the potential of vapor intrusion as long as the property use or the building do not change, which may require an LUC restricting residential use of the property and requiring vapor intrusion assessment for any new buildings.*	
C2. Off-Site Vapor Intrusion		
C2-a	Do off-site indoor air chemical concentrations of the contaminant exceed residential VISL benchmarks?	☐ Yes ☐ No
	If "Yes": Proceed to Question C2-b. *If "No": Contaminant passes De Minimis vapor intrusion screening, and no further action is required for the potential of off-site vapor intrusion. However, future buildings will need to be assessed by screening sub-slab or near source soil gases in Section B or requiring vapor mitigation on all new buildings via an LUC.*	
C2-b	Is the off-site property currently used for residential purposes, or could it be in the future?	☐ Yes ☐ No
	If "Yes": Proceed with one of the following actions. • *Determine Uniform or Site-Specific Standards for vapor intrusion into residences due to contaminated indoor air.* • *Select a remedial action for vapor intrusion due to contaminated indoor air and submit a Remedial Action Work Plan.* • *Obtain written consent from off-site property owner to allow contaminant migration onto their property.* • *Have off-site property owner restrict residential use of site and evaluate the potential of vapor intrusion for a commercial/industrial site.* *If "No": Proceed to Question C2-c.*	
C2-c	Do off-site indoor air chemical concentrations of the contaminant exceed commercial VISL benchmarks?	☐ Yes ☐ No
	If "Yes": Proceed with one of the following actions. • *Determine Uniform or Site-Specific Standards for vapor intrusion into a commercial/industrial building due to contaminated indoor air.* • *Select a remedial action for vapor intrusion due to contaminated indoor air and submit a Remedial Action Work Plan.* *If "No": Contaminant passes De Minimis vapor intrusion screening for a commercial/industrial setting, and no further action is required for the potential of vapor intrusion as long as the property use or the building do not change, which may require an LUC restricting residential use of the off-site property and requiring vapor intrusion assessment for any new buildings.*	

ATTACHMENT 4

Attachment 4: Figures and Tables Formatting Guidance

The Formatting Figures and Tables Guidance suggests the format for submitted figures and tables in VRP work plans and reports; however, the exact format is not required. Use of the suggested format will facilitate the review/comment and response-to-comment process, thereby expediting movement of a site through the program and ultimately obtaining the Certificate of Completion.

Formatting Figures and Tables Guidance

Figures

Figures should include the following elements:

- Figure #
- Name and Address of Site
- Legend
- Scale Bar
- North Arrow
- Revision #

VRP reports must include figures in a single section, with the following suggested figures listed below.

- Figure 1: Site Location Map (generally in the context of a USGS topographic map), including:
  - Location of any Wellhead Protection Areas within 1 mile of the site
  - Location of any Zones of Critical Concern for surface drinking water sources within 3 miles of the site
- Figure 2: Site Drawing, including:
  - Boundary lines and property lines
  - Current and former buildings
  - Waste units, ASTs, and USTs
  - Underground utilities, storm water drains, storm sewers, surface water drainage features, and other potential contaminant migration pathways
- Sample Location Map(s) – *May include all elements below one map or multiple maps.*
  - Surface soil samples
  - Boring (subsurface soil sample locations)
  - Monitoring wells (groundwater sample locations)
  - Soil vapor points (soil gas sample locations)
  - Sediment and surface water sample locations
- Contaminants of Potential Concern Concentration Map(s), including:
  - Concentrations of COCs that exceed the relevant standard for the medium (e.g., Residential De Minimis, Groundwater De Minimis, or BTAG standards) by sample locations or in data table on map (also included in text).
  - *NOTE: In some cases, isoconcentration contours may be useful in depicting the distribution of contaminants in the various media.*
- Potentiometric Surface Map(s), showing:

  - Monitoring well locations and elevation values used to develop groundwater contours.
  - *NOTE: Use light blue lines for contours. In cases where multiple flow zones are present, multiple figures will generally be necessary to adequately depict this information.*

