



Bureau of Underground Storage Tank Regulations

Technical Guidance Manual

For 1999 Closure and Corrective Action Rules

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Ohio Department of Commerce
Division of State Fire Marshal
Bureau of Underground Storage Tank Regulations
6606 Tussing Road P.O. Box 687
Reynoldsburg, OH 43068-9009
(614) 752-7938 FAX (614) 752-7942

<https://www.com.state.oh.us/odoc/sfm/BUSTR>

ACKNOWLEDGEMENTS

BUSTR Committee Members

Jason Anthony
Dave Biskner
Ray Ladrick
Mark Rickrich
Brian Tarver
Charlie Zepp

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Common Acronyms

ACOC(s)	additional chemical(s) of concern
AL(s)	action level(s)
API	American Petroleum Institute
ASTM	American Society of Testing and Materials
BDL	below detection limit
BQL	below quantitation limit
BTEX	benzene, toluene, ethylbenzene, xylene
BUSTR	Bureau of Underground Storage Tank Regulations
CA	corrective action
COC(s)	chemical(s) of concern
CUSTI	Certified Underground Storage Tank Inspector
FID	flame ionization detector
FPR	free product recovery
GPS	global positioning system
HEAST	Health Effects Assessment Summary Tables
HSA	hollow stem auger
IRA	Interim Response Action
IRIS	Integrated Risk Information System
MCL	maximum contaminant level
MSDS	material safety data sheet
MTBE	methyl tertiary butyl ether
MW	monitoring well
ND	not detectable
NFA	no further action
NIOSH	National Institute for Safety and Health
OAC	Ohio Administrative Code
ODH	Ohio Department of Health
ODNR	Ohio Department of Natural Resources
OEPA	Ohio Environmental Protection Agency
O/O	owner/operator
ORC	Ohio Revised Code
OSHA	Occupational Safety and Health Act
PAH	polynuclear aromatic hydrocarbon
PCS	petroleum contaminated soil
PID	photo ionization detector
POD	point of demonstration
POE	point of exposure
PPB	part per billion
PPM	part per million
PRG	preliminary remediation goals
PSA	Preliminary Site Assessment
PUSTRCB	Petroleum Underground Storage Tank Release Compensation Board
QA/QC	quality assurance/quality control
RAP	Remedial Action Plan
RBAL(s)	risk-based action level(s)
SB	soil boring

SIR	statistical inventory reconciliation
SSTL	site-specific target level
SWAP	(Ohio) Source Water Assessment and Protection Program
TGM	technical guidance manual
TPH	total petroleum hydrocarbon
TTT	tank (system) tightness test
UCL	upper confidence limit
USCA	United States Contractors Association
USCS	Unified Soil Classification System
USGS	United States Geological Survey
UST	underground storage tank
USEPA	United States Environmental Protection Agency
VAP	Voluntary Action Program
VOC	volatile organic compound
WHP	Wellhead Protection Program

1.0 Introduction

This Technical Guidance Manual (TGM) is designed to help you understand the closure and corrective action (CA) processes, and provide a discussion of the activities that are required for complying with the Bureau of Underground Storage Tank Regulations (BUSTR) rules, as stated in Ohio Administrative Code (OAC) rule 1301:7-9-12 (effective July 2, 1999), and OAC rule 1301:7-9-13 (effective March 31, 1999.)

The TGM explains:

- What you need to do when an UST system is closed;
- What you need to do when a release or suspected release occurs;
- What reports are required;
- Who is responsible for submitting the reports.

The BUSTR risk-based CA may include some or all of the following steps:

1. Underground storage tank (UST) closure;
2. Investigating suspected releases:
 - Tank tightness testing;
 - Sampling potentially contaminated drinking water wells;
 - Site check;
3. Tier 1 evaluation:
 - Initial data collection;
 - Preliminary site assessment;
 - Action level determination;
 - Tier 1 decisions;
4. Tier 2 evaluation:
 - Site conceptual exposure model;
 - Site assessment;
 - Tier 2 decisions;
5. Tier 3 evaluation:
 - A complex site-specific approach requiring pre-approval.

Applying the 1999 Corrective Action Rule

Effective March 31, 1999, OAC rule 1301:7-9-13 (the CA rule) was revised to include a more comprehensive risk-based approach to CA at petroleum UST release sites. For releases that were reported, or confirmed prior to March 31, 1999, you may continue to use the 1992 CA rule, effective September 1, 1992. **For owners and/or operators (O/O) of sites, with releases that were reported or confirmed prior to March 31, 1999, you may elect to address CA activities under the 1999 CA rule.** For suspected or confirmed releases reported, and closures conducted on or after March 31, 1999, you must use the 1999 CA rule.

For releases reported prior to March 31, 1999, the O/O must submit a signed notification letter to BUSTR if you want to use the 1999 CA rule. Only the O/O can make this election (i.e., consultants/contractors cannot sign a letter for an O/O). This correspondence should identify the site's BUSTR facility/release number, and the name and address of both the site and the O/O. It should contain a statement similar to the following:

We (O/O) hereby inform BUSTR of our election to apply the 1999 CA rule (effective March 31, 1999) to the release site referenced in this correspondence. We also acknowledge that once this

election is made, it cannot be reversed. This notification is provided in accordance with current BUSTR policy.

See the BUSTR Fact Sheet titled *Electing to Use the Revised (1999) Corrective Action Rule, June 1999* for additional information on moving to the 1999 CA rule.

Definition of Owner and Operator

Owner

UST Systems In Service On or After November 8, 1984

In the instance of an UST system in use on November 8, 1984, or brought into use after that date, the person who owns the UST system;

UST Systems Taken Out of Service Prior to November 8, 1984

In the instance of an UST system in use before November 8, 1984, but no longer in use on that date, the person who owned the UST system immediately before the discontinuation of its use;

The term includes any person who holds, or, in the instance of an UST in use before November 8, 1984, but no longer in use on that date, any person who held immediately before the discontinuation of its use, a legal, equitable, or possessory interest of any kind in an UST system or in the property on which the UST system is located, including, without limitation, a trust, vendor, vendee, lessor, or lessee. The term does not include any person who, without participating in the management of an UST system and without otherwise being engaged in petroleum production, refining, or marketing, holds indicia of ownership in an UST system primarily to protect the person's security interest in it.

Operator

Means the person in daily control of, or having responsibility for the daily operation of, the UST system.

Regulated UST Systems

A regulated tank is an underground storage tank, including the underground piping connected to the tank that has at least 10% of its volume below ground containing a regulated substance. The 1999 CA rule applies to UST systems storing petroleum products.

The UST systems that are **exempt** from the 1999 CA rule are listed below:

- Farm or residential tanks of 1,100 gal. or less capacity used for storing motor fuel for noncommercial purposes;
- Tanks used for storing heating fuel for consumptive use on the premises where stored;
- Pipeline facilities, including gathering lines, regulated under the Natural Gas Pipeline Safety Act of 1968, 82 Stat. 720, 49 U.S.C.A. 2001, as amended;
- Surface impoundments, pits, ponds or lagoons;
- Storm or wastewater collection systems (i.e., oil/water separators);
- Flow-through process tanks;
- Storage tanks located in underground areas, including without limitation, basements, cellars, mine workings, drifts, shafts or tunnels, when the tanks are located on or above the surface of the floor and visible for inspection on all sides;
- Septic tanks;

- Liquid traps or associated gathering lines directly related to oil or gas production and gathering operations;
- Any UST system holding hazardous wastes listed or identified under Chapter 3745-51 of the OAC, or a mixture of such hazardous wastes and other regulated substances;
- Any wastewater treatment tank system that is part of a wastewater treatment facility regulated under section 402 or 307(B) of the Federal Water Pollution Control Act (33 U.S.C.A. 1251 and following);
- Equipment or machinery that contains regulated substances for operational purposes such as hydraulic lift tanks and electrical equipment tanks;
- Any UST system whose capacity is 110 gal. or less;
- Any UST system that contains a *de minimis* concentration of regulated substances;
- Any emergency-spill or overflow-containment UST system that is emptied expeditiously after use;

Important Terms

Many terms in the 1999 rules and the TGM may have specific regulatory definitions within other existing federal, state, or local programs or may be used as common terms elsewhere in the environmental field. You should review the following important terms and definitions, so that as you proceed, you correctly understand the meaning intended by BUSTR. (See OAC 1301:7-9-02 for additional terms.)

Action Level(s) - Generic concentrations for chemical(s) of concern that are protective of human health.

Chemical(s) of Concern (COCs) - The chemical(s) or specific constituents of the petroleum released that are identified for evaluation during the CA process.

Delegated Authority – The fire department given authority by the State Fire Marshal to issue permits, determine fees, and perform inspections for regulated UST sites within the fire department’s jurisdiction.

Exposure Pathway – The mechanism by which an individual or population may be exposed to a COC originating from a UST site. Each exposure pathway includes a source or release from a source, a point of exposure, and an exposure route. If the exposure point is not at the source, a transport medium (e.g., air or water) also is included.

Free Product:

- A separate liquid hydrocarbon phase that has a measured thickness of greater than 0.01 ft.; or
- COCs or petroleum contamination that is determined to be present above the saturation limits in soil.

Hazardous Substance – Any substance listed in OAC 1301:7-9-03, but not including any substance regulated as a hazardous waste under OAC chapter 3745-50 to 3745-69, or any mixture of such substance and petroleum that is not contained in a petroleum UST system.

Known (when used in the phrase, “ground water is known to contain”) – a ground water source that contains COC concentrations and/or soil concentrations that exceed the soil-to-drinking water leaching action level look-up table.

Overfill – A release that occurs when a tank is filled beyond its capacity, resulting in a discharge of the regulated substance into the environment.

Petroleum – Includes crude oil or any distillate of crude oil that is liquid at 60° F and a pressure of 14.7 psi absolute. The term includes, without limitation, motor fuels, jet fuels, distillate fuel oils, residual fuels, lubricants, petroleum solvents, and used oils.

Point of Demonstration – A location selected between the source area and the potential point of exposure, where COC concentrations at the point of exposure must be at or below a determined target level in environmental media that is protective of human health.

Point of Exposure - The point at which an individual or population may be exposed to a chemical of concern originating from an UST site.

Release:

- Any spilling, leaking, emitting, discharging, escaping, leaching, or disposing of a petroleum product from an UST system into the ground water, a surface water body, subsurface soil, or otherwise into the environment; or
- Any spilling, leaking, emitting, discharging, escaping, or disposal of a petroleum product into ground water, a surface water body, subsurface soil, or otherwise into the environment while transferring or attempting to transfer petroleum products into an UST system; or
- COCs in subsurface soil or ground water on the UST site found in concentrations above the action level specified in paragraph (I) of the CA rule and confirmed through laboratory analysis.

Source Area – The location of free product, the location of highest measured soil and ground water COC concentration, or the location where the COCs were released.

Spill – A release resulting from improper dispensing practices into an UST system including, without limitation, the disconnecting of a delivery hose from a tank's fill pipe before the hose has drained completely.

Surrounding Area – An area within a 2000 ft. radius of the UST system.

Suspected Release:

A release is suspected when one of these events occurs:

- A release-detection method, such as inventory control, indicates a release may have occurred (unless the monitoring device is found to be defective or a second month of monitoring does not confirm initial result);
- Unusual operating conditions of the UST system;
- Presence of free product during removal of an UST system in any excavation on or near the UST site;
- Presence of petroleum vapors in or along man-made structures or in drinking-water wells on or near the UST site;
- Presence of free product in a monitor well and/or observation well located on or near the UST site; or
- Presence of free product on a surface-water body on or near the UST site.

UST Site – The parcel of property where an UST system is or was formerly located.

2.0 UST Closure Requirements

Introduction

OAC 1301:7-9-12, often referred to as the “closure rule”, establishes the requirements for conducting a variety of activities that involve the closure of UST systems.

Removal Requirements

The Ohio Fire Code [OAC 1301:7-7-28 (H)(11)(c)] requires that any underground tank, which contains a flammable or combustible liquid and has not been used for a period of one year or longer, be removed from the property (by the property owner). In some instances, if the appropriate fire official or fire safety inspector determines that the removal is not necessary, that official can allow the tank to be abandoned in place. **Only property owners that meet the definition of an UST O/O are held responsible for performing the closure assessment and submitting a closure report.** (See the BUSTR fact sheet titled, *So You Want to Buy an Old Gas Station*, for additional information.)

Closure Options

Temporarily Out of Service (fewer than 90 days)

When you take an operating UST system out of service for 90 days or less, it is “temporarily out of service.” You must secure the fill line, gauge opening, and dispensing unit against tampering. BUSTR regulations continue to apply, except that release detection requirements do not apply if the system is empty. The system is considered empty when regulated substances have been removed so that no more than 1 in. of residue or 0.3% by weight of the system’s capacity remains in the tank. **Neither a closure assessment nor a permit is required** for taking an UST system temporarily out of service.

Temporary Closure (more than 90 days but less than 12 months)

When you take UST systems out of service for more than 90-days, you must:

- Empty all contents;
- Keep all vent lines open and maintained;
- Cap and secure all lines, pumps, man-ways, and ancillary equipment; and
- Obtain a permit from BUSTR or a Delegated Authority.

UST systems that have not been used for more than 12 mo. must be permanently removed, abandoned, or replaced. The 12 mo. period includes the 90 day “temporarily out of service.” The State Fire Marshal may grant an extension if a written request is received at least **30 days prior** to the end of the initial 12-mo. closure period. However, before applying for an extension, you must perform a closure assessment. If the extension is granted, all BUSTR regulations continue to apply to UST systems during the extended temporary closure, except for release detection requirements.

Permanent Abandonment

Only BUSTR or a delegated authority may grant permission for all or part of an UST system to be abandoned in place. The Certified Underground Storage Tank Inspector (CUSTI) **does not** have the authority to approve abandonment. If approved, you must clean and fill the UST system with a solid, inert material (i.e., concrete slurry mix). In addition, you must obtain a permit, perform a closure assessment, and submit a closure report.

Permanent Removal and Replacement

When an UST system or any part of an UST system is removed from the ground, you must complete the following:

1. Obtain a permit;
2. Remove all portions of the UST system from the ground unless prior approval has been granted from BUSTR or a Delegated Authority;
3. Clean and remove the UST system according to the following standards;
 - API Recommended Practice 1604-96; *Removal and Disposal of Used Underground Storage Tanks*.
 - API Publication 2015-94; *Safe Entry and Cleaning Petroleum Storage Tanks*.
 - *NIOSH Criteria for a Recommended Standard for Working in Confined Space*
4. Remove all backfill from the tank cavity excavation, piping trenches, and dispensing unit areas and handle according to the Petroleum Contaminated Soil (PCS) rules (OAC 1301:7-9-16 and 17). (See Appendix D for PCS action levels.)
5. Remove no more than 1 ft. of native soil from the sidewalls, bottom of the tank cavity excavation, piping trenches, and dispensing unit areas.

If site conditions (e.g., bedrock) interfere with collecting any samples required in this rule, you must submit an alternative sampling plan and have it approved by BUSTR. Such site limitations may require the installation and sampling of one or more monitoring wells.

After removing all or part of the UST system, you must conduct a closure assessment, prepare a closure report, and submit the report to BUSTR. You may replace the UST system before completing the closure report, but not before the closure assessment has been completed. Replacing the old system with a new system does not relieve the O/O from complying with CA regulations.

Change in Service

A “change in service” means that the substance stored in the UST system has been changed from a regulated to a non-regulated substance (e.g., gasoline to water). Before you actually change the content of the UST system you must 1) empty the UST system, 2) clean the UST system, 3) conduct a closure assessment, and 4) prepare a closure report. However, a change from a regulated substance to a regulated substance does not require a closure assessment (e.g., gasoline to kerosene).

Permitting

Closure Permit Requirements

OAC 1301:7-9-12(D) specifies that you must obtain a permit for:

- Temporary closure;
- Permanent abandonment;
- Permanent removal and/or replacement; or
- Change in service.

Upgrades and repairs do not always require that you conduct a closure assessment. However, if you conduct a repair on a portion of the system from which a release has or may have occurred, then you must report the release and conduct a site check. If any portion of the system is replaced during the upgrade, then you must conduct a closure assessment and submit a closure report to BUSTR.

Permits are issued by:

- BUSTR; or
- The local fire department that has delegated authority status.

Even if BUSTR issues a closure permit, the local fire department and/or government may require an additional permit.

Notification

Before any of the closure activities listed above takes place, the O/O must notify BUSTR in writing of the intent to perform an UST closure. Filing a permit application with BUSTR satisfies the notification requirement. **(If a permit application is filed with a delegated authority, a separate notification must be sent to BUSTR.)** In emergencies, UST removal permits can be issued with fewer than 30-days notice at the discretion of BUSTR or the delegated authority.

Required On-Site Personnel

A Certified Installer and an UST Inspector must be on-site for every UST removal/abandonment that requires a permit.

The Certified Installer directs all removal activities and is in direct control of the personnel performing the work. However, a BUSTR-Certified Installer may not be qualified to perform a closure assessment and/or a closure report.

The UST Inspector may be either a BUSTR Inspector, an Inspector from a delegated authority, or a CUSTI. The UST Inspector is on site to ensure that all potential fire and explosion hazards are properly handled. The UST Inspector observes and documents the actions of personnel performing the closure work. **UST Inspectors do not determine the environmental status of the site nor are they in control of on-site personnel.** Closure activities may take place only if the UST Inspector is on site.

Permit Application Process

BUSTR Closure Permits

After receiving a completed permit application, BUSTR will determine and verify that the UST system complies with all applicable BUSTR registration requirements. If the system is not registered, BUSTR may require that the O/O pay back registration fees before a permit is issued.

Delegated Authority Closure Permits

If the local fire department has delegated authority in the area where the closure will take place, that fire department will issue permits, determine fees, and schedule inspections. However, local fire departments are not required to determine if the UST system complies with BUSTR requirements. All UST system O/Os should verify compliance before closure work is initiated. Compliance with both BUSTR and the Petroleum Underground Storage Tank Release Compensation Board (PUSTRCB) requirements is crucial to establishing eligibility for reimbursement if corrective action is required.

Other Permits

In addition to BUSTR requirements, other local, regional, or state regulations may affect the closure process. For example, the Ohio Environmental Protection Agency (OEPA) may require permits for air emissions and water discharges. In addition, local governments may require special permits.

Closure Assessment

The O/O must perform a closure assessment if any of the closure activities discussed in this section are conducted. Sampling required by the closure rule determines if a release has occurred, but is not intended to determine the extent of a release.

A closure assessment is not required if:

1. The portion of the UST system being closed is already being assessed under the CA rule (OAC 1301:7-9-13). Contact BUSTR prior to making this determination.
2. Vapor monitoring or ground water monitoring release detection systems that satisfy the requirements of paragraphs (E)(5) to (E)(6)(i) rule 1301:7-9-07, have been used prior to the closure assessment, and show no evidence of a release. These monitoring systems must have been in place long enough to demonstrate that they are working properly. The O/O should have historical records showing that a release has not occurred. Contact BUSTR prior to making this determination.

Closure Assessment Requirements

Site History

The site history section of the closure report should describe:

- Historical and current land use of the site and surrounding properties;
- Previous closures, releases, and suspected releases;
- Known locations of any former UST systems on the site; and
- Any out-of-service UST systems still existing on the site and substance(s) stored during use.

Visual Site Evaluation

A visual site evaluation should identify, but is not limited to, the following:

- Evidence of past or current operational problems, (e.g., surface soil staining, concrete or asphalt staining, or concrete patchwork); and
- Evidence of other sources of site contamination, such as areas where piping and pump islands appear to have existed.

Closure Assessment Sampling

The following section identifies all locations where you are required to field screen/sample during closure and/or abandonment of an UST system. Field screening determines which samples must be submitted to the laboratory. (See Appendix A for sampling and field screening procedures.)

Sample Locations for Removal

Soil samples must be taken at the following locations within 24 hrs. of completing the excavation:

1. At both ends of each tank, if a tank is 35 ft. or less in length. If a tank is longer than 35 ft., take another sample under the middle of the tank;
2. Every 20 ft. along piping runs. For example, if a piping release is identified, submit a sample from the release location and at the 20 ft. intervals required in the closure rule.
3. Below each dispenser, unless the dispenser is located directly above the tank;
4. Below any remote fill pipe area greater than 10 ft. from the tank cavity.

Any water encountered in the excavation must be evacuated. If within 24 hrs. of pumping water out of the excavation, the water recharges, then you must collect a ground water sample. Collect ground water samples from any dispenser and piping trenches or tank cavity areas that contain ground water. If no water recharges within 24 hrs., then only soil sampling is required. (See Appendix A for ground water sampling procedures.)

Sample Locations for Abandonment, Change in Service, and Temporary Closure

In all of these cases, the UST system remains in place. Conduct soil sampling as follows:

1. Collect soil samples using one of these procedures:
 - Thoroughly remove all sludge and waste products from the tank, and purge it of all vapors. Cut holes in the bottom of both ends of the tanks; use a hand-sampling tool to collect samples from the backfill; (See API 2015-94 Publication, *Safe Entry and Cleaning of Petroleum Storage Tanks*.)
 - Install borings at each end of the tank as close to the tank as possible in the backfill. Install the borings to a depth where native soil is encountered. Then sample from the bottom of the backfill material. If you cannot determine the boundary of the native soil, then take a sample from within 12 in. of the bottom of the tank. If water is encountered in a soil boring, collect a soil sample directly above the soil/water interface (as well as a water sample).
2. From the backfill, every 20 ft. along piping runs;
3. Below each dispenser, unless the dispenser is directly above the tank;
4. Below any remote fill pipe area, if it is greater than 10 ft. from the tank cavity.

Stockpile Soil Samples

All excavated soil and backfill are assumed to be petroleum contaminated soil (PCS). Handle this soil according to OAC 1301:7-9-16 and 17. The chart below indicates the number of samples that must be field screened and submitted for laboratory analysis.

Table 1 – Stockpile Sampling Requirements

	Cubic yards of soil generated				
	0-25	26-100	101-500	501-1000	>1000
1. Minimum number of grab samples to collect and field screen	2	6	8	10	10 plus 1 sample per each additional 100 yd ³ (or fraction thereof)
2. Minimum number of grab samples to submit to the laboratory, if field screened	1	1	2	3	4 plus 1 sample per each additional 500 yd ³ (or fraction thereof)

Samples Required for Analysis

Submit these samples for laboratory analysis:

1. One sample from each piping run that has the highest field screening reading;
2. One sample from the dispensing unit sample that has the highest field screening reading;
3. One sample from each remote fill area that is greater than 10 ft. away from the UST system;
4. One sample from the tank cavity that has the highest field screening reading per set of 3 tanks or fraction thereof in that cavity; for example, if the cavity contained 1, 2, or 3 tanks, submit only 1 sample; if the cavity contained 4, 5, or 6 tanks, submit 2 samples;
5. All water samples collected; (See Appendix A)
6. Soil stockpile samples according to the volume of the stockpile. (See Table 1 for stockpile sampling requirements.)

Unless field screening has been conducted, you must submit all the required samples for laboratory analysis.

BUSTR requires that you use specific laboratory methods for analyzing samples collected during closure assessment activities. (See Appendix C for analytical methods.)

Closure Reports

Upon completing the closure assessment, you must submit a closure report describing the results to BUSTR within 45 days of receiving the laboratory analysis, but no later than 90 days after collecting the samples. (See Appendix B: Data Presentation for a list of tables, figures, maps etc. in closure assessment reports.) You must submit a BUSTR closure form with each closure report. The closure form lists all information required to prepare a complete closure report. Although the typical UST O/O hires an environmental consultant to prepare the report, BUSTR holds the O/O (not the consultant) responsible for the report's accuracy and completeness. Therefore, as the UST O/O, you must sign, date, and submit the closure form. Before signing, the O/O should carefully review the report and ask the consultant to explain any unclear issues.

Action Levels for UST Closure

During a closure assessment, COCs are to be selected and analyzed as discussed in Appendix C. Table 2 provides the action levels and saturation levels applicable to a UST closure. Use the ASTM or Unified Soil Classification System to determine the appropriate soil type and select the applicable soil action levels (from the soil to drinking water leachate and direct contact pathways). (See Appendix D for the BUSTR soil classification form.) If no soil determination is made, then assume the soil type is sand/gravel.

For closure assessments, assume that ground water underlying the UST site is a drinking water source (see Table 2). If the product stored in the UST being closed is in Analytical Group 3 (e.g., used oil), then additional chemical(s) of concern (ACOCs) may need to be evaluated (See Appendix C). If concentrations of COCs/ACOCs at any location on the UST site are above the action levels, the O/O must conduct a Tier 1 evaluation. If no release is indicated and the Closure Assessment Report is complete and accurate, BUSTR will send the O/O a communication indicating that no further action (NFA) is necessary.

Release Reporting

The O/O must report a release to BUSTR and the local fire department within 24 hrs. of receiving analytical results that exceed site action levels. Likewise, report hazardous substance releases to the U.S. Environmental Protection Agency (USEPA) within 24 hrs. If you discover free product during closure, you must report this as a suspected release to BUSTR and the local fire department, and you must conduct a site check. Report emergencies immediately (i.e., threats to human health and/or the environment).

Table 2 – A Summary of Closure and Site Check Action Levels

Chemical(s) of Concern	Soil Action Levels (mg/kg)			Drinking Water Action Levels (mg/L)
	Sand/Gravel	Silty/Clayey Sands	Clay/Silt	
Risk Based Action Levels				
Benzene	0.150	0.240	0.910	0.005
Toluene	58.700	112.000	520.000	1.000
Ethylbenzene	71.100	131.000	230.000	0.700
Total xylenes	1500.000	1500.000	1500.000	10.000
Methyl Tertiary Butyl Ether (MTBE)	0.530	0.890	3.800	0.040
Benzo (a) anthracene	5.500	5.500	5.500	N/A
Benzo (a) pyrene	0.550	0.550	0.550	0.0002
Benzo (b) fluoranthene	5.500	5.500	5.500	N/A
Benzo (k) fluoranthene	55.000	55.000	55.000	N/A
Chrysene	550.000	550.000	550.000	N/A
Dibenz (a,h) anthracene	0.550	0.550	0.550	N/A
Indeno (1,2,3 -cd) pyrene	5.500	5.500	5.500	N/A
Naphthalene	1800.000	1800.000	1800.000	0.570
Soil Saturation Levels				
Analytical Group 1	Benzene	444.500	491.600	592.200
	Toluene	268.200	313.700	374.600
	Ethylbenzene	149.300	178.800	213.000
	Total xylenes	124.700	147.400	175.800
	MTBE	5483.000	6111.000	8493.000
Analytical Group 2 (TPH – C10-C20)	2,000	10,000	20,000	
Analytical Group 3 (TPH – C20-C34)	5,000	20,000	40,000	

Notes:

1. For the purpose of closure assessment and site check, assume that the ground water underlying the UST site and surrounding area is a drinking water source.
2. Compare site data to both risk based action levels (RBALs) and soil saturation values.
3. For Analytical Group 3, derive COC action levels.

3.0 Immediate Responses to Releases and Suspected Releases

Reporting Releases

The O/O must report a release or suspected release to BUSTR and the local fire department within 24 hrs. of discovery. However, if the spill/overfill is 25 gal. or less, and it does not reach a surface water body, and is cleaned up within 24 hrs., you do not need to report a release.

Suspected Release

A release is suspected when one of these events occurs:

- A release-detection method, such as inventory control, indicates a release may have occurred (unless the monitoring device is found to be defective or a second month of monitoring does not confirm initial result);
- Unusual operating conditions of the UST system;
- Presence of free product during removal of an UST system in any excavation on or near the UST site;
- Presence of petroleum vapors in or along man-made structures or in drinking-water wells on or near the UST site;
- Presence of free product in a monitor well and/or observation well located on or near the UST site; or
- Presence of free product on a surface-water body on or near the UST site.

Release

A release is defined as:

- Any spilling, leaking, emitting, discharging, escaping, leaching, or disposing of a petroleum product from an underground storage tank system into the ground water, a surface water body, subsurface soil, or otherwise into the environment; or
- Any spilling, leaking, emitting, discharging, escaping, or disposal of a petroleum product into ground water, a surface water body, subsurface soil or otherwise into the environment while transferring or attempting to transfer petroleum products into an underground storage tank system; or
- COCs in subsurface soil or ground water on the UST site found in concentrations above the action level specified in paragraph (I) of the CA rule and confirmed through laboratory analysis. (See Appendices C and D.)

Immediate Response Actions

Once a release is confirmed through testing and other evidence, you must initiate immediate response actions (within 24 hrs.) to minimize potential risks to human health and the environment. Do not confuse the immediate response action with an interim response action, which may only be conducted during a tier evaluation.

These are the immediate response actions:

- Clean up or otherwise contain any spills or overfills;
- If free product is present for any reason other than soil saturation, begin free product recovery;
- Take immediate action to prevent further release, (e.g., remove product from the UST system);
- Immediately identify and mitigate fire, explosion, vapor, and safety hazards associated with such release;
- Inspect for releases and take steps to prevent further migration of releases into surrounding soil and ground water through use of absorbent pads, absorbent booms, dikes, siphon dams, or similar items;

- Continue to monitor and mitigate any additional fire and safety hazards posed by vapors or free product that have migrated to subsurface structures, such as basements, sewers, or similar locations; and
- Manage contaminated materials that are generated in a manner that complies with applicable federal, state, and local requirements.

Immediate Response Actions Report

BUSTR must receive an Immediate Response Actions Report documenting the proper cleanup of a spill or overfill within 20 days of starting the free product removal activities. (See Appendix I for the Immediate Response Actions Checklist.)

4.0 Free Product

Introduction

Free product can be present as either a separate phase liquid **or** as soil saturation. Free product must be reported to BUSTR within 24 hrs. of discovery. Free product must be evaluated during closure assessment, site check, and tier evaluations.

Free Product as a Separate Phase Liquid

Free Product is present as a separate liquid hydrocarbon phase if it is at least 0.01 ft. thick on ground water, surface water, or in an excavation. Where free product is present as a separate phase liquid, the O/O must implement a free product recovery program that removes free product to the maximum extent practicable, while continuing other required CA activities. Free product recovery includes activities such as manual bailing, skimming, pumping, or other removal techniques. You must notify BUSTR (i.e., by telephone, facsimile) within 24 hrs. of starting free product recovery activities.

Free product recovery is an immediate response action and pre-approval from BUSTR is not required. However, you may need to secure permits required by federal, state, or local regulatory agencies. Whenever free product is discovered, the O/O must implement these actions:

- Submit an initial written Free Product Recovery Report to BUSTR. The report must be received by BUSTR within 20 days of starting the recovery activities. (See the Free Product Recovery Report Checklist in Appendix I.)
- Prepare monthly reports and submit them to BUSTR until termination of recovery activities or implementation of CA, whichever is earlier.
- Report to BUSTR and the local fire department immediately (i.e., by telephone, email) if a free product recovery system cannot be repaired within 24 hrs. of discovering its malfunction. Correct the malfunction and place the system back into service as promptly as is technically feasible.

You may discontinue free product recovery activities when free product has been removed to the maximum extent practicable (e.g., when recovery is limited by the technology available or free product occurrence has become intermittent). If, at this point, a free product thickness of greater than 0.01 ft. remains after maximum recovery efforts have been made, then address the free product during the tier evaluation.

Free Product as Soil Saturation

The 1999 CA rule includes the concept of "soil saturation" in the definition of "free product." Soil saturation is the condition in which the pores of a soil/rock material are entirely filled (with COCs or petroleum, and water), such that no more can be added without free-phase product existing.

Soil saturation limits and COC action levels are different concepts. Saturation limits are based on the physical properties of soil and COCs. Action levels are risk-based.

The 1999 CA rule divides petroleum products into three analytical groups. Group 1 (light distillates) includes gasoline and aviation gas; Group 2 (middle distillates) includes diesel fuel and kerosene; and Group 3 (heavy products/unknowns) includes waste oil and new oil.

Determining Soil Saturation

Analytical Group 1

To determine a soil saturation for Analytical Group 1 chemicals, use the following saturation equation: (See Appendix F: Solubility and Saturation for additional information.)

$$C_{sat} = \frac{S}{\rho_s} \times [H \Theta_{as} + \Theta_{ws} + k_d \rho_s]$$

See Table 3 for saturation values for Group 1 COCs, calculated using BUSTR defaults.

Table 3 - Soil Saturation Levels for Group 1 COCs

COCs*	Sand/Gravel	Silty/Clayey Sands	Clay/Silt
Benzene	444.5	491.6	592.2
Toluene	268.2	313.7	374.6
Ethylbenzene	149.3	178.8	213.0
Total Xylenes	124.7	147.4	175.8
MTBE	5,483.0	6,111.0	8,493.0

*Results in ppm.

Analytical Groups 2 & 3

BUSTR has adopted TPH analysis (SW 846 method 8015 modified) as the preferred method for determining soil saturation limits for Groups 2 and 3. However, BUSTR will accept (for review and pre-approval) any comparably valid method. Paint filter (and similar) tests are not valid methods for this determination. For Groups 2 and 3, use the following methods for evaluating soil saturation.

For Groups 2 and 3, in addition to the standard COC analytical requirements, you will need to have each sample analyzed by TPH 8015 for carbon range C10 - C34. Report the laboratory analytical data in two separate carbon ranges: C10 - C20, and C20 - C34. If the TPH value for C10 - C20 is the greater of the two TPH values, then the combined (C10 - C34) TPH value is compared to the middle distillate saturation level. If the TPH value for C20 - C34 is the greater, then the combined (C10 - C34) TPH value is compared to the heavy product/unknown saturation level. (See Table 4 below.) The TPH values in Table 3 are from the OEPA, Voluntary Action Program (VAP).

Table 4 - TPH Saturation Values

Analytical Group*	Sand/Gravel	Silty/Clayey Sands	Silt/Clay
Light Distillates	Table 3	Table 3	Table 3
Middle Distillates	2,000	10,000	20,000
Heavy Product/Unknowns	5,000	20,000	40,000

*Results in ppm.