- Geologic Cross Section Map(s), depicting:
  - Soil and bedrock strata
  - Boring and monitoring well locations
  - Sample intervals
  - Groundwater levels
  - *NOTE: Cross sections may not necessary for smaller sites, or where contaminants are limited to surface soil and shallow subsurface soil.*

- Conceptual Site Model, including the following elements:
  - Sources
  - Media
  - Pathways (denote potentially complete and/or actually complete pathways)
  - Routes
  - Receptors
  - *NOTE: Conceptual Site Models for human and ecological receptors may be separated into different figures or combined on one figure.*

Tables

VRP reports must include tables in a single section. When presenting data in tables, always:

- Arranged data in descending chronological order from most recent to oldest historical samples, and discuss any apparent time trends in the text, especially in the context of natural attenuation.
- Highlight or bold COCs (target analytes that exceed screening values for each sample).
  - Use separate highlight color for those constituents that are less than the detection limit, but the detection limit exceeds the relevant screening level.

Presenting Soil Data in Tables

- Report results and detection limits in mg/kg.
- Present surface soil and subsurface in two separate tables as distinct media and include:
  - Target analytes (chemical names)
  - CAS numbers
  - Residential and Industrial De Minimis values for screening

- Date sample was collected
- Results of analysis or detection limit if non-detect
  - use "<numerical value" of detection limit ("<0.001") rather than "ND"

- The default, calculated, or measured Migration to Groundwater screening levels may also be used to screen which target analytes need to be sampled in groundwater.

Presenting Groundwater Data in Tables

- Report results and detection limits in µg/L.
- Provide first table that indicates boring log/monitoring well gauging information, such as:
  - Date
  - Top-of-casing elevation
  - Depth to NAPL and depth to water
  - NAPL surface elevation and water surface elevation
  - NAPL thickness
  - Corrected water surface elevation
  - Elevation and depth of screened interval
  - Total depth of boring/well
  - Any aquifer test results
- Provide second table that includes:
  - Target analytes (chemical names)
  - CAS numbers
  - Groundwater De Minimis values for screening
  - Residential and Industrial Vapor Intrusion Screening Level (USEPA VISL) values for screening (if applicable)
  - Date sample was collected
  - Results of analysis or detection limit if non-detect
    - use "<numerical value" of detection limit ("<0.001") rather than "ND"

Presenting Surface Water Data in Tables

- Report results and detection limits in µg/L.
- Provide a table that includes:
  - Target analytes (chemical names)
  - CAS numbers
  - Relevant screening levels (e.g., BTAG or ERASG)
  - Date sample was collected

- Distance from bank
- Depth of sample from water/air interface
- Results of analysis or detection limit if non-detect
  - use "<numerical value" of detection limit ("<0.001") rather than "ND"

Presenting Sediment Data in Tables

- Report results and detection limits in mg/kg.
- Provide a table that includes:
  - Target analytes (chemical names)
  - CAS numbers
  - Relevant screening levels (e.g., BTAG or ERASG)
  - Date sample was collected
  - Distance from bank
  - Depth of sediment sampled
  - Results of analysis or detection limit if non-detect
    - use "<numerical value" of detection limit ("<0.001") rather than "ND"

Presenting Soil Gas Data in Tables

- Report results and detection limits in $\mu g/m^3$.
- Present a table that includes:
  - Target analytes (chemical names)
  - CAS numbers
  - Residential and Industrial Vapor Intrusion Screen Level (USEPA VISL) values for screening sub-slab and near source soil gas
  - Date sample was collected
  - Depth of well sampled
  - Results of analysis or detection limit if non-detect
    - use "<numerical value" of detection limit ("<0.001") rather than "ND"

Presenting Indoor Air/Ambient Air Data Tables

- Report results and detection limits in $\mu g/m^3$.
- Present a table that includes:
  - Target analytes (chemical names)
  - CAS numbers

- Residential and Industrial Vapor Intrusion Screen Level (USEPA VISL) values for screening indoor air
- Date sample was collected
- Either:
  - *Indoor Air*: Height above floor for indoor air samples
  - *Ambient Air*: Height above the ground surface, wind direction, and wind speed
- Barometric pressure and temperature
- Depth of well sampled
- Results of analysis or detection limit if non-detect
  - use "<numerical value" of detection limit ("<0.001") rather than "ND"

Presenting Summary Tables

- Provide a summary table showing the COPC screening process and he justification for their elimination or inclusion as COCs for each medium that includes the following columns (and discuss the justification in the text):
  - Chemical name
  - CAS number
  - Units
  - Detection Limit (or range thereof)
  - Number of detections/number of analytes analyzed
  - Range of detected concentrations or actual data (if only a few samples were taken)
  - Location of maximum concentration
  - Exposure Point Concentration used for screening, which would be the lower of the 95% UCL or the maximum value (mean for Lead)
  - Screening criteria (e.g., De Minimis)
  - Background concentration (if applicable)
  - Indication if retained as a COC (yes or no)
  - Reason for retaining or not retaining the COPC as a COC (e.g., Below Screening Level)

Presenting Risk Tables

- Provide tables showing all of the values of the parameters used to calculate hazard quotients (HQ) and hazard indices (HI) and Excess Lifetime Cancer Risks (ELCR), if applicable. These tables may include:
  - A table of exposure factors (e.g., Exposure Frequency, Soil Ingestion Rate, etc.)
  - A table of chemical-specific data depending on pathways assessed (e.g., Molecular Weight, Henry's Law Constant, Partition Coefficient, etc.)
  - A table of toxicity data for each COC, including:

- Oral Cancer Slope Factor (CSF)
- Reference Dose (RfD), chronic and subchronic
- Inhalation Unit Risk (IUR)
- Reference Concentration (RfC), chronic and subchronic
- Mutagenic potential
- Target organs/systems or critical effect
- Sources of the values (e.g., IRIS, PPRTV, HEAST, ATSDR, and CalEPA)

- Provide a table showing results of the calculation of HQ, HI, and ELCR. These tables should include:
  - Chemical names
  - CAS numbers
  - Exposure Point Concentrations for each chemical, pathway, route, and receptor
  - Results of HQ and ECLR for each chemical, pathway, and route of exposure
  - Sum of the results for the cumulative HI and ECLR for each chemical, pathway, route of exposure, and receptor

  Note that HQ/HI and ELCR results may be presented in separate tables or combined. It may be most efficient to organize each risk table to include the HQ/HI and ELCR results for a single receptor. Equations used to calculate the HQ/HI and ECLR are required to be presented within the text of the Risk Characterization section, but the equations should also be provided as part of the footnotes to the table(s).

ATTACHMENT 5

Attachment 5: Risk Assessment Report Format Guidance

The Risk Assessment Report Format Guidance suggests the format for submitted Risk Assessment Reports; however, this exact format is not required. Use of the suggested format will facilitate the review/comment and response-to-comment process, thereby expediting movement of a site through the program and ultimately obtaining the Certificate of Completion.

ATTACHMENT 5

Risk Assessment Report

Site Name

City and County

VRP Project Number

Submittal Date

<u>VRP Applicant Information</u>
Company Name
Address
Contact Name, Position
Phone
Email

<u>Preparer Information</u>
Licensed Remediation Specialist Name and No.
Company Name
Address
Phone
Email

<u>Risk Assessor Information (if different than LRS)</u>
Name
Company Name
Address
Phone
Email

LRS Company's Project No.

ATTACHMENT 5

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2.2 General History and Land Use	X
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3.0 SITE ASSESSMENT AND IDENTIFICTION OF CHEMICALS OF CONCERN	X
3.1 Site Assessment and Supplemental Site Assessment Activities	X
3.2 Chemicals of Concern (COC)	X
3.3 Conceptual Site Model (CSM)	X
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4.0 HUMAN HEALTH EXPOSURE AND RISK ASSESSMENT	X
4.1 Exposure Assessment	X
4.2 Toxicity Assessment	X
4.3 Risk Characterization	X
5.0 ECOLOGICAL RISK ASSESSMENT	X
5.1 De Minimis Ecological Screening Analysis	X
5.2 Uniform Ecological Screening (if applicable)	X
5.3 Site-Specific Ecological Risk Assessment (if applicable)	X
6.0 UNCERTAINITY ANALYSIS	X
6.1 Data and Exposure Point Concentrations	X
6.2 Toxicity	X
6.3 Chemical Interactions	X
6.4 Exposure Factors	X
7.0 CONCLUSIONS AND RECOMMEDATIONS	X
7.1 Summary	X
7.2 Conclusions	X
7.3 Recommendations	X
8.0 REFERENCES	X