Example Scenario:

You have just removed a diesel UST system, classified the soil as sand/gravel, and arranged for analyses of both the standard COC analytical requirements and soil saturation. The TPH value for carbon range C10 - C20 is 1,000 ppm, while the TPH value for carbon range C20 - C34 is 200 ppm. Since the C10 -

C20 range is the greater TPH value, the combined TPH value of 1,200 ppm should be compared to the middle distillate fraction, and specifically to the sand/gravel category. You note that the combined TPH value of 1,200 ppm is less than the 2,000 ppm saturation limit, and correctly conclude that the saturation limit has not been exceeded.

Corrective Action for Soil Saturation

If, on the basis of soil saturation limits, you determine that free product is present, you must conduct an interim response action or a Tier 2 evaluation. BUSTR recommends that you conduct a Tier 1 prior to implementing an IRA or a Tier 2. The 1999 CA rule requires that the discovery of soil saturated with free product (via laboratory analytical data) must be reported to BUSTR within 24 hrs. In such situations, you must perform the following activities.

Interim Response Action (IRA) for Saturated Soil

Upon discovery of soil exceeding saturation limits, you must determine whether to implement an IRA for reducing contaminant levels or whether to remove the saturated soil. If site action levels have been exceeded, then you must perform a Tier 1 evaluation before the IRA. If you intend to conduct an IRA, you must notify BUSTR at least 10 days before implementing the IRA. An IRA may include source removal and/or short-term recovery actions, if applicable. (See Appendix I for an IRA Checklist.)

You must obtain prior approval from BUSTR if:

- The time to complete an IRA exceeds 3 mo.;
- More than 800 yd³ are to be excavated; or
- More than one IRA will be conducted.

You might need to perform additional subsurface site investigation prior to an IRA, to accurately determine the volume of saturated soil to be addressed and/or to determine what IRA is appropriate. BUSTR recommends that you submit (and have approved, as required) sampling plans for all IRAs to be performed. If you select to excavate saturated soil during the IRA, manage all excavated soil as if it were PCS, according to OAC rule 1301:7-9-16 and 17. Please contact PUSTRCB for voluntary or mandatory cost pre-approval requirements associated with these activities.

Tier 2 Evaluation

The goal of a Tier 2 evaluation is to demonstrate (based on site-specific data) that the soil at the site is not saturated. However, if site-specific data demonstrates that saturated soil exists at the site, you must complete an IRA or submit a remedial action plan (RAP).

5.0 Investigating a Suspected Release

Suspected Release

Any of these items constitute a suspected release:

- Indication of a release by a release-detection method, such as inventory control (i.e., if the monitoring device proves to be defective or a second month of monitoring does not confirm initial result). If two consecutive months of statistical inventory reconciliation (SIR) show inconclusive results, then you must conduct a tank tightness test (TTT). If there is a SIR failure, you must conduct a TTT; (See the *BUSTR Compliance Guidance for SIR* for additional information.)
- Unusual operating conditions of the UST system;
- Presence of free product or petroleum contamination above saturation limits in any excavation on or near the UST site;
- Presence of petroleum vapors in man-made structures or in drinking-water wells near the UST site;
- Presence of free product in a monitor well and/or observation well; or
- Presence of free product on a surface-water body on or nearby the UST site.

The O/O must conduct one or a combination of the following to confirm or otherwise disprove a suspected release:

- Perform a TTT and line tightness test on all suspected UST systems;
- Sample drinking water well(s) if a drinking water well(s) is suspected or known to be impacted by the release;
- Conduct a site check within 60 days of a failed tightness test, physical discovery or spill/overfill; if free product is discovered during the site check investigation, you may discontinue the site check and initiate a Tier 1 evaluation. You must notify BUSTR if a site check is discontinued for any reason.

Tightness Testing

The O/O must confirm or disprove a suspected release by conducting a TTT on all suspected UST systems as follows:

- Conduct a TTT using a BUSTR approved method (see OAC 1301:7-9-07) within 7 days of reporting the release;
- Notify BUSTR of the TTT results within 3 days of receiving the results;
- Submit copies of the TTT results to BUSTR within 10 days of receipt by the O/O.

Drinking Water Well Analysis

If a release is suspected to have impacted a drinking water well on the UST site or on a nearby property, the O/O is responsible for:

- Sampling the well(s) within 3 days of discovery of the impact; (See Appendix C for appropriate analytical parameters);
- Notifying BUSTR of the test results within 24 hrs. of receipt; BUSTR must receive a copy of the test results within 7 days of receipt.

If a drinking water well shows any impact, it should be reported to the local health department.

Site Check (3 Options)

You must complete and submit a site check and deliver a report to BUSTR within 60 days of discovering a suspected release.

The three (3) options for conducting a site check are:

1. Install soil borings;
2. Close all or a portion of the UST system (BUSTR approval may be required); or
3. Perform limited source removal.

The appropriate option for a particular UST site will depend upon the site-specific circumstances.

Option 1: Install Soil Borings

The O/O may choose soil borings/monitoring wells for investigating a suspected release. Place a **minimum** of 3 soil borings around the **source area** (i.e., locations where the highest concentrations of COCs would most likely be present). Boring locations should consider information known about the UST site, the suspected release, and the likely distribution of COCs (See Figures 5.1 – 5.5 for examples of soil boring placement among several different release scenarios.)

The specific circumstances of the release and UST site characteristics may warrant alternative placement and/or additional borings.

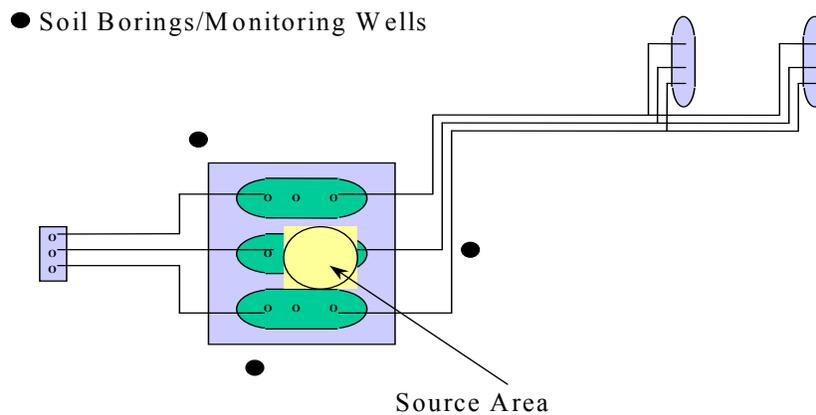


Figure 5.1 - Suspected Release from UST

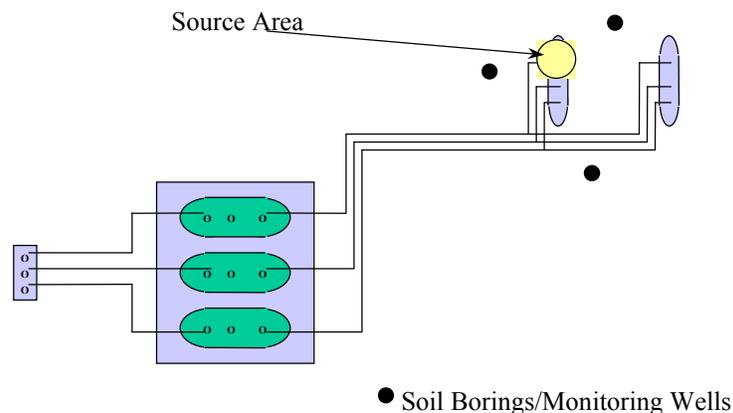


Figure 5.2 - Suspected Release from Piping in Dispenser Area

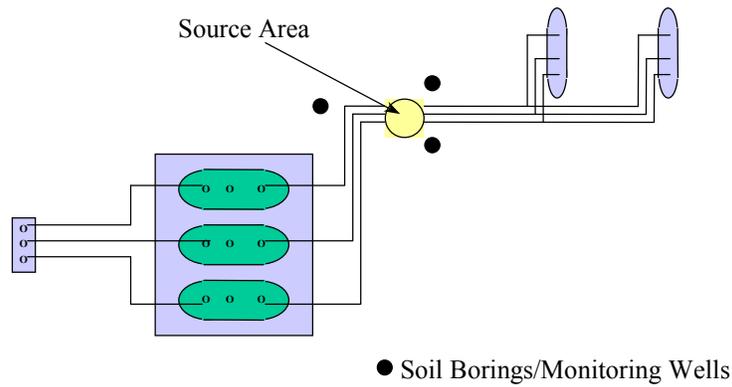


Figure 5.3 - Suspected Release from Piping

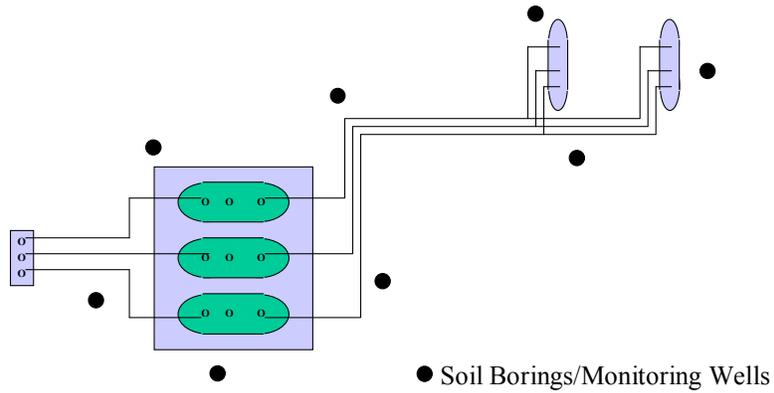


Figure 5.4 - Suspected Release from Unknown Source Area

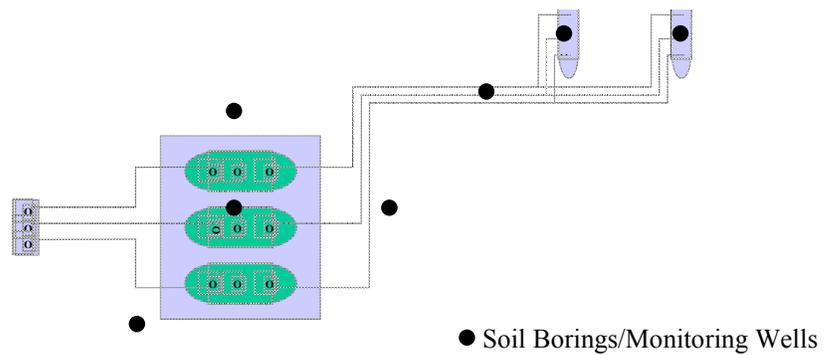


Figure 5.5 - Suspected Release from a Removed System

When using soil borings to investigate a suspected release or to conduct a site check, extend the soil borings to:

- Uppermost saturated zone;
- Ground water confining layer;
- Bedrock; or
- 50 ft., whichever is encountered first.

However, if ground water is “known” to contain COCs, soil borings must extend to ground water. (See Figure 5.6 below.)

Continuously sample soil borings and log/classify the stratigraphy using ASTM or USCS methods.

In some cases, exploratory trenching may be used in lieu of soil borings. The O/O must obtain approval from BUSTR prior to proceeding with an exploratory trench. (See Appendix D for the BUSTR Soil Classification Form.)

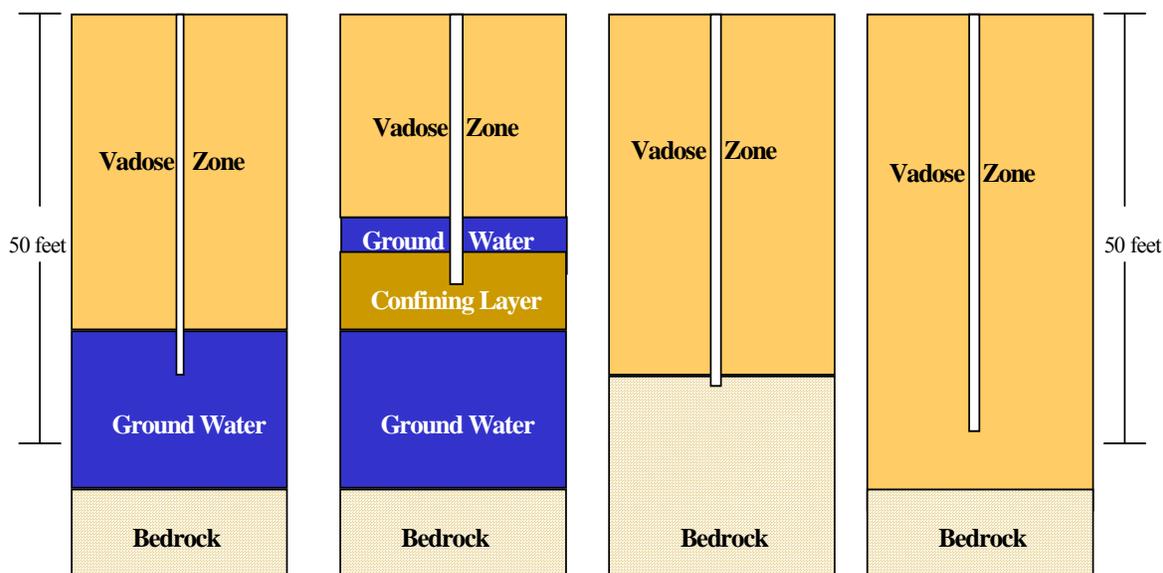


Figure 5.6 - Site Check Soil Borings

Site Check Considerations

Bedrock

If you encounter bedrock prior to reaching ground water, then assume that ground water is present at bedrock depth. The soil type and depth to bedrock will aid in selecting the appropriate action levels for the UST site.

Confining Layers

There is no minimum strata thickness that defines a confining layer. A confining layer must be a continuous layer (across the site) of sufficient thickness and area to restrict the vertical migration of water (i.e., you must find water above the layer to have a confining layer). Therefore, unless a saturated zone is encountered, drilling activities must continue to 50 ft., as appropriate.

Direct Push Technology

You may use direct push technology for evaluating soil and water in a site check. Rod refusal with this technology does not necessarily mean you have encountered bedrock (i.e., auger refusal); an auger rig may be required to confirm bedrock/auger refusal. If soil data from the site check will be used in the tier evaluation, then it must conform to the tier evaluation requirements. Additional soil samples (from each boring) may be required.

If soil borings are converted to ground water monitoring wells, construction must conform to the preliminary site assessment requirements described in Section 7.0 (Tier 1 evaluation) and in Appendix A.

Sampling

Continuously sample soil borings at 2 ft. intervals and describe the stratigraphy on soil boring logs. Screen samples from each soil boring or excavation using FID or PID headspace techniques. Collect samples for analysis as follows:

1. If ground water is encountered:
 - Submit for laboratory analysis the sample above the soil/water interface exhibiting the highest headspace reading;
 - If no soil samples exhibit headspace readings above background, take a sample from immediately above the soil/water interface and submit it for laboratory analysis;
 - If a saturated zone is encountered in a soil boring or excavation, collect a sample of the ground water from each soil boring, well, or excavation.
2. If ground water is not encountered:
 - Submit for laboratory analysis the sample with the highest headspace readings;
 - If no soil samples exhibit headspace readings above background, take a sample from the bottom of the boring and submit it for laboratory analysis.

(See Appendix A for a discussion of soil boring/monitoring well installation and associated data collection.)

Option 2: Close UST in lieu of Site Check

The O/O may elect to remove all or a portion of the UST system that is the potential source of the suspected release, and conduct a closure of all or a portion of the UST system according to rule 1301:7-9-12.

Obtain prior approval from BUSTR for the closure or removal of all or a portion of the UST system if any of the following conditions exist:

- The ground water is known or suspected to contain concentrations of COCs;
- Free product is present;
- A receptor or surface water is known to be impacted by the release; or
- The UST site is in a sensitive area defined in OAC 1301:7-9-09.

This approval may have conditions that require additional work, most likely involving additional soil and ground water sampling.

Site Check Closure Sampling

Where a UST closure is to be used to meet site check requirements, **at least one of the required samples must be taken from the suspected area** of highest COC concentration (i.e., sample any obvious areas of contamination).

For example, if you identify a piping release, submit a sample from that location and from the 20 ft. intervals required in the closure rule. For purposes of site check, BUSTR recommends that you take at least 1 sample from piping runs less than 20 ft. long.

Option 3: Perform Limited Source Removal for the Site Check

This approach is most appropriate for overfills/surface spills, where a limited excavation (**less than 5 yd³**) has removed soil containing concentrations of COCs. Take samples in the native soil below the source of the spill or suspected release to demonstrate that COC concentrations in the native soil are below the action levels.

You must collect a minimum of 3 soil samples for field screening; submit the highest field-screened sample for laboratory analysis. Bias your samples towards the areas suspected of having the highest concentrations of released COCs.

Release Determination

After completing a site check, determine the appropriate action levels for the UST site. In a site check, any ground water underlying or surrounding the UST is assumed to be a drinking water source. But if all of the following are true, further CA may not be necessary:

- All suspected UST systems pass the TTT;
- No free product is present;
- Soil and ground water analytical results do not exceed the applicable soil and drinking water action levels; and
- All required documentation has been submitted to BUSTR.

If any of the above requirements are not met, additional investigation/documentation will be necessary. If COC concentrations at any location on the UST site are above the action levels, conduct a tier evaluation. (See Appendix D for a thorough explanation of how to determine action levels.)