ATTACHMENT 5

1.0 EXECUTIVE SUMMARY

2.0 SITE DESCRIPTION AND HISTORY

2.1 Site Location and Description

- Geographic location (*reference Figure 1*)
- Description of physical setting of site and surround area (*reference Figure 2*)
- Significant site reference points

2.2 General History and Land Use

2.2.1 Historical Land Use

- Ownership, operations, chemical usage

2.2.2 Current Land Use

- Ownership, operations, chemical usage

2.2.3 Anticipated Future Land Use

2.2.4 Adjacent Property Land Use

2.3 Geology

- Geologic Cross Section map?

2.4 Hydrogeology

- Potentiometic Surface map?

2.5 Previous Site Investigations

3.0 SITE ASSESSMENT AND IDENTIFICATION OF CHEMICALS OF CONCERN

3.1 Site Assessment and Supplemental Site Assessment Activities (*reference applicable data tables*)

3.1.1 Chemicals of Potential Concern in Soils

3.1.2 Chemicals of Potential Concern in Groundwater (reference GW/NAPL gauging data table)

3.1.3 Chemicals of Potential Concern in Surface Water

3.1.4 Chemicals of Potential Concern in Sediment

3.1.5 Chemicals of Potential Concern in Vapor Intrusion

3.2 Chemicals of Concern (*reference applicable screening tables*)

3.2.1 Chemicals of Concern in Soil

3.2.2 Chemicals of Concern in Groundwater

3.2.3 Chemicals of Concern in Surface Water

3.2.4 Chemicals of Concern in Sediment

3.2.5 Chemicals of Concern in Vapor Intrusion

3.2.6 Summary of COCs

VRP #, Site Name, Baseline/Residual Risk Assessment

3.3 Conceptual Site Model (*reference CSM diagram or figure*)
3.3.1 Sources of contamination and receiving media
3.3.2 Migration pathways
3.3.3 Exposure points and exposure routes
3.3.4 Receptors

3.4 Checklist to Determine Applicable Remediation Standards
- Report results and attached checklists as an appendix

4.0 HUMAN HEALTH EXPOSURE AND RISK ASSESSMENT

4.1 Exposure Assessment
4.1.1 Incomplete Exposure Pathways
- Explanation of why each pathway is incomplete
- Availability of public water supply
- Deed restrictions or land use covenants
- Engineering and institutional controls
- Geology or hydrogeology of site
- Fate and transport characteristics of chemicals of concern

4.1.2 Complete Exposure Pathways
- Pathways evaluated qualitatively
- Pathways evaluated quantitatively
  - Exposure point concentrations
  - Exposure models, equations, and corresponding parameter values
  - Estimated chemical intake values for each pathway

4.2 Toxicity Assessment (*reference toxicity tables*)
4.2.1 Noncarcinogens
- Reference Dost (RfD)
- Reference Concentrations (RfC)

4.2.2 Carcinogens
- Oral Cancer Slope Factor (CSF)
- Inhalation Unit Risk (IUR)

4.3 Risk Characterization
4.3.1 Risk Estimation Methods (reference risk estimation tables)
- Noncarcinogen Hazard Estimation Methods
- Cancer Risk Estimation Methods

4.3.2 Risk Assessment Results (reference risk results tables)
- Noncancer Hazard Quotients and Hazard Indices
- Cancer Risks

VRP #, Site Name, Baseline/Residual Risk Assessment

5.0 ECOLOGICAL RISK ASSESSMENT

5.1 De Minimis Ecological Screening Evaluation

- Conceptual Site Model
- Evidence of readily apparent harm
- Surface water data (if applicable)
- Sediment data (if applicable)
- Checklist to Determine Applicable Remediation Standards

5.2 Uniform Ecological Screening (if applicable)

5.2.1 Ecological Chemicals of Potential Concern

5.2.2 Ecological Chemicals of Concern

- Compare COPC to relevant Ecological Benchmarks

5.3 Site-Specific Ecological Risk Assessment (if applicable)

5.3.1 Ecological Exposure Assessment

5.3.1.1 Incomplete Exposure Pathways

- Explanation of why each pathway is incomplete
- Engineering and institutional controls
- Geology or hydrogeology of site
- Fate and transport characteristics of chemicals of concern

5.3.1.2 Complete Exposure Pathways

- Pathways evaluated qualitatively
- Pathways evaluated quantitatively
  - Exposure point concentrations
  - Exposure models, equations, and corresponding parameter values
  - Estimated chemical intake values for each pathway

5.3.2 Ecological Toxicity Assessment

5.3.3 Ecological Risk Characterization

5.3.3.1 Ecological Risk Estimation Methods

5.3.3.2 Ecological Risk Assessment Results

6.0 UNCERTAINTY ANALYSIS

6.1 Data and Exposure Point Concentrations

6.2 Toxicity Values

6.3 Chemical Interactions

6.4 Exposure Factors

VRP #, Site Name, Baseline/Residual Risk Assessment

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 Summary

- Site history and land use
- Chemicals of concern
- Exposure assessment
- Risk characterization

7.2 Conclusions

- Risks to human health
- Risks to ecological receptors

7.3 Recommendations

- Proposed engineering and institutional controls
- Proposed remedial actions

8.0 REFERENCES

TABLES

See the *Figures and Tables Formatting Guidance* for details on the necessary tables, the required information for each table, and how to format tables.

FIGURES

See the *Figures and Tables Formatting Guidance* for details on the necessary figures, the required information for each figure, and how to format figures.

APPENDICES

Required Appendices:

- Checklist to Determine Applicable Remediation Standards
- *ProUCL* 95% Upper Confidence Limit Calculations Output (if applicable)
- USEPA Vapor Intrusion Screening Level (VISL) output (if applicable)
- Output of any model used in the risk assessment (e.g., BIOCHLOR, BIOSCREEN, Johnson &Ettinger, etc.), including the required Sensitivity Analysis

Optional Appendices that can be referenced to the Site Assessment Report:

- Boring Logs
- Chain(s) of Custody for Samples
- Chemical Analysis Output
- Data Validation Report

ATTACHMENT 6

Attachment 6: Site Assessment Work Plan (SAWP) Checklist

The Site Assessment Work Plan (SAWP) Checklist contains elements that should be included in each SAWP submitted to WVDEP for review. The checklist was created to assist Applicants and Licensed Remediation Specialists in gathering information necessary for a complete and thorough review to ensure the work plan is approved as quickly as possible.

ATTACHMENT 6

Site Assessment Work Plan (SAWP) Checklist

Site Information	
	General Description – street address, size, tax parcels, ownership, site access, adjoining property uses, etc. *Provide figures that clearly depict site boundary overlaid on a topographic map, road map, and aerial, as appropriate. Label structures and areas of concern.*
	Physical/Geological Description – topography, soils, geology, depth to bedrock, depth to groundwater and flow direction, etc.
	Site History – current and historical uses of site and adjoining properties, known/suspected locations of contamination, any previous assessment or remediation, summary of any previous data collected, etc.
Personnel	
	Identification of Project Personnel – including contractors and subcontractors
	Project Chain of Command and Project Roles
	Personnel Training Requirements
	Identification of WVDEP Certified Laboratory
Samples	
	Sample Locations (both assessment and background) – organized by environmental matrices, presented in both tabular format and figures
	Rationale/Justification for Locations, Numbers, and Types of Samples
	Sample Collection Techniques – *Attach Standard Operating Procedures, if appropriate.*
	Description, Number, and Rationale for Quality Control Samples – field duplicates, equipment rinsate, trip blanks, MS/MD, etc.
	Field Screening Techniques and/or Field Data Collection – summary of technique, equipment used, calibration and maintenance requirements, appropriateness of method, etc.
	Sample Handling, Labeling, Preservation, and Chain of Custody Requirements
	Decontamination Procedures
Laboratory Analysis	
	Discussion of Specific Analytical Methods – including a tabular presentation of compound/analyte lists, project required reporting limits, etc.
	Applicable Regulations and Action Limit Rationale
	Data Quality Objectives, Level of Data Validation Required, Number/Percentage of Samples to be Validated
Documentation	
	Data Acquisition and Management Process – including sample documentation, field logbooks, boring logs, photographs, recording of non-direct measurements, and any other data collection requirements
	Investigation Derived Waste Storage, Documentation, Transportation, and Disposal Process
	Site-Specific Health and Safety Plan (HASP)
	Quality Assurance Project Plan (QAPP)
	Project Schedule