If any analytical results from a study or survey (e.g., Phase II ESA, Property Transfer Audit) indicate any COCs above action levels, then you must conduct a site check. The O/O may forego the site check and initiate a tier evaluation.

Site Check Report

Submit the Site Check Report and attachments to BUSTR within 60 days of a failed TTT, physical discovery, or a spill or overfill greater than 25 gal. (See Appendix B for a list of tables, figures, maps, etc. in the Site Check Report; see Appendix I for the Site Check Report Checklist.)

6.0 Overview of the Tier Evaluation Process

Tier 1 Evaluation

The Tier 1 evaluation consists of:

1. An Initial Data Collection to identify and evaluate;
 - The potential source(s) of a confirmed release,
 - The potential source area(s),
 - The potential COCs,
 - The ground water use.
2. A Preliminary Site Assessment;
 - Identify any interim response action that may be appropriate,
 - Determine if the upper saturated zone is ground water,
 - Investigate source area to see if COCs are above action levels,
 - Determine the geologic and hydrogeologic characteristics of the site.
3. An Action Level Determination;
 - Compare the highest concentrations of COCs to action levels determined for the site.

The Tier 1 evaluation assumes that the point of exposure (POE) is in the source area (i.e., the area with the highest concentration of COCs). If COC concentrations are above the Tier 1 action levels, the O/O has the following options:

- Conduct an IRA;
- Submit a Remedial Action Plan;
- Submit a Tier Evaluation Notification and conduct a Tier 2 evaluation; or
- Perform a combination of these options.

If COC concentrations are below site action levels, submit a Tier Evaluation Report to BUSTR within 180 days after confirming the release. (See Section 7.0 for details concerning the Tier 1 process.)

Tier 2 Evaluation

The Tier 2 evaluation may involve comparing the highest, or statistically derived, representative concentrations of COCs to site-specific target levels. The Tier 2 evaluation consists of:

1. Developing a site conceptual exposure model to identify potentially complete exposure pathways and to focus on additional data collection;
2. A site assessment, which at minimum:
 - Evaluates exposure pathways;
 - Determines the distribution of COCs (determine the extent based on the appropriate Tier 1 action levels for pathways that were not eliminated);
 - Determines the geological and hydrogeological characteristics of the UST site;
 - Evaluates the COC concentrations at the POE;
 - Determines the point of demonstration;
 - Evaluates the fate and transport of COCs for completed pathways.
3. Determine the appropriate Tier 2 option(s):
 - Statistically derives COC concentrations; and/or
 - Develops site-specific target levels (SSTLs); and/or

- Applies the action levels at POE and back calculate Tier 2 SSTLs in the source area; use analytical fate and transport modeling. (A Monitoring Plan must be developed to validate modeling results).
4. Establishes land use restrictions to eliminate exposure pathways;
 5. If the COCs are above the Tier 2 SSTLs for a complete exposure pathway, then the O/O must submit a Tier Evaluation Report and conduct one or a combination of the following:
 - Interim response action to remove or reduce concentrations of COCs at the source area(s) or eliminate an exposure pathway;
 - Submit a RAP using the SSTL as the remedial action target level; or
 - Submit a Tier 3 Evaluation Plan to determine SSTLs for the exposure pathways identified for further evaluation.

If COC concentrations are below the site action levels, submit a Tier 2 Evaluation Report to BUSTR within 2 yrs. after submitting the Tier 1 Evaluation Notification. (See Section 8.0 for details concerning the Tier 2 process.)

Tier 3 Evaluation

The Tier 3 evaluation, usually a more complex and sophisticated chemical fate and transport evaluation, uses site-specific numerical models (e.g., Monte Carlo analysis or other analytical tools) to develop SSTLs. Obtain prior approval from BUSTR before beginning a Tier 3 evaluation. This evaluation will likely require extensive data collection, the use of complex modeling and analytical tools, and consequently require a more costly evaluation and more sophisticated resources.

If COC concentrations are above the Tier 3 SSTL for a complete exposure pathway, then the O/O must submit a Tier Evaluation Report and conduct/submit one or both:

- IRA to remove or reduce concentrations of COCs at the source area(s) or eliminate an exposure pathway; and/or
- RAP using the SSTL as the remedial action target level.

If COC concentrations are below action levels, submit a Tier 3 Evaluation Report to BUSTR within the timeline established by the Tier 3 work plan. (See Section 9.0 for details about the Tier 3 process.)

Conduct interim response actions when you anticipate that short-term (less than 3 mo.) actions will reduce COC concentrations below the appropriate action levels or SSTLs.

Remedial Action

Conduct remedial action when each completed exposure pathway contains COC concentrations above the action level or SSTL. Choose the remedial action method(s) according to its ability to achieve the action levels or SSTLs, as determined in the tier evaluation. Remedial options include source removal, design and installation of treatment system, natural attenuation processes, engineering controls, and institutional controls.

Monitoring

You must implement a monitoring program to verify the assumptions of any fate and transport conclusions used in the Tier 2 and Tier 3 evaluations. Where remedial action is appropriate, you must implement a monitoring program to evaluate the progress of the remedial action.

7.0 Tier 1 Evaluation

Introduction

The Tier 1 evaluation compares the highest COC concentrations in the soil and ground water to the action levels developed for the specific exposure pathways identified in the generic site conceptual exposure model. The Tier 1 evaluation consists of an initial data collection and a preliminary site assessment.

If COC concentrations are below action levels, then no further action is necessary. However, you must evaluate all previously collected data (e.g., closure, site check, phase II environmental site assessment). If COC concentrations are above the appropriate action level, then further action is required.

Site Conceptual Exposure Model

The BUSTR default site conceptual model identifies the following exposure pathways for Tier 1 evaluation:

- Ground water ingestion;
- Direct contact with soil;
- Soil to non-drinking water leaching;
- Soil to drinking water leaching;
- Soil to indoor air; and
- Ground water to indoor air.

The site conceptual model assumes that the receptor is located in the source area (i.e., the area with the highest COC concentrations) and will be exposed to the highest COC concentrations identified at the site.

In addition, this model assumes that any saturated zone encountered is drinking water and the POE (e.g., a drinking water well) is located within the source area.

Initial Data Collection

The initial data collection is a non-intrusive evaluation of the site and surrounding area that must answer these 5 questions:

1. What is the source of the release?
2. Where is the source area?
3. What COCs need to be evaluated?
4. What are the regional geological, hydrogeological, and physical characteristics of the UST site and surrounding area?
5. Is the ground water a drinking water source?

What is the Source of the Release?

If the source of the release is unknown, you must investigate all potential source(s) related to the release on the UST site. This investigation should include a review of current and historical uses of the site. Information sources might include site plans, personal interviews, fire departments etc.

Where is the Source Area?

The source area(s) is the area of highest COC concentrations in soil and ground water, and/or any area containing free product. Locate the source area based on knowledge of known releases, the location of a

known source (e.g., storage tanks that failed a tightness test), or through field screening methods (e.g., soil gas survey).

What Chemicals of Concern Need to be Evaluated?

Determine which COCs must be evaluated, based on which petroleum product(s) are known or suspected to have been released at the site. (See Appendix C for details concerning COCs and ACOCs. See Section 4.0 for details regarding soil saturation.)

What are the Regional Geological, Hydrogeological, and Physical Characteristics of the UST Site and Surrounding Area?

Knowing the regional geological, hydrogeological, and physical characteristics of the UST site will help guide the placement and installation of soil borings and ground water monitoring wells during the preliminary site assessment (PSA). Such knowledge will also help you understand the potential for COC migration in the soil and ground water.

Review data concerning the site, surrounding area, and previous investigations to identify the following:

- Depth to and productivity of the uppermost saturated zone;
- Representative soil type and characteristics of major stratigraphic units;
- Regional aquifers, including those underlying the UST site and surrounding area;
- Ground water recharge and discharge areas;
- Topographical features that might influence the ground water flow;
- UST site characteristics (e.g., property size, system locations); and
- Surface water bodies (e.g., size of the water body, source of the water).

Is the Ground Water a Drinking Water Source?

The ground water usage determination is the most important determination in a Tier 1 evaluation. For purposes of Tier 1 evaluation, evaluate the current and potential future use of ground water underlying the UST site and surrounding area (within 2,000 ft. of the UST system) to determine whether ground water is or is not a drinking water source. During this evaluation, assume that:

- The ground water use being evaluated is the upper most saturated zone underlying the UST site; and
- Any identified current or potential future drinking water source in the surrounding area is within the source area.

For purposes of closure assessment, consider that ground water underlying the UST site and surrounding area is considered a potential drinking water source. Note here that it can be difficult to eliminate the drinking water pathway during a Tier 1 evaluation. In Tier 1, the drinking water determination is optional. The O/O can assume that ground water underlying the UST site is drinking water and avoid the costs associated with this determination. However, under a Tier 2 evaluation, data can be collected to determine if COCs in the upper aquifer will present a risk to a current or reasonable potential future drinking water source in the lower aquifer.

Drinking Water Evaluation – Current and Potential Future Usage

During Tier 1 evaluation, ground water underlying the UST site will always be considered a drinking water source if any of the following apply:

1. The UST site or surrounding area is located within a wellhead protection area. [current]
2. A drinking water source is identified within the surrounding area, even if the source is totally within a lower saturated zone other than the saturated zone being evaluated on the UST site. [current] (See Section 8 for details on identifying a drinking water source.)

3. A surface water body is located within 300 ft. of the UST site. Surface water means any lake or pond greater than 1 acre or a continuously running river, creek, or stream. The site conceptual exposure model assumes that ground water is discharging into a surface water body if the surface water body is within 300 ft. of the UST site. [current]
4. The UST site or surrounding area is located in a “sensitive area” per OAC 1301:7-9-09. [potential future] (See Appendix G for details about sensitive areas.)
5. The UST site or surrounding area overlays a sole-source aquifer, as listed by the USEPA. [potential future]
6. Ground water yield at the site is at or above 3 gal./min., unless one of the following exist:
 - Greater than 90% of the properties in the surrounding area are tied into a municipal water system [potential future]
 - An ordinance requires a mandatory tie-in to a municipal water system for all properties in the surrounding area. [potential future]
 - An ordinance prohibits the installation of potable water wells at all properties in the surrounding area. [potential future]

Figure 7.1 (below) shows a scenario that warrants a drinking water use determination. (See Appendix I for a drinking water determination checklist.)

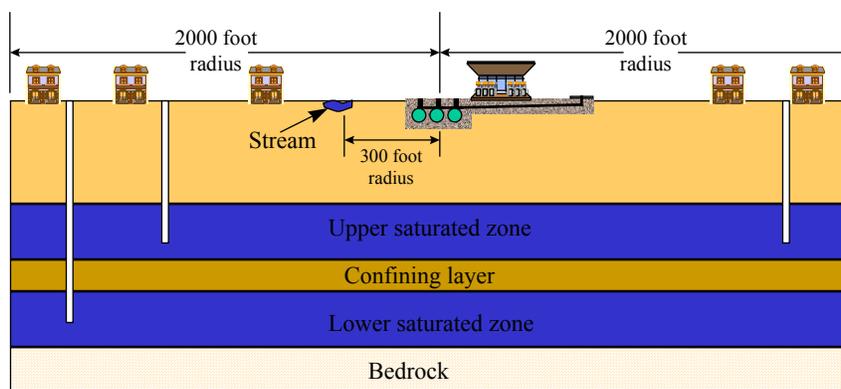


Figure 7.1 - Example Drinking Water Use Scenario

Water Well Search

The following section clarifies the requirements for locating drinking water sources (i.e., water wells, dug wells, industrial process water, irrigation or other non-potable purposes, etc.) within the 2,000 ft. surrounding area.

Consider these points before attempting to locate water wells:

- An owner may default to drinking water instead of performing the drinking water and ground water determination during the tier evaluation;
- When attempting to eliminate the drinking water pathway, you will be required to perform a thorough search (as discussed below) for drinking water sources within the surrounding area;
- If a well log (excluding logs for monitoring wells) is identified to be within the surrounding area of the site, classify the ground water as drinking water;
- Any identified current or potential future drinking water source in the surrounding area is assumed to be within the source area;

- Assume that wells completed in lower saturated zones are drawing water from the upper saturated zone;
- If a well noted in a well log cannot be physically located, or if documentation of proper abandonment cannot be provided, ground water still must be classified as drinking water. However, you can eliminate from consideration any wells that are properly decommissioned (i.e., drinking ingestion pathway). (See Appendix A for information concerning well decommissioning.)

Well Log Search

Standard Search

Most searches for drinking water sources (i.e., water well logs) begin at the Ohio Department of Natural Resources (ODNR), Division of Water. To perform a well log search, you will need to know the county and township containing the site, the major intersection nearest to the site, and have a portion of a topographic map (7.5 min. series) with the site and search area clearly identified. Typically, searchers visit ODNR and review their well log records, or request (via mail or fax) that ODNR staff perform (and report) the search. The well log records are classified as either “located” or “unlocated” wells. Many “unlocated” well logs do not contain enough information (i.e., street address, nearest intersection, map) to determine the specific location, which is necessary for making the drinking water determination. Thus, additional research may be necessary. This typically involves a door-to-door survey and correspondence with the local/municipal water provider. If so, you will be required to thoroughly document and submit an account of your activities performed during your additional search for drinking water sources.

Contact local county health departments to determine whether they have any well log records within the surrounding area of the site. The Ohio Department of Health (ODH) website at www.odh.state.oh.us has contact information regarding local county health departments.

Online Search

For tier evaluation purposes, you must include both the (field) located and unlocated well logs in a search and subsequent report to BUSTR. To determine whether any unlocated wells are located within the surrounding area of the site, perform an online well log search at ODNR by accessing their well log website at www.dnr.state.oh.us.

The ODNR online well log search allows queries for both the located and unlocated well logs. Other sources of information such as city or county street maps, Sanborn maps, tax maps, and city address directories can help locate the wells. Also note that ODNR online web logs might contain a hand-drawn sketch that could cover your area of interest.

Door-To-Door Survey

A door-to-door survey of all properties within 300 ft. of the release site property boundaries might be necessary. It should involve correspondence with all property owners within 300 ft. of the release site property boundaries. All such reports should include a map denoting the 300 ft. line surrounding the property boundary, information concerning property and area zoning, and documentation of all correspondence from the door-to-door survey. If such correspondence is inconclusive (or unobtainable), BUSTR will evaluate overall survey results for each site on a case-by-case basis.

Municipal Water Sources

Your site might be located within an Ohio Wellhead Protection Program (WHP, Ohio EPA, 1992) area and/or the Ohio Source Water Assessment and Protection Program (SWAP, Ohio EPA, 1999). If so, then the site determination defaults to drinking water. Because many new studies of municipal well fields (and

the areas providing water to them) are being completed, you should correspond with the local municipal water provider and with the OEPA Division of Drinking and Ground Waters regarding newly established WHP and SWAP areas. Source water protection areas for all public water supplies must be established by May 2003. Access the OEPA Division of Drinking and Ground Waters website, www.epa.state.oh.us/ddagw for more information.

Yield Determination for Ground Water and Drinking Water Ground water

To determine if a saturated zone meets the definition of ground water, the O/O must evaluate the site's ground water yield and in situ hydraulic conductivity of the saturated zone. If the saturated zone is capable of yielding at least 1.5 gal./8 hrs., and has an in situ hydraulic conductivity greater than 5.0×10^{-6} cm/sec., then the saturated zone is ground water. However, if the initial field study for one of the criteria fails to meet the definition of ground water, then additional evaluation is not required.

If a saturated zone (less than 5 ft. thick) is encountered and determined to yield less than 1.5 gal./8 hr., then you must demonstrate that a lower saturated zone underlying the UST site will not produce a yield above 3 gal./min. In addition, both the saturated zone and the confining layer beneath the saturated zone must be continuous throughout the site.

Ground water resource maps or other published ground water data may be used only when the data are based on a well located on the UST site or in the surrounding area, and if the well is located in the same saturated zone being evaluated at the site. Otherwise, verify the data by site-specific field tests for the ground water determination.

Drinking Water

To determine if ground water is a drinking water source, you must perform pumping tests to determine whether a yield of more than 3 gal./min. can be sustained. However, you might need to adjust the minimum pumping rate to account for seasonal fluctuations, well diameter, and partial penetration of the saturated zone. (See examples of such adjustments in the Yield Adjustments section below.)

Yield Determination

For purposes of Tier 1 evaluations, extend monitoring wells to the bottom of the saturated zone or to at least 5 ft. into the saturated zone, whichever is less. Screen monitoring wells to make sure they can accommodate seasonal fluctuations in the ground water table. However, monitoring wells installed only 5 ft. into a saturated zone might not provide suitable observation points, unless you make appropriate adjustments to the minimum rate of 3 gal./min.

Conduct yield tests in properly located and installed wells. For wells used as observation points, you must know the well depth, length and slot size of the screen, and the distribution of the filter pack. You also need to characterize the materials comprising the screened interval (i.e., thickness and grain size).

Before conducting the field pump test, calculate any appropriate adjustments to the minimum pump rate. Determine the actual yield after the draw down stabilizes at the calculated (adjusted) pump rate. To satisfy the yield requirements for ground water, you must maintain the calculated pump rate for 15 min. Regardless of what the yield determination shows, you must submit all appropriate test data, including the actual pump rate, for review.

If any wells installed during the Tier 1 evaluation exceed the minimum pump rate for the yield determination, you do not need to test the other wells. You must characterize all wastewater generated during the yield determination and dispose of it according to state and federal regulations.

Yield Adjustments

Review the following factors to determine the appropriate minimum yield rate for the evaluation. Make potential adjustments as follows:

1. If you perform the yield determination during high water level (March through May, per OEPA VAP), then no adjustment is needed. However, if you make the determination during the low water level (June through February), then an adjustment will be necessary. The recommended default multiplier (for the 3 gal./min. rate) will be 0.35, which reduces the minimum pump rate to 1.95 gal./min. Please note that this seasonal adjustment must also be made for the ground water determination (i.e., 1.5 gal./8hrs.), as appropriate.
2. 4-in. wells are preferred, however, if 2 in. diameter wells have been installed then a 0.85 adjustment factor must be used. Therefore, the minimum pump rate would be reduced to 2.6-gal./min.
3. If a well is installed only 5 ft. into a saturated zone for the yield determination, then make an adjustment to the yield target rate on a site-specific basis. Use the Walton & Butler equation (Walton, W. C., "Selected Analytical Methods for Well and Aquifer Evaluation", *Illinois State Water Survey*, Bulletin No. 49, 1962) to determine a multiplier by dividing the length of the saturated zone screen by the thickness of the aquifer. If you cannot determine the thickness, then use a default thickness of 25 ft. Therefore, if 5 ft. of a saturated zone is screened and you use the 25 ft. default thickness, the multiplier would be 0.2. That would reduce the minimum pump rate from 3 gal./min. to 0.6 gal./min. Although various equations can be used to make this adjustment, apply the Walton & Butler equation as the default equation.

Note that one or more of these adjustments may be appropriate. You must ensure that all the wells are evaluated and compared to the appropriately adjusted value. Contact BUSTR when using site-specific criteria or equations other than the default.

Preliminary Site Assessment

The preliminary site assessment should collect information necessary to compare the highest COCs to site action levels. Accomplish this by collecting only the data necessary to:

1. Investigate the source area for the highest concentrations of COCs;
2. Determine the geological, hydrogeological, and physical characteristics of the UST site and surrounding area that might influence the migration and transport of COCs including:
 - The direction and gradient of ground water flow if ground water is encountered;
 - A description of faults, fissures, fractures, or other geologic transport routes;
 - Soil type; and
 - Depth to ground water.
3. Determine if the upper saturated zone is ground water;
4. Identify any interim response actions that might be appropriate.

Investigate the Source Area

The initial source area investigation should determine the following:

- The COCs present in the source area;
- The geological, hydrogeological, and physical characteristics of the UST site and surrounding area;
- The highest concentrations of COCs in soil and ground water.

During the preliminary site assessment, install at least 3 soil borings/monitoring wells within or as close to, the source area as possible to determine the highest concentration for each COC. The locations selected should consider the location of potential sources and the likely distribution and temporal variations in COC concentrations in soil and ground water. **In many instances, more than 3 soil**

borings/monitoring wells will be necessary to characterize the source area. Make sure you investigate the area immediately down gradient of the source.

An example of soil boring/monitoring well placement is shown in Figure 7.2.

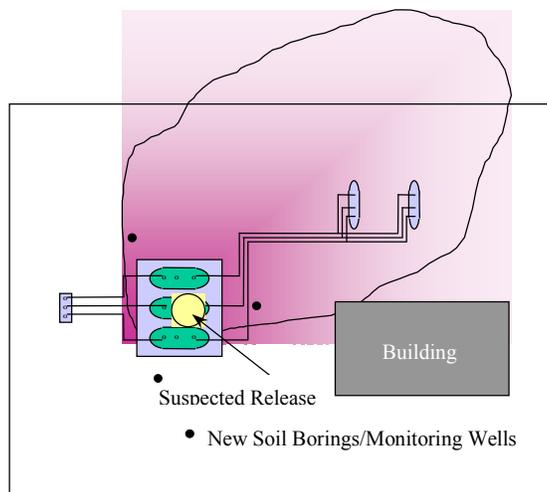


Figure 7.2 - Typical Well Placement for a Preliminary Site Assessment

Installing Soil Borings and Ground Water Monitoring Wells

Install soil borings and ground water monitoring wells as follows:

1. Extend soil borings/monitoring wells (MWs) to bedrock, a ground water confining layer, the uppermost-saturated zone, or 50 ft., whichever is encountered first. If ground water is not encountered within 50 ft., provide justification to eliminate the ground water pathways. If ground water is “known” to contain COCs, extend borings to ground water. If you encounter bedrock or a confining layer during soil boring/MW installation, please refer to the bedrock and confining layer discussion presented later in this section;
2. Continuously sample soil borings. Describe the stratigraphy on soil boring logs and test pit logs for each soil boring and excavation, respectively;
3. Characterize soil encountered during drilling or excavation according to ASTM D2488-93: *Standard Practice for Description and Identification of Soil/Visual-Manual Procedures* or the USCS (See Table 4);
4. For monitoring wells, include data collection that at minimum includes the depth to free product, free product thickness, depth of water below the top of casing, and the elevation of top of casing;
5. Extend ground water monitoring wells at least 5 ft. into the saturated zone and screen them to accommodate seasonal fluctuations in the ground water table.

Table 4: BUSTR Soil Classification Form

Major Divisions		Letter Symbol	Typical Description	BUSTR Class
Coarse Grained Soils (More than 50% of material is GREATER than #200 sieve)	Gravel and Gravelly Soils (More than 50% of coarse fraction RETAINED on #4 sieve)	Clean Gravels (Little or no fines)	GW Well-graded gravels, gravel-sand mixtures, little or no fines	Sand/ Gravel Soil
		Gravels With Fines (Appreciable amount of fines)	GP poorly-graded gravels, gravel-sand mixtures, little or no fines	
			GM Silty gravels, gravel-sand-silt mixtures	
		Sand and Sandy Soils (More than 50% of coarse fraction PASSING on #4 sieve)	Clean Sand (Little or no fines)	
	SW Well-graded sands, gravelly sands, little or no fines			
	Sands with Fines (Appreciable amount of fines)		SP Poorly-graded sands, gravelly sands, little or no fines	
			SM Silty-sands, sand-silt mixtures	
	Fine Grained Soils (More than 50% of material is SMALLER than #200 sieve)	Silts and Clays Liquid limit <50	SC Clayey sands, sand-clay mixtures	
ML Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity				
CL Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays				
Silts and Clays Liquid limit >50		OL Organic silts and organic silty clays of low plasticity		
		MH Inorganic silts, micaceous or diatomaceous fine sand or silty soils		
		CH Inorganic clays of high plasticity, fat clays		
Highly Organic Soils			OH Organic clays of medium to high plasticity, organic silts	Clay/ Silt Soils
	PT Peat, humus, swamp soils with high organic contents			

Pathway	Symbol	Pathway	Symbol
Direct contact with soil		GW to indoor air	
Soil to DW leaching		GW ingestion	
Soil to indoor air		Soil to non-DW leaching	

Borings and Monitoring Wells in Bedrock

When you encounter bedrock, the following conditions apply:

1. When no evidence of ground water contamination exists, extend soil borings to bedrock;
2. When ground water contains concentrations of COCs, a minimum of 3 soil borings/MWs must be installed in the source area(s) to ground water, regardless of depth;
3. When soil contamination exceeds soil-to-drinking water action level look-up tables, a minimum of 1 soil boring/MW must be installed in the source area(s) to ground water; if you discover ground water contamination, additional soil borings/MWs might be necessary.

Confining Layers

No minimum strata thickness defines a confining layer. Instead, a confining layer must be a continuous layer of sufficient thickness to restrict the vertical movement of water (i.e., you must find water above the layer for it to be a confining layer). Therefore, unless you encounter a saturated zone, you must continue drilling activities to 50 ft., as appropriate. If ground water is “known” to contain COC concentrations, refer to items 2 and 3 in the *Borings and Monitoring Wells in Bedrock* discussion above.

Collecting Soil and Ground Water Samples

Collect ground water samples from each monitoring well. Analyze the samples for COCs using one or more standard laboratory analytical methods. (See Appendix C (Table C1) or other analytical methods selected for ACOCs.)

Screen soil samples using FID or PID headspace techniques. In general, collect 2 samples per soil boring for analysis. Based on the headspace screening results, collect samples for laboratory analysis as indicated below. (See Appendix A for field screening and sampling methods.)

If ground water is encountered:

- Submit the sample from above the soil/water interface, exhibiting the highest headspace reading/concentration and a sample from immediately above the soil/ground water interface as encountered during drilling;
- If the highest headspace reading is the sample immediately above the soil/ground water interface, submit the highest and the second highest samples from above the soil/ground water interface;
- If no soil samples exhibit headspace readings above background for the headspace technique, submit a sample from immediately above the soil/water interface as encountered during drilling.

If ground water is not encountered:

- Submit the sample with the highest headspace readings and the sample from the bottom of the boring;
- If no soil samples exhibit headspace readings above background for the headspace technique, submit a sample from the bottom of the boring only.

Establish data quality objectives consistent with the intended use of the analytical data (e.g., low detection limits to demonstrate meeting action levels or higher detection limits for screening samples). (See Appendix A for a discussion of data collection.)

Action Level Determination

Determining Site Characteristics

Determine the appropriate action level for each environmental media and exposure pathway for the UST according to the information collected during the initial data collection and the preliminary site assessment:

- Identify the COCs based on the petroleum product released (see Appendix C);
- Determine if the saturated zone is ground water. The saturated zone is assumed to be ground water unless you make a determination;
- Calculate the average depth of the upper most saturated zone that contains ground water. If you encounter bedrock before extending the boring to 50 ft. then assume that the ground water is at the top of the bedrock;
- Select a soil type that best represents the soil under the UST site and is most appropriate to the specific exposure pathway (see Table 4). For purposes of the Tier 1 evaluation, classify the bedrock as a sand/gravel soil type;
- Determine if ground water is drinking or non-drinking water; the ground water is assumed to be drinking water unless you make a determination.

Point(s) of Exposure

The point(s) of exposure is the point(s) at which an individual or population may encounter COCs originating from a UST site. In the Tier 1 evaluation, we assume that the POE is located in the source area(s). In Tier 1, we assume that any identified current or potential future drinking water source in the surrounding area is within the source area(s). In Tier 2, we evaluate the fate and transport of COCs in the dissolved phase in ground water.

Site Action Levels

Use the complete exposure pathways to determine the appropriate action level table(s). Use the initial data collection and the preliminary site assessment data to determine the appropriate action level within each table. (See Appendix D for the site action level tables and additional information on determining action levels.)

Drinking Water Scenario

If ground water is determined to be drinking water, then you must compare the highest concentration of each COCs in soil and ground water to the action levels in the following tables:

- Ground Water Ingestion;
- Direct Contact;
- Soil to Drinking Ground Water Leaching;
- Soil to Indoor Air;
- Ground Water to Indoor Air.

Non-Drinking Water Scenario

If ground water is determined to be non-drinking water, then you must compare the highest concentration of each COCs in soil and ground water to the action levels in the following tables:

- Direct Contact;
- Soil to Non-Drinking Ground Water Leaching;
- Soil to Indoor Air;
- Ground Water to Indoor Air.

No Ground Water Scenario

If no ground water has been encountered, then you must compare the highest concentration of each COC in soil to the action levels in the following tables:

- Direct Contact;
- Soil to Indoor Air.

Tier 1 Decisions

Submit one or more of the following within 180 days of the release determination:

- Tier Evaluation Report (see Appendices B and I) – if all COCs are below action levels;
- RAP along with the Tier Evaluation Report;
- IRA Notification (see Appendix I) and conduct an IRA along with the Tier Evaluation Report; and/or,
- Tier 1 Evaluation Notification (see Appendix I) if moving to Tier 2. The Notification serves to summarize the activities completed to date and to inform BUSTR that you intend to conduct further tier evaluation.

Interim Response Action

Upon the completion of a tier evaluation, determine if implementing an IRA will reduce or eliminate source areas or otherwise eliminate exposure pathways. Having implemented an IRA, you should then re-evaluate previously identified potentially complete exposure pathways. The IRA may include source removal and short-term actions.

Submit an IRA Notification Form to BUSTR a minimum of 10 days prior to beginning the IRA. Include summaries of any IRAs in the Tier Evaluation Report. (See Appendix I for an IRA Notification Checklist.)

Obtain prior approval from BUSTR if:

- The combined total volume of soil to be excavated for all tier evaluations is greater than 800 yd³;
- The combined anticipated time to initiate and complete all IRAs is greater than 3 mo.; or
- More than one IRA will be conducted during a tier evaluation.

Your request for approval should include a description of the confirmatory sampling planned during the IRA evaluation. For any IRA requiring prior approval from BUSTR, you must also submit your plan to the Petroleum Underground Storage Tank Release Compensation Board for cost pre-approval (if your sites are eligible for reimbursement).

Confirmatory Sampling

After completing an IRA, collect a sufficient number of samples to determine the COC concentrations that remain in soil or ground water. If you plan to request a No Further Action (NFA) from BUSTR, your samples must demonstrate that the COC concentrations remaining in the soil or ground water are below the action levels or SSTLs. When determining the appropriate quantity and quality of samples to be collected, consider the spatial distribution of sampling locations and the temporal variations in the media or the COC concentrations.

Confirmatory Sampling for Soil

Collect soil samples from the excavation's side walls and bottom. Collect samples on a 10 ft. grid and field screen them. Send a minimum of 3 soil samples with the highest field screening results to the laboratory for analysis of the COCs identified for the UST Site.

Confirmatory Sampling for Ground Water

If the IRA addressed localized ground water contamination, then you should develop a ground water sampling program to demonstrate that the IRA was effective. At a minimum, collect a ground water sample from each monitoring well within the affected area. Collect samples immediately after completing the IRA and again 1 mo. later.

Remedial Action

If remedial action is appropriate, choose a method that would effectively achieve the appropriate action levels or SSTLs, as determined in the tier evaluation. More than one remedial action may be appropriate for a particular UST site based on the exposure pathways and COCs to be addressed by the remedial action. Remedial options include source removal, design and installation of cleanup equipment, natural attenuation processes, engineering controls and institutional controls. Note that institutional controls and engineering controls may be considered remedial actions. Therefore, you must submit a RAP describing the implementation of these controls when exposure pathways have been determined to be incomplete due to institutional or engineering controls such as a deed restriction.

Remedial Action Plan

If remedial action is planned, prepare a RAP and submit it to BUSTR for approval with the Tier Evaluation Report. You must also submit RAPs for cost pre-approval to the Petroleum Underground Storage Tank Release Compensation Board for sites that are eligible for reimbursement. A RAP must include:

- A description of the planned remedial action program;
- Proposed targets levels for remedial action, as identified by compound and environmental media;
- A conceptual design of the remedial action system (a detailed engineering drawing is not necessary);
- A brief description of remedial action alternatives considered, including a discussion of the reliability, effectiveness, relative cost, and time needed for completion, and the rationale for the selected program;
- A monitoring plan describing the sampling methodologies and locations for determining whether action levels or SSTLs are being achieved. This plan must demonstrate that concentrations of COCs will remain at or below SSTLs;
- A description of reporting frequency and proposed content of reports;
- A description of permits or other governmental approvals required for implementing the plan;
- A description of activities or studies, if any, that must be performed prior to implementing the proposed RAP; and
- An implementation schedule and the projected completion date of the proposed remedial action.

Public Participation

For each confirmed release where a RAP is submitted to BUSTR, you must provide notice to the public in a format approved by BUSTR so you can reach those members of the public directly affected by the release and the planned remedial action. The notice may include, but is not limited to, public notice in local newspapers, block advertisements, public service announcements, publication in a state register, letters to individual households, or personal contacts by field staff.

If sufficient public interest exists, or for any other reason, BUSTR may hold a public meeting to consider comments on the proposed RAP before approving it. The O/O must likewise give similar public notice if an approved RAP is not achieving its established cleanup levels and BUSTR is considering a termination of that plan.

Implementing Remedial Action Plans

Upon approval of the remedial action plan, implement your plan according to the approved actions. You must monitor, evaluate, and report the results of your implementation efforts to BUSTR according to the monitoring plan.

If, after following your implementation plan for a minimum of 1 year, the installed and operational treatment technology approved by BUSTR is unable to reduce the COC concentrations to or below action levels, then you must:

- Re-evaluate and revise the remedial action alternatives and resubmit a RAP, or
- Submit a RAP summary report and conduct a Tier 2 evaluation.

Completion Reports

Following completion of remedial action and monitoring according to this rule, you must complete and submit to BUSTR a report showing that the remedial action or monitoring objectives have been met. The report must contain documentation supporting termination of the remedial action or monitoring program. Upon approval, BUSTR will issue a written notice to the O/Os that no further action is required at the UST site.

8.0 Tier 2 Evaluation

Introduction

Conduct a Tier 2 evaluation when Tier 1 action levels are not appropriate for site-specific conditions. The Tier 2 evaluation is an exposure assessment. It develops SSTLs for exposure pathways identified in the site conceptual exposure model that exceed Tier 1 action levels or were not previously evaluated during the Tier 1 evaluation. Under the Tier 2 evaluation, you might need to conduct further site assessment to develop and evaluate the site conceptual exposure model, and to determine the distribution of COCs in soil and ground water.