Attachment 7: Quality Assurance Project Plan (QAPP) Checklist

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The Quality Assurance Project Plan (QAPP) Checklist contains elements that should be included in each QAPP submitted to WVDEP for review. The checklist was created to assist Applicants and Licensed Remediation Specialists in gathering information necessary for a complete and thorough review to ensure the QAPP is approved as quickly as possible.

ATTACHMENT 7

Quality Assurance Project Plan (QAPP) Checklist

Site Information	
	General Description – street address, size, topography, soils, geology, and groundwater
Personnel	
	Identification of Project Personnel – including contractors and subcontractors
	Project Chain of Command and Project Roles – including contact information
	Personnel Training Requirements
	Identification of WVDEP Certified Laboratory
Field Quality Assurance	
	Listing of Samples to be Collected (both assessment and background) – organized by environmental matrices and analytical methods, presented in tabular format
	Description, Number, and Rationale for Quality Control Samples – field duplicates, equipment rinsate, trip blanks, MS/MD, etc.
	Sample Handling, Labeling, Preservation, and Chain of Custody Requirements
	Assessment and Oversight Activities – including performance and system audits for both field and lab, and the frequency for oversight of field activities
Laboratory Analysis	
	Discussion Specific Analytical Methods – including a tabular presentation of compound/analyte lists, project required reporting limits, etc.
	Analytical Methods – including standard operating procedures and discussion of method detection limit issues
	Required Laboratory Quality Control – detection and reporting limits, calibrations, method blanks, laboratory control samples, etc.
	Instrument/Equipment Maintenance and Calibration Frequency
	Applicable Regulations and Action Limit Rationale
	Data Quality Indicators
	Data Quality Objectives, Level of Data Validation Required, Number/Percentage of Samples to be Validated
	Discussion of the Methodology and Level of Data Validation

Attachment 8: Data Validation Report Checklist

The Data Validation Report Checklist contains elements that should be included in each Data Validation Report submitted to WVDEP for review. The checklist was created to assist Applicants and Licensed Remediation Specialists in gathering information necessary for a complete and thorough review to ensure the data validation report is approved as quickly as possible.

Data Validation Report Checklist

Project Narrative	
	General Overview or Summary Narrative of Validation Project
	Summary of Samples, Media, Laboratory, and Analytical Methods Validated
	Statement Defining Level of Data Validation Performed (i.e., Stage 4) and Reference to Its Scope (i.e., EPA guidance, the QAPP, etc.) *If a reduced level of data validation was applied, clarify who approved and why.*
	Reference to Methodology Applied in Data Validation (i.e., data is being reviewed in accordance with National Functional Guidelines)
	Identification of Personnel Performing Data Validation and Qualifications (i.e., degree in chemistry and/or copy of resume/experience summary)
	Conclusion Statements Concerning Overall Data Usability – including if the data met the data quality objectives of the project
Quality Assurance Review	
	Overview/Summary of Validation Activities
	Major and Minor Issues/Problems Associated with Analysis or Laboratory Deliverable
	Description of Qualified Data and Reasons for Qualification
	QC Measures Related to Specific Analysis – discussed in the context that they were reviewed and any impact to the data
	Supplemental Documentation
	List of Data Validation Qualifiers and Key to Meaning (i.e., J = Estimated Value)
	Copies of Chain of Custody Records and Laboratory Case Narratives
	Summary of Data with Data Validation Qualifiers – tabulated or hand corrected laboratory reports
	Supporting Documentation with Changes Made or Notes as to Why Data Was Impacted (i.e., data validator should notate on analytical sheets, but should not obliterate the original document)