Where free product exists due to soil saturation, the O/O may conduct an IRA, develop site-specific soil saturation concentrations for TPH, COCs, or ACOCs; or submit a RAP.

If COC concentrations are at or below the SSTLs for all complete exposure pathways, then no further action is required. However, you must monitor your site for a minimum of 1 year to validate modeling results. If the COC concentrations are above the appropriate action level, then further action is required. (See Appendix I for the Tier 2 Evaluation Checklist.)

BUSTR's Tier 2 spreadsheets contain recommended models, assumptions, and default values that should be used when developing SSTLs. **Effective January 1, 2002, BUSTR will require that you use these spreadsheets to streamline the review process.**

Site Conceptual Exposure Model

The generic site conceptual exposure model used in the Tier 1 evaluation is based on a very specific exposure scenario that could not be modified. In the Tier 2 evaluation, you may modify the generic site conceptual exposure model by considering site-specific characteristics, such as activity and land use, types of receptors, and transport mechanisms.

The site-specific conceptual exposure model is developed to:

1. Define the site-specific characteristics and relationships among the source area, the transport mechanisms, and all potential receptors and exposure routes for both current and potential future activity and land uses. You must clearly describe the conceptual model both in the text and pictorially;
2. Evaluate all current and potential future receptors identified at the UST site and in the surrounding area including:
 - Adults and children as residents on the UST site and in the surrounding area; and
 - Adults as commercial or industrial workers employed on the UST site or businesses in the surrounding area; and
 - Construction/excavation workers, if all other pathways are eliminated;
3. Include all environmental media that are likely to contain COC concentrations identified for evaluation. Evaluate the following environmental media, as appropriate:
 - Surface soil;
 - Subsurface soil; and
 - Ground water.
4. Evaluate current and reasonably anticipated future use (residential/commercial) for the UST site and adjacent properties.

Land Use Determination

The generic site conceptual model, developed for the Tier 1 action levels, assumes that the current and future land use for the UST site and the adjacent properties is residential. During the Tier 2 evaluation, you may make arguments for a non-residential land use.

Residential Land Use Category

Examples of residential land uses include, but are not limited to: family residences; day care facilities and schools with open-air facilities and exposed soil; and nursing homes and other long-term health care facilities. For the Tier 2 evaluations, if the UST site is entirely recreational or agricultural, the land use is considered residential.

For residential land use, adults and children are assumed to be full time residents living and sleeping on the property. The residents are potentially subject to inhalation of vapors both indoors and outdoors, direct contact with surface soil (i.e., ingestion, inhalation of vapors, dermal contact, and inhalation of particulates), and ingestion of drinking water from a well on the property.

Non-Residential Use

Examples of non-residential land uses include, but are not limited to: facilities that supply goods and/or services, and are open to the public, such as warehouses, retail gasoline stations and automobile service facilities, office buildings, retail businesses, hospitals, religious institutions, hotels, and parking facilities.

For non-residential land use, adult workers are assumed to spend a typical workweek on the property. The commercial worker is potentially subject to inhalation of vapors both indoors and outdoors, and direct contact with surface soil (i.e., ingestion, inhalation of vapors, dermal contact, and inhalation of particulates). For purposes of drinking water ingestion, treat the exposure considerations of any drinking water supply well on the property the same as residential land use.

Current Land Use

Determine the current and reasonably anticipated future use for the UST site based on:

- The historical land use of the UST site;
- The current land use of the UST site;
- The current land use of properties immediately adjacent and across streets from the UST site;
- The current zoning or planning designation for the UST site; and,
- The current zoning or planning designation for the UST site and the properties immediately adjacent and across streets from the UST site, including zoning restrictions.

In addition, you will need an evaluation of the anticipated future land uses of the UST site and adjacent properties. The evaluation needs to consider both historic and current land use of the surrounding area. For example, if the surrounding area has been in industrial use for the past 50 years, it may be more likely to continue as an industrial land use into the future. Whereas, a property adjacent to agricultural land may be in an area that could likely be developed as residential or non-residential property.

Future Land Use

Consider future land use as non-residential if one of the following scenarios exist:

1. The current land use at the UST site is not residential and at least 75% of the area within 300 ft. of the property boundaries of the site is non-residential land use. Figure 8.1 shows an example of a non-residential land use determination based on 75% of the adjacent properties as non-residential use.

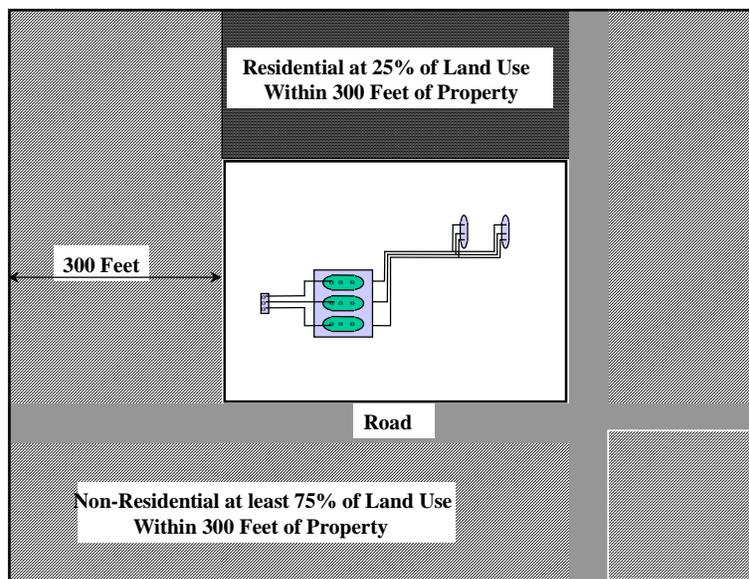


Figure 8.1 – Non-Residential Land Use Determination

2. The current land use at the UST site is not residential and at least 75% area within 300-ft. of the site's property boundaries is recreational or agricultural. Evaluate the recreational or agricultural land use to show that the activities on the land are consistent with the exposure criteria for non-residential land use.
3. The O/O maintains a legal, equitable, or possessory interest in the UST site; or a land use restriction for the UST site has been implemented. If the O/O transfers the UST site and thus no longer maintains a legal, equitable or possessory interest in the UST site, then either:
 - Implement a land use restriction before the UST site is transferred; or
 - Demonstrate that a restricted use is no longer appropriate for the UST site based on demonstrating that the COC concentrations remaining in environmental media at the UST site are appropriate for residential land use.

Site Assessment

The Tier 2 assessment is a continuation of the Tier 1 evaluation and should provide information to:

- Evaluate exposure pathways;
- Determine the likely distribution of COCs;
- Determine geological, hydrogeological, and physical characteristics necessary to evaluate exposure pathways and to develop SSTLs;
- Evaluate concentrations at the POE;
- Determine appropriate point(s) of demonstration;
- Compare statistically derived upper confidence levels for COCs to Tier 1 action levels; and
- Evaluate the fate and transport of COCs.

Exposure Pathway Evaluation

You must evaluate each complete or potentially complete exposure pathway identified by the site conceptual exposure model. An exposure pathway may be considered "incomplete" if sufficient documentation and data collected during the Tier 2 evaluation demonstrate that one of the following exist:

- All concentrations for a COC in the identified environmental media are at or below the Tier 1 action level for the site;
- No transport mechanisms will cause COC concentrations to be above the action levels identified for the UST site at the POE;
- No POE(s) are identified;
- There is no transport mechanism in the identified environmental media to move the COCs from the source area(s) to the POE;
- An existing resource use or land use restriction enforceable, by local government or regulatory agencies, will eliminate a POE.

If an exposure pathway is determined to be incomplete, there is no further evaluation required for that exposure pathway. An incomplete exposure pathway must be fully documented and based on information and data collected during the Tier 1 PSA and the Tier 2 site assessment. If an exposure pathway cannot be conclusively determined to be incomplete, then you must consider that exposure pathway as complete in the Tier 2 evaluation.

Distribution of Chemical(s) of Concern

The likely distribution of COCs must be defined according to the lowest applicable Tier 1 action level determined for the UST site for each identified environmental media. You must install soil borings and ground water monitoring wells to determine the distribution of COCs in each environmental media. Figure 8.2 provides an example of placing soil borings and ground water monitoring wells to determine the likely distribution of COCs. (See Appendix A for a discussion of environmental data collection.)

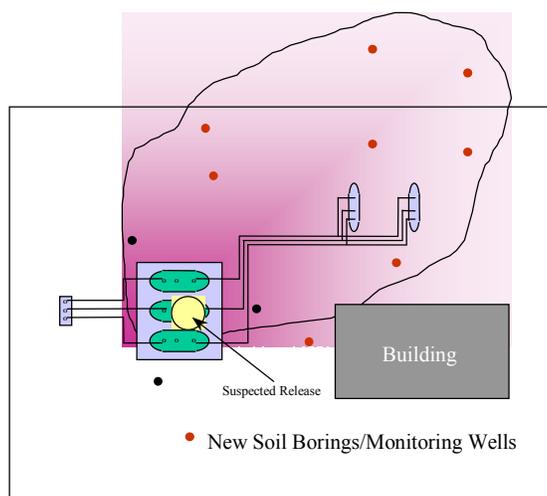


Figure 8.2 - Typical Placement of Soil Borings or Ground Water Wells for Determining the Distribution of Chemical(s) of Concern

If the highest COC concentration is below detection limits of a PSA, then that COC may be excluded from future assessment. If COC concentrations are below detection limits on subsequent sampling events and if you determine that the results are representative of temporal and spatial conditions, then the COC may be excluded from future monitoring.

Geological, Hydrogeological and Physical Characteristics

The amount and extent of UST's site-specific geological, hydrogeological, and physical characteristics dictate which Tier 2 Evaluation option(s) to select. Where fate and transport modeling is needed,

information such as soil porosity, hydraulic conductivity, and depth to ground water is required. You must collect sufficient data to show that the values selected are representative of the UST site.

Point(s) of Exposure

Collect sufficient data to determine if COC concentrations at the POE are above the appropriate action levels. This will generally require that you install soil borings or monitoring wells at each POE. In some cases, you must collect samples from existing drinking water wells. Identify POEs based on the current and future land use at the UST site and in the surrounding area. At a minimum, the following potential POE(s) must be evaluated:

(1) Drinking Water Wells

For public and private drinking water supply wells where ground water has been identified as a drinking water source, the POE must be one of the following:

- If a potable water supply exists within 300-ft. down gradient of the source area(s), then the POE will be the actual well location; (See Figure 8.3.)

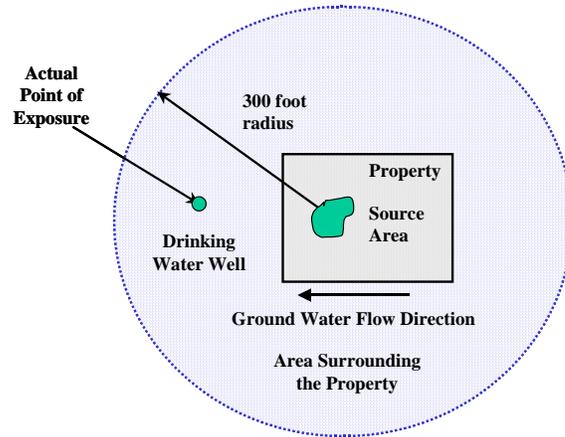


Figure 8.3 - Point of Exposure at Actual Location of Drinking Water. Well Located within 300-Ft. Radius of UST System

- If there is not a potable well located within 300 ft. of the source area(s), then the POE is assumed to be located 300 ft. down gradient of the source area(s) (see Figure 8.4) or property line of the UST site (see Figure 8.5), whichever is further;

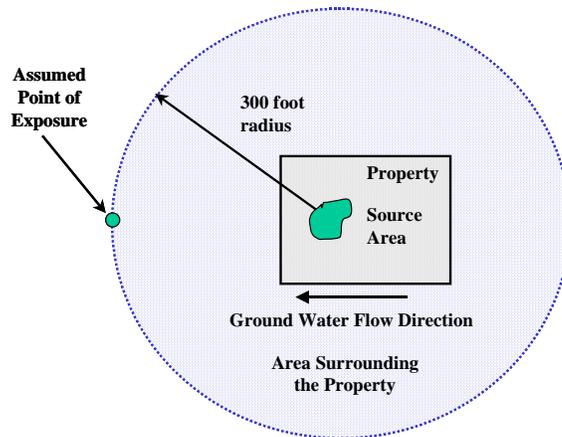


Figure 8.4 - Point of Exposure within a 300-Ft. Radius of the UST System with No Drinking Water Wells

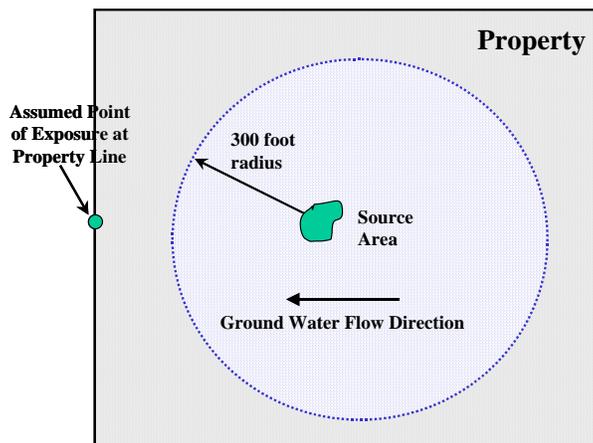


Figure 8.5 - Point of Exposure at Property Line Where Property Line Is Greater Than 300 Ft. from UST System with No Drinking Water Wells

(2) Surface Water

The POE is to be the point where the ground water containing COC concentrations discharges to the surface water (See Figure 8.6).

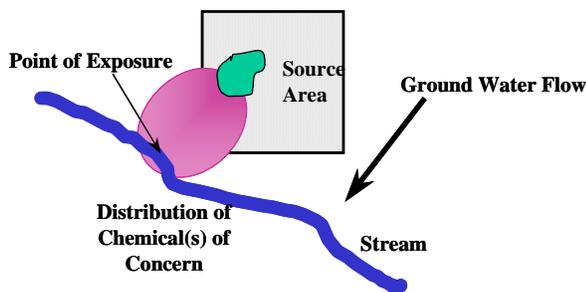


Figure 8.6 - Point of Exposure Where Ground Water Discharges to Surface Water

(3) Residences and Other Buildings

Residences and other buildings are assumed to be directly above the source area (See Figure 8.7) unless site conditions (e.g., zoning restrictions) prevent this. For off-site buildings, the anticipated maximum concentration (i.e., based on modeling) under the building would be used for the evaluation. Where SSTLs are based on land use other than residential and a land use restriction is required, you must implement an appropriate mechanism to restrict land use to activities to those consistent with the land use determination (e.g., deed restriction). You must verify which mechanism is used in your tier evaluation report.

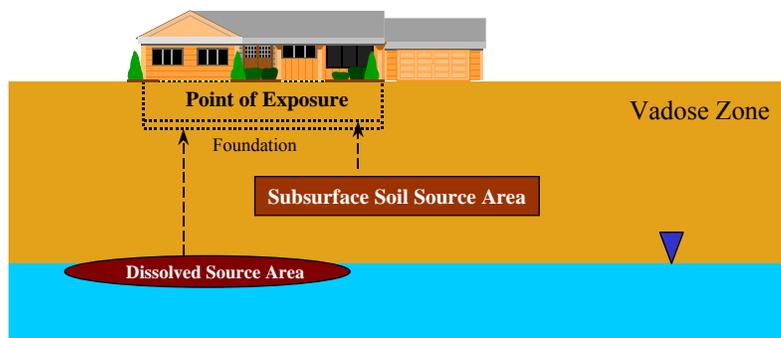


Figure 8.7 - Point of Exposure Where Building Is To Be Located Directly Above the Source Area

(4) Subsurface Structures

For subsurface structures, such as utility man-ways and underground tunnels located or anticipated to be located directly above COC concentrations, the POE is area within the subsurface structures.

(5) Surface Soil (Direct Contact)

For **residential** land use, the POE for direct contact with surface soil is 0 - 10 ft. below ground surface (See Figure 8.8).

For **non-residential**, the POE for direct contact with surface soil is 0 - 2 ft. below ground surface (See Figure 8.8).

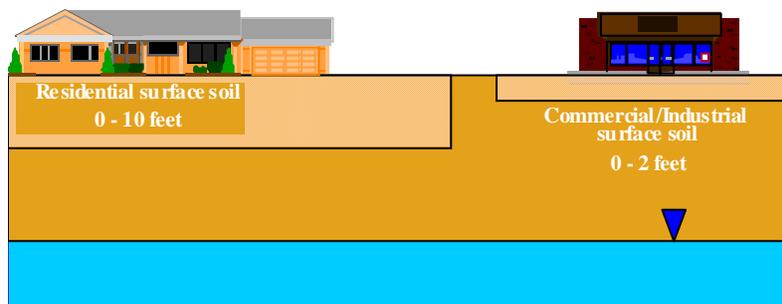


Figure 8.8 - Surface Soil for Residential and Non-Residential Land Use

Point(s) of Demonstration

Selecting the point(s) of demonstration (POD) depends on the POE location (including the receptor and exposure route), the transport mechanism (e.g., ground water migration, vapor migration), and the estimated travel time from the source to the POE.

In cases where the POE is located within the source area (the area of highest concentration of the COCs), the POD and the POE will be the same.

In general, locate the POD(s) between the source area(s) and the POE to verify the predictions related to the potential fate and transport of the COCs. By implementing a monitoring plan, you can use the POD(s) to monitor the progress of the remedial action and demonstrate that no further action is appropriate for an exposure pathway. Locate the POD(s) sufficiently up gradient from the POE to act as an early warning for continuing COC migration and to validate the fate and transport model.

Fate and Transport Model Selection

Fate and transport models used during the Tier 2 evaluation must be publicly available and be peer-reviewed models approved by BUSTR. You may use all models in the RBCA ASTM E1739-95 standard and those listed in Appendix I of BUSTR's January 1995 *Risk Assessment Guidance Document*, plus those models generally accepted by USEPA. For fate and transport models not previously accepted by BUSTR, you must submit them for approval before use in the Tier 2 evaluation.

Fate and transport modeling helps describe the distribution and movement of COCs and helps predict their concentrations at the source area(s), point(s) of demonstration, or POE. Use simple analytical models first and whenever possible. More complex models, such as numerical models, will require a significantly greater quantity and quality of data, and should be considered in a Tier 3 evaluation. Additional modeling may be used to augment the BUSTR Spreadsheet. Select appropriate fate and transport models based on:

- The exposure pathways being modeled;
- The fate and transport mechanisms being considered;
- Assumptions that are consistent with the UST site conditions;
- A reasonable approximation of the fate and transport of the COCs at the UST site and surrounding area;
- Availability and representative character of data or input parameters needed for the model of the UST site conditions;
- Capabilities of the model to match both the modeling effort objectives and the accuracy required for the results;
- An appropriate level of conservatism inherent in the model considering the quantity and quality of site-specific data available;
- The model's limitations related to site-specific conditions at the UST site;
- Limitations associated with the output results.

Model Input Parameter Considerations

Directly measure the model's input parameters at the UST site or use the BUSTR default values representing site-specific conditions. If default values do not exist for a particular parameter, use values found in published literature. Direct measurements from the UST site or chemical-specific parameters are often beyond the scope of the effort for the model. **You must reference and justify all parameters that differ from BUSTR's recommended defaults values.** (See Appendix F for many default values.)

Many published values (and some of the default values presented in Appendix F) for input parameters are presented as broad ranges, which can make it difficult to select a specific value (e.g., values of biodegradation rate constants may be given in order-of-magnitude ranges). Here you should determine the sensitivity of the model being used as compared to the input parameter values available. For those input parameters whose values have the greatest effect on the model output, evaluate the possibility of collecting and using direct measurements. The need for direct measurement data increases as the complexity of the modeling algorithm increases. Determine chemical-specific properties, such as the carbon-water sorption coefficient and biodegradation rate constants from site-specific sample analysis.

Many input parameters to fate and transport models relate to spatial and geometric factors, such as source width, area of enclosed building, thickness of affected soil zone, thickness of vadose zone, saturated thickness of water-bearing unit, and distance along a flow-path from the down-gradient edge of a plume. Determine values for these site-specific geometric input parameters from such sources as maps and available cross-sections, or from measurements made by on-site personnel before you collect site-specific data.

Model Input Parameter Sensitivity

Conduct sensitivity testing to determine how the output of a fate and transport model changes as values of input parameters are changed. A model is "sensitive" if its output changes notably when the value of the input parameter is changed only slightly. For models highly sensitive to an input parameter for which you are using an assumed or default value, you should obtain more relevant values from the literature or from field or laboratory measurements.

Analytical Models

Typically, during a Tier 2 evaluation, use analytical models for fate and transport modeling. Such analytical models sometimes predict COC concentrations that are greater than actual measured concentrations. This is an important consideration in selecting fate and transport models. Evaluations

based on conservative predictions can preclude the need to collect additional site-specific data if the predicted COC concentrations are below action levels or SSTLs.

Data collection objectives for analytical fate and transport models are typically limited to practicably attainable site-specific data or easily estimated quantities. Most data collected for analytical models relate to geometric descriptions of the model area, physical properties of the environmental media through which migration is occurring, potential gradients causing advective movement of fluids, and COC concentrations in source areas. When selecting an analytical fate and transport model, consider the availability of values for key input parameters.

In analytical fate and transport models, use default values for input parameters that have not been measured. Default values are typically used for chemical and physical properties of COCs, and for some properties of the environmental media. Choose reasonably appropriate default values for the analytical fate and transport models you select. You should measure any default values that are not representative of the UST site. The conservative nature of many analytical fate and transport models compensates to varying degrees for uncertainties in the modeling process. However, take care to select fate and transport models that will conservatively predict COC concentrations, especially if you have a limited amount of data from input parameters.

Tier 2 Options

For exposure pathways that have not been eliminated, evaluate **one or a combination** of the following under Tier 2:

1. Statistically derive the representative concentration by calculating the 95% upper confidence level (UCL) of the arithmetic mean and compare them to Tier 1 action levels;
2. Develop Tier 2 SSTLs (i.e., using BUSTR Tier 2 spreadsheets) by replacing the assumptions for the geological, hydrogeological, and physical parameters used in the algorithms for the action levels in Tier 1 with site-specific values;
3. Apply the Tier 1 action level at site-specific POE and back calculate the Tier 2 SSTL for environmental media in the source area(s) using fate and transport modeling.

Statistically Representative Concentrations (Option 1)

During the Tier 1 evaluation, action levels are compared to the highest measured concentration of each COC in the environmental media. When using statistically derived concentrations of COCs, the action levels identified for the UST site during the Tier 1 Evaluation are compared to the 95% UCL of the arithmetic mean for each identified COC. In addition, as was the case in the Tier 1 evaluation, the POE is assumed to be located in the source area(s). Statistically derived ground water concentrations of COCs cannot be used in fate and transport modeling.

Apply statistically representative concentrations of COCs only to soil source areas. Calculate the 95% UCL of the arithmetic mean using techniques for sampling normal or log normal distributions based on appropriate peer-reviewed statistical methodology. Your data sets must contain a sufficient number and quality of samples for deriving a normal, log normal, or other applicable frequency distribution. (See Appendix E for an example calculation of the statistically representative concentration of a COCs in soil.)

Calculating SSTLs Using Site-Specific Parameters (Option 2)

You can also calculate the SSTL by replacing the default geological, hydrogeological and physical parameters used in the Tier 1 action level calculations with site-specific geological, hydrogeological, and physical parameters. In addition, you may substitute non-residential exposure factors where a non-residential land use determination has been made. However, residential exposure factors cannot be changed from the default exposure factors used to develop the action levels. If you want to use residential

or non-residential exposure factors other than those identified in Appendix F, then you must submit a Tier 3 Evaluation Plan. (See Appendix F for algorithms and default parameters used in action level calculations.)

When using SSTLs calculated this way, assume that the exposure pathways identified in the Tier 1 evaluation apply, and compare the SSTL to the highest concentration for each COC for each exposure pathway. As in the Tier 1 evaluation, assume that the SSTLs are located at the POE. This approach is also appropriate for calculating SSTLs for chemicals that have no calculated Tier 1 action levels.

Back Calculating SSTLs Based on Site-Specific Point(s) of Exposure (Option 3)

Another option for calculating SSTLs is using modeling to evaluate the fate and transport of COCs in the environmental media for the complete exposure pathways identified in the site conceptual exposure model.

Fate and transport modeling is generally used to calculate COC concentration at the source area that will not cause COC concentrations at the POE to exceed appropriate action levels. If an action level does not exist for an exposure pathway, calculate that action level using the appropriate default values in Appendix F.

Tier 2 Decisions

Submit one or more of the following within 2 years after submitting the Tier 1 Evaluation Notification Report:

- Tier Evaluation Report (see checklist in Appendix I) if all COCs are below action levels;
- Monitoring Plan (may be required with the Tier Evaluation Report) to verify modeled assumptions or to prove if COC concentrations will remain at or below Tier 2 SSTLs;
- RAP with the Tier Evaluation Report;
- IRA Notification Form (see Appendix I), conduct the IRA, and submit the results as part of the Tier Evaluation Report; and/or,
- If COCs are above Tier 2 SSTLs and a more advanced modeling approached is chosen, a Tier 3 Evaluation Plan for BUSTR approval with the Tier Evaluation Report.

Interim Response Action

Upon completing a tier evaluation, determine if implementing an IRA is appropriate for reducing or eliminating source areas or otherwise eliminating exposure pathways. Conduct IRAs before submitting the RAP. Once an IRA has been implemented, re-evaluate previously identified potentially complete exposure pathways. An IRA may include source removal and short-term remedial actions.

Submit an IRA Notification Form to BUSTR at least 10 days prior to beginning the IRA. Include a summary of any IRA in the Tier Evaluation Report. (See Appendix I for the IRA Notification Checklist.)

Obtain prior approval from BUSTR if:

- The combined total volume of soil to be excavated for all tier evaluations is greater than 800 yd³;
- The combined anticipated time to initiate and complete all IRAs is greater than 3 mo.; or
- More than one IRA will be conducted during a tier evaluation.

Include in your request for approval a description of the planned confirmatory sampling for evaluating the IRA results.

Confirmatory Sampling

After completing an IRA, collect a sufficient number of samples to determine the COC concentrations that remain in soil or ground water. If you plan to request an NFA from BUSTR, then these samples must demonstrate that COC concentrations remaining in the soil or ground water are below the action levels or SSTLs. When determining the appropriate quantity and quality of samples to be collected, consider the spatial distribution of sampling locations and the temporal variations in the media or the concentrations of COCs.

Confirmatory Sampling for Soil

Collect soil samples from the excavation's sides and bottom. Collect samples on a 10ft. grid and field screen them. You must submit for laboratory analysis a minimum of 3 soil samples from the entire excavation with the highest field screening results for the COCs identified at the UST site. Some site-specific conditions or large excavations may require collecting additional samples. Please consult the BUSTR site coordinator for assistance.

Confirmatory Sampling for Ground Water

If the IRA addressed localized ground water contamination, then you must develop a ground water sampling program to demonstrate that the IRA was effective. At a minimum, collect a ground water sample from each monitoring well within the affected area. Collect samples after completing the IRA and 1 mo. after completing the IRA.

Remedial Action

If remedial action is appropriate, choose a method that would effectively achieve the appropriate action levels or SSTLs, as determined in the tier evaluation. More than one remedial action may be appropriate for a particular UST site based on the exposure pathways and COCs to be addressed by the remedial action. Remedial options include source removal, design and installation of cleanup equipment, natural attenuation processes, engineering controls and institutional controls. Note that institutional controls and engineering controls may be considered as IRAs or remedial actions. Therefore, you must submit a RAP describing the implementation of these controls when exposure pathways have been determined to be incomplete due to institutional or engineering controls such as a deed restriction.

Remedial Action Plan

If remedial action is planned, prepare a RAP and submit it to BUSTR for approval with the Tier Evaluation Report. You must also submit RAPs for cost pre-approval to the Petroleum Underground Storage Tank Release Compensation Board for sites that are eligible for reimbursement. A RAP must include:

- A description of the planned remedial action program;
- Proposed targets levels for remedial action, as identified by compound and environmental media;
- A conceptual design of the remedial action system (a detailed engineering drawing is not necessary);
- A brief description of remedial action alternatives considered, including a discussion of the reliability, effectiveness, relative cost, and time needed for completion, and the rationale for the selected program;
- A monitoring plan describing the sampling methodologies and locations for determining whether action levels or SSTLs are being achieved. This plan must demonstrate that concentrations of COCs will remain at or below SSTLs;
- A description of reporting frequency and proposed content of reports;
- A description of permits or other governmental approvals required for implementing the plan;

- A description of activities or studies, if any, that must be performed prior to implementing the proposed RAP; and
- An implementation schedule and the projected completion date of the proposed remedial action.

Public Participation

For each confirmed release where a RAP is submitted to BUSTR, you must provide a notice to the public in a format approved by BUSTR so you can reach those members of the public directly affected by the release and the planned remedial action. The notice may include, but is not limited to, public notice in local newspapers, block advertisements, public service announcements, publication in a state register, letters to individual households, or personal contacts by field staff.

If sufficient public interest exists, or for any other reason, BUSTR may hold a public meeting to consider comments on the proposed RAP before approving it. The O/O must likewise give similar public notice if an approved RAP is not achieving the established cleanup levels and BUSTR is considering a termination of that plan.

Implementing Remedial Action Plans

Upon approval of the remedial action plan, implement your plan according to the approved actions. You must monitor, evaluate, and report the results of your implementation efforts to BUSTR according to the monitoring plan.

If, after following your implementation plan for a minimum of 1 year, the installed and operational treatment technology approved by BUSTR is unable to reduce the COC concentrations to or below action levels, then you must:

- Re-evaluate and revise the remedial action alternatives and resubmit a RAP, or
- Submit a RAP Summary Report and conduct a Tier 2 evaluation.

Monitoring Plan

Develop a monitoring plan to:

- Demonstrate that no further action is appropriate due to COC concentrations in environmental media for complete exposure pathways being below and remaining below the action levels or SSTLs;
- Monitor the progress of a remedial action and demonstrate that a remedial action has achieved action levels or SSTLs, as appropriate;
- Verify fate and transport model assumptions and predictions related to the development of SSTLs.

When developing a monitoring plan, the data collection approach must consider the spatial distribution of sampling locations, temporal variations in the media, and in COC concentrations in the environmental media. Submit a monitoring plan with the Tier Evaluation Report or RAP, as appropriate. The monitoring plan must include all the following, as a minimum:

- A description of the purpose and objective of the monitoring activity;
- A description of planned monitoring activities, including those conducted to implement engineering controls;
- The location of the POD(s);
- A summary of the sampling procedures developed;
- A description of the anticipated length and frequency of the monitoring activity;
- An identification and description of the termination criteria for remedial activities, as appropriate;
- An identification and description of the termination criteria for monitoring activities, as appropriate;

- Operation and maintenance data for equipment and engineering controls.

Conduct monitoring for a minimum of 4 consecutive quarters unless you can demonstrate that a shorter time is appropriate. Upon approval, you must implement the RAP according to the approved plan. Monitor the results of the remedial action plan's implementation efforts; evaluate them and report them to BUSTR according to the monitoring plan. If you have not succeeded in meeting the monitoring plan's objective, you must perform one or more of the following:

- Conduct an IRA;
- Revise the RAP;
- Re-evaluate assumptions used in developing action levels or SSTLs;
- Conduct additional tier evaluation.

Completion Reports

Following completion of remedial action and monitoring according to this rule, you must complete and submit to BUSTR a report showing that the remedial action or monitoring objectives have been met. The report must contain documentation supporting termination of the remedial action or monitoring program. Upon approval, BUSTR will issue a written notice to the O/Os that no further action is required at the UST site.

9.0 Tier 3 Evaluation

Introduction

The Tier 3 evaluation is anticipated to be a more **complex and sophisticated** chemical fate and transport evaluation that uses site-specific numerical models (e.g., Monte Carlo analysis or other analytical tools) to develop SSTLs.

Tier 3 Evaluation Plan

If a Tier 3 evaluation is conducted, you must prepare a site-specific project plan and submit it to BUSTR for approval with the Tier 2 Evaluation Report. The O/O should meet with BUSTR prior to submitting a Tier 3 Evaluation Plan to determine what information needs to be submitted and to identify the significant issues that will need to be addressed in the plan. Unless otherwise provided in this rule, the Tier 3 Evaluation Plan is to include the following:

- A description of the objectives of the Tier 3 evaluation and the planned activities;
- A discussion of the effectiveness, cost and the rationale for selecting the Tier 3 evaluation; and
- An implementation schedule and the projected completion date for the proposed Tier 3 evaluation.

The Tier 3 Evaluation Plan may be implemented after the plan is approved by BUSTR.

Appendix A Environmental Data Collection

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For additional information concerning many of these topics, see the Ohio Environmental Protection Agency's (EPA) *Technical Guidance Manual for Hydrogeologic Investigations and Ground Water Monitoring* (February 1995) or subsequent revisions, and the *State of Ohio Technical Guidance for Sealing Unused Wells* (1996) or subsequent revisions issued by the State Coordinating Committee on Ground Water.

Soil Sampling

Excavation Sampling

Wear clean latex gloves to handle soil samples retrieved from the excavation or borehole. Use a clean hand trowel to remove 3 - 4 in. of native soil from the bottom and/or sidewalls of the excavation. Collect undisturbed and discrete soil samples (i.e., no composites) from the exposed area using a stainless steel spoon or a sampling tube. Split each sample into 2 representative soil samples. Place 1 split sample into a jar or baggie used for field screening. Immediately place the other sample into a laboratory-supplied glass jar (with a Teflon[®]-lined lid); preserve it on ice to 39° F. You must completely fill sample containers submitted for laboratory analysis. Affix sample labels to each jar; labels must correspond to the site sample log and chain-of-custody. Either deliver the sample jars directly, or send via overnight shipper to a laboratory; use standard chain-of-custody procedures. You must complete this process for all sampling locations.