ATTACHMENT 9

Attachment 9: UECA-LUST Process Checklist

The UECA-LUST Checklist is a process checklist to guide Applicants and Licensed Remediation Specialists through the UECA-LUST process, from entering the site into the program to obtaining closure with a No Further Action letter. Following the outlined process will ensure that Applicants receive site closure as quickly as possible.

ATTACHMENT 9

UECA-LUST Process Checklist

Program Application	
	LUST Responsible Party/Applicant submits Notice of Intent to enter LUST site into program.
	LUST Tanks Corrective Action Unit (TCAU) Program Manager reviews LUST file for any enforcement violations for site and emails determination to OER.
	UECA-LUST Applicant signs and submits UECA-LUST Agreement for DLR Director signature. *If property owner differs from UECA-LUST Applicant, property owner must sign Agreement to agree to any potential activity and use limitations (AULs).*
Assessment	
	LRS conducts initial site visit with OER Project Manager, OER Environmental Toxicologist, and Applicant's risk assessor. Parties review all currently available assessment data and the conceptual site model (CSM) and agree on the scope of work required to meet UECA-LUST data quality objectives. *See analyte table below for gasoline and diesel releases.*
	Applicant submits Site Assessment Work Plan (SAWP) with Health and Safety Plan (HASP) and Quality Assurance Project Plan (QAPP).
	OER Project Manager reviews and either approves SAWP or sends comment letter.
	Upon SAWP approval, OER Project Manager sends a cost estimate letter to Applicant with an approximate cost of WVDEP's oversight to bring project to closure.
	Applicant submits Site Assessment Report (SAR). *Surface soil, subsurface soil, and groundwater contamination must be vertically and horizontally delineated. Sediment, surface water, and soil gas sampling may also be required.*
	OER Project Manager reviews and either approves SAR or sends comment letter.
Risk Assessment	
	Applicant submits Human Health and Ecological Risk Assessment (HHERA). *If only remedial action is institutional controls, HHERA can be combined with Remedial Action Work Plan (RAWP). A draft Land Use Covenant (LUC) must also be provided with the HHERA/RAWP.*
	OER Environmental Toxicologist reviews and either approves HHERA or provides comments.
Remedial Action	
	Upon HHERA approval, Applicant submits RAWP with draft LUC, as necessary.
	OER Project Manager reviews and either approves RAWP or sends comment letter.
	Upon RAWP approval, OER files public notice in the local newspaper to fulfill public participation requirements as mandated by 40CFR280.67.
	Applicant submits Remedial Action Completion Report, as necessary.
	OER Project Manager reviews and either approves report or sends comment letter.
	Applicant signs, notarizes, and submits original LUC for DLR Director signature.

	Applicant records LUC to property deed and returns original document to WVDEP.
Project Closure	
	Applicant submits Final Report.
	OER Project Manager reviews and either approves Final Report or sends comment letter.
	Applicant abandons monitoring wells and submits documentation to WVDEP's Groundwater Office and OER Project Manager, unless post-NFA groundwater monitoring is necessary.
	Upon Final Report approval, monitoring well abandonment documentation submittal (as appropriate), LUC recording, and payment of all WVDEP invoices older than 6 months, WVDEP issues No Further Action (NFA).
Long-Term Monitoring	
	Property owner submits LUC inspection reports (and post-NFA MNA Monitoring Reports, as applicable) to WVDEP annually.

Analyte Table

Analyte	Gasoline Releases	Diesel Releases
BTEX	✓	✓
Lead *(if release occurred before 1988)*	✓	
MTBE *(if release occurred between 1990-2006)*	✓	
Naphthalene	✓	
PAHs		✓
TBA *(if released occurred between 1990-2006)*	✓	
1,2,4- and 1,3,5-Trimethylbenzenes	✓	✓