Subsurface Soil Sampling

Wear clean latex gloves to handle soil samples retrieved from the borehole. All samples must be undisturbed, discrete samples. Split samples from each interval into 2 representative soil samples. Place 1 split sample in a jar or baggie and use for field screening. Immediately place the other sample into a laboratory-supplied glass jar (with a Teflon-lined lid); preserve on ice to 39° F. You must completely fill sample containers submitted for laboratory analysis. Affix sample labels to each jar; labels must correspond to the site sample log and chain-of-custody. Either deliver the sample jars directly, or send via overnight shipper to a laboratory; use standard chain-of-custody procedures. You must complete this process for all sampling locations.

Bedrock Sampling

When diamond-bit drilling is used to retrieve a continuous sample, it can show the characteristics of a specified interval, but core losses frequently occur. Core losses can occur in relatively consolidated materials when the rock that is being cored is highly fractured and broken, or when a fragment of the rock becomes wedged in a portion of the core bit or barrel. Carefully monitor every core run to determine the percent recovery; amount and location of core loss; and the actual depth at the beginning and end of each core run.

During coring activities, keep a core log that contains 1) all relevant information obtained during the drilling and coring, and 2) a field description of the core. Core log forms are more specialized than standard soil boring log forms, and generally will contain columns for recording percent core recovery, rock quality designation (RQD), and number and orientation of fractures.

After removing each core from the core barrel, you should inspect it, log it, and carefully place the core into a properly labeled core box. Include the following information: depth to top and bottom of core, core loss zones, and identification of fractures. Fractures made after removing the core from the core barrel should be distinguished from fractures that are interpreted as in-place fractures. Place spacers inside the core boxes to mark ends of core runs and the positions of core loss zones.

Field Screening (Headspace Analysis)

You must use a headspace analysis (e.g., photo ionization detector/flame ionization detector - PID/FID) when site investigation activities include soil sampling and/or field screening. Split samples from each interval into 2 representative soil samples. Place 1 split sample in a jar or baggie for field screening. This container should be no more than half full and sealed to prevent the loss of volatiles. Allow this container with the soil sample to stand for a minimum of 10 - 15 min. at a minimum of 70° F. Insert a calibrated field screening instrument probe into the container, be careful not to lose volatiles. Record the highest field screening reading. Typically, you must submit the highest field screening reading for laboratory analysis. Sampling requirements vary with the investigation being performed.

For the other half of the sample, immediately place it into a laboratory-supplied glass jar (with a Teflon-lined lid); preserve on ice to 39°F. Submit completely filled sample containers for laboratory analysis. If field screening is not performed, submit all samples for laboratory analysis.

Soil Sampling for Geotechnical Analysis

Site-specific soil characteristics may be necessary during a Tier 2 or 3 evaluation. If geotechnical analysis is necessary, select one or more soil boring locations (as appropriate) and collect a sample from each representative zone identified in each boring. Analyze samples to determine the following parameters:

- Atterberg limits;
- Unified Soil Classification System (USCS) classification;
- Dry bulk density;
- Grain size;
- Specific gravity;
- Moisture content;
- Total porosity;

- Volumetric air content;
- Volumetric water content;
- Vertical hydraulic conductivity;
- Total organic carbon (obtained from outside the contaminated zone).

You may collect soil samples for geotechnical analysis using split-spoon samplers, Shelby Tubes, California Samplers, or direct push sample tubes. However, analyses for many of these parameters require that you collect undisturbed soil using a thin-walled sampling device (e.g., Shelby Tube) according to American Society of Testing and Materials (ASTM) Standard Practice D1587, and preserve and transport the samples according to ASTM Standard Practice D4220.

You must also classify the soil samples according to USCS or ASTM D2488-93 (Standard Practice for Description and Identification of Soil/Visual-Manual Procedures). In some cases, you might need to have your samples analyzed in a laboratory via ASTM 2487.00 Standard Classification of Soil for Engineering Purposes. Your soil boring logs and monitoring well construction diagrams should include, at minimum, the information listed in Appendix B.

Ground Water Sampling

Ground Water Sampling from an Open Excavation

It may be necessary to sample surface water or ground water from a tank cavity excavation or trench. Before collecting a water sample, first recover any free product or sheen, and dispose of it properly. When collecting the sample, lower the container into the water in an inverted position and slowly turn it over. Collect the sample within the first 6 in. of the water surface. Carefully fill the sample jar to minimize turbulence and to minimize the amount of soil and foreign matter obtained. In certain circumstances, you might need to use a bailer to avoid entering an excavation to collect a water sample. When conducting a closure, evacuate any water in the underground storage tank (UST) pit; if water recharges within 24 hrs., collect a water sample.

Ground Water Sampling from Monitoring Wells

Prior to sampling activities, perform appropriate measurements (i.e., static water level, total well depth, detection of free product or gases). Depth measurements must be accurate to within 0.01 ft. Additionally, survey all wells using a survey reference point (benchmark).

You must characterize and record the presence and thickness of any free product. Measure free product thickness using an oil/water interface probe. If free product is not detected, you may collect a ground water sample and submit it to the laboratory for analysis.

Monitoring wells must be properly developed prior to purging and sampling to ensure that representative ground water samples are collected. Use a clean hand bailer or other suitable equipment to purge the monitoring well of a minimum of 3 - 5 times its calculated volume of water. Allow the well to recover to near static water levels prior to collecting the sample, but sample as soon as possible. To avoid cross contamination of monitoring wells, use dedicated or disposable bailers. (For additional details, see the Well Development and Maintenance section below in this Appendix.)

Bladder pumps are generally acknowledged as good ground water sampling devices, but the need for a power source and compressed air limit their use. Typically, bottom-draining bailers are used for sampling ground water. Bailers should be lowered and raised slowly (not dropped) into the

well to minimize disturbance and aeration of the ground water. Submerge bailers into the water only as far as necessary to collect the sample volume and minimize aeration.

Properly identify each sample with the appropriate soil boring or monitoring well before submitting to the laboratory. At a minimum, field logging should include the identification and location of the samples; the number and quantity of well purging volumes; the date and time of sampling; and the results of pH, temperature and conductivity field measurements.

Drilling Technologies

When selecting the primary drilling method used to investigate UST release sites, consider the following factors:

- Hydrogeological and geological conditions;
- Contaminant type and concentrations;
- Scope of the investigation;
- Future use of the boring as a monitoring well;
- Physical site limitations (e.g., overhead obstructions, subsurface utilities, service station canopies).

If you select a drilling method other than hollow stem augering, direct push, or air rotary, you must discuss this choice with BUSTR prior to implementing.

Hollow Stem Augers

Hollow-stem augers (HSA) are the primary choice for subsurface investigations of UST release sites involving the installation of monitoring or recovery wells. When applying this technique, collect soil samples by using clean split-spoon samplers driven through the hollow-stem augers with a 140-lb. hammer according to ASTM D1586 (Standard Method for Penetration Test and Split-Barrel Sampling of Soil). Split-spoon samplers should be driven continuously throughout the depth of the borehole. For BUSTR purposes, use a 2 ft. sample interval (i.e., 0 - 2 ft., 2 - 4 ft.).

Direct Push

Direct push methods (e.g., Geoprobe[®], Powerprobe[®], hand-held sampling systems) can be used during a subsurface investigation where accelerated assessment is applicable and recovery wells will not be necessary. For BUSTR purposes, use a 2-ft. sample interval (i.e., 0 - 2 ft., 2 - 4 ft.).

Air Rotary Drilling

Use air rotary or rock coring methods to conduct subsurface investigations involving the installation of monitoring or recovery wells into bedrock. Use caution when considering air rotary drilling, as this specialized type of drilling requires personnel with substantial experience in air rotary methods.

Monitoring Well Installation

Provide details of well installation materials and techniques used, and the field conditions encountered via “as-built” monitoring well construction diagrams. In the corresponding report, you must include the actual monitoring well installation procedures. Additionally, Ohio Revised Code requires that you must submit to the Ohio Department of Natural Resources (ODNR) Division of Water all boring logs and construction diagrams for all monitoring wells installed in Ohio. For additional information concerning this requirement and the applicable Well Log Form, please contact ODNR.

Upon completing the borehole to the required depth, use the following well installation procedures:

- If necessary, backfill the hole with 1 ft. of sand/gravel prior to installing the screen and casing into the borehole;
- Assemble the well screen and casing, and lower the assembled well to the necessary depth. You must keep the well screen casing plumb in the hole. Threaded joints are required, as glued or solvent welded joints may alter the chemistry of future water samples. The well screen should be new, machine-slotted (typically 0.010-in. slot size) or continuously wrapped wire wound, and should be composed of schedule 40 PVC material;
- Install a sand/gravel pack (with a grain size appropriate for the well screen) in the annular space between the well and the side of the borehole. Install the sand/gravel pack 2 ft. above the top of the well screen;
- Place a 1 ft. (minimum) bentonite/cement seal above the sand/gravel pack to form a seal;
- Fill the remaining annular space in the borehole with bentonite/cement grout to a depth of approximately 1 - 2 ft. below the ground surface;
- Seal the well from surface contamination with a 1 - 2 ft. concrete layer;
- Place a water-resistant, bolt-down manhole cover or protective casing within a 2 ft. x 2 ft. square concrete pad overlying the well location;
- Cap the top of the well casing with a tightly fitted, locking well cap to prevent vandalism; and to prevent surface water, debris, and/or other contaminants from entering the well.

Pre-Packed Wells Installed Using Direct Push

BUSTR accepts the use of pre-packed monitoring wells greater than or equal to 1 in. diameter as an approved method for obtaining ground water samples. Pre-packed wells allow for an accelerated assessment of the release site, and can be installed in areas where access is restricted. However, using these wells is limited to collecting ground water samples, measuring water levels, and as a way to observe wells during pump tests; these wells are not recommend for determining hydraulic conductivity (i.e., slug tests). The 1-in., pre-packed wells must be installed according to manufacturer's recommendations. BUSTR must approve the use of pre-packed wells less than or equal to 1 in. in diameter.

Well Development and Maintenance

To ensure that representative ground water samples are collected, monitoring wells must be properly developed. Well development improves the hydraulic interface with subsurface strata and removes particulates produced during the well installation. Upon completion, develop the wells by using clean disposable bailers and dedicated polypropylene rope, a properly decontaminated centrifugal or submersible pump, or other suitable equipment. For development with a pump, initially use a bailer to remove accumulated sediments.

Development and purged fluids generated from the well should be containerized in DOT-approved 17-H or 17-E 55-gal. drums and disposed of according to federal, state, and local regulations.

You should periodically redevelop monitoring wells to ensure that representative samples can be collected. Maintenance should include 1) inspections of hydraulic performance and 2) a comparison to baseline data. If hydraulic performance is diminished, you should rehabilitate the well. **You must either perform frequent (monthly or quarterly) sampling or implement a well maintenance program to ensure appropriate well monitoring and sample integrity.**

Borehole Abandonment/Well Decommissioning

To prevent the potential downward migration of surface contaminants, properly abandon boreholes not completed as wells and wells on release sites that have received no further action status.

Borehole Abandonment

Borehole abandonment should consist of grouting the borehole. The basic equipment for most abandonment procedures is the same as for tremie-grouting of a monitoring well. Use a grout mixer or other method of mixing the grout and a positive displacement pump to deliver the mixture with positive pressure to the bottom of the borehole.

There are several alternative methods for borehole abandonment:

- Place bentonite pellets through a conductor pipe into water-filled, uncased boreholes;
- Use direct gravity placement in boreholes that are free of water and in deeper boreholes that have sufficient open diameter to prevent bridging;
- With special precautions, you may use bentonite pellets/chips to abandon deep water-filled boreholes that have sufficient open diameter to prevent bridging. Removing all the fines should prevent the development of drilling mud that impedes proper settling of the bentonite chunks.

To be effective, a sealing material should not react with any contaminants, should form a tight seal with the borehole wall, should be resistant to cracking/shrinking, and should have an effective hydraulic conductivity less than the native materials. Two principal grouting materials, neat cement and bentonite, best meet the needs for abandonment.

Well Decommissioning

Measure the well's depth before it is sealed. Do this to ensure that no obstructions might interfere with effective sealing. Record static water levels.

To properly seal a well:

- Remove (pull or overdrill) or drill through the well casing with hollow stem augers);
- Cut off casing 2 ft. below grade and grout in place.

Note that removal is the preferred method for well abandonment.

Use bentonite, neat cement, or a bentonite/cement mixture as the primary sealing material. Use a single, continuous operation to place such material upward from the bottom of the well to within 2 ft. of the surface. Backfill the remaining 2 ft. of annular space with materials that match the existing surface conditions (i.e., soil, asphalt, concrete).

The Ohio Revised Code requires that you file an abandonment report with the ODNR Division of Water. Contact ODNR for the appropriate form (e.g., Water Well Sealing Report). You must contact BUSTR prior to abandoning and/or decommissioning wells at sites still undergoing corrective action.

Data Quality Objectives

Quality assurance (QA) and quality control (QC) procedures help to minimize sources of errors and the potential for cross-contaminating samples, and help to maximize the quality of the data collected. Establish data quality objectives that will be consistent with the intended use of the

data (e.g., low detection limits to demonstrate meeting action levels or higher detection limits for screening samples). Data quality objectives should:

- Define the most appropriate types of samples to collect;
- Determine the most appropriate conditions to sample;
- Define the quality and quantity of required samples;
- Define the quality and quantity of samples needed to support the sampling strategy.

Sample QA/QC

Blanks

Use field and trip blanks as controls for detecting field-introduced contamination of water samples, or contamination occurring during transit to or from the sampling site. In situations where laboratory analytical data are suspect or inconsistent, use control samples (i.e., blanks) to validate/document the appropriate sampling and preservation methods.

Trip Blanks

Prepare trip blanks as samples of organic-free water, which must be prepared at the same location and time as the sample bottles. Keep trip blanks with the sample bottles while in transit to the site, during sampling, and during the return trip to the laboratory. Upon return to the laboratory, trip blanks will be analyzed as if they were another sample. If these samples are accidentally opened, you must record this on the chain-of-custody form.

Field Blanks

Prepare field blanks by filling sample containers with deionized water at the site and preserving them with an appropriate reagent(s). Upon return to the laboratory, field blanks are analyzed as if they were another sample. If these samples are accidentally opened, you must record this on the chain-of-custody form.

Equipment Blanks

Prepare equipment blanks by pouring deionized water over or through the decontaminated sample collection device and collecting this water in a sample container. Upon return to the laboratory, equipment blanks will be analyzed as if they were another sample. If these samples are accidentally opened, you must record this on the chain-of-custody form.

Sample Preservation

Proper soil and water sample preservation is important for maintaining sample integrity and analytical data validity. Seal samples in glass jars that are tightly capped with Teflon-lined lids. You must properly label and identify all sample containers. Once in containers, you must immediately place samples for laboratory analysis on ice or in a refrigerator or cooler maintained to 39° F for transport. Please contact the laboratory for information on the appropriate container sizes and preservation methods for the desired analyses. Improper sample handling, such as excessive holding times, may alter the analytical results and invalidate the data. Holding times vary depending on the constituent being analyzed.

Chain of Custody

A chain-of-custody record tracks the transfer of custody for a sample from the time of its collection to its delivery to the laboratory. Fill out a chain-of-custody form immediately after collecting the samples. The individual collecting, relinquishing, and receiving the samples must

sign a chain-of-custody each time the sample changes hands. Most laboratories can provide a copy of a standard chain-of-custody form. Appropriate forms should include sample identification; sample type; date and time collected; analysis requested for each sample; preservation; and, in the case of soil samples, depth and location.

Decontamination Procedures

The main purposes of decontamination are to ensure that valid, representative samples are collected and to prevent cross-contamination among sample locations. The lack of effective and standardized procedures typically results in critical scrutiny of the generated data.

At a minimum, steam-clean or wash all sampling equipment (e.g., drill augers and rods, split spoons, bailers) in an area specifically set aside for decontaminating equipment (i.e., decon pad). Clean the sampling equipment before beginning to sample and between collecting each sample. Scrub soil sampling equipment with non-phosphatic soap and water, and rinse with distilled/deionized water. Collect/contain all decontamination fluids (rinseates) properly and transfer to labeled 55-gal. DOT approved 17-H or 17-E steel drums. Characterize all contaminated soil and rinseates, and dispose of them (as necessary) according to federal, state, and local regulations.

Personnel Safety (Site Specific Health and Safety Plan)

You must prepare a Site Specific Health and Safety Plan and implement it at all UST release sites. Additionally, all personnel working at a UST release site should have completed the OSHA 40-hour HAZWOPER (Hazardous Waste Operations) course, and annual 8-hr. refresher courses. For additional information concerning health and safety issues, please see 29 CFR (Code of Federal Regulations) 1910.120, and other standard industry health and safety references (i.e., National Institute for Safety and Health - NIOSH, American National Standards Institute - ANSI, National Fire Protection Association - NFPA, and/or ASTM).

Appendix B Data Presentation

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Site Figures

This suggested list of figures may be included in reports, as applicable:

- Topographic Map;
- Site and Surrounding Area Map;
- Site Map;
- Sample Location Map;
- Potentiometric Surface Map;
- Soil Analytical Data Map;
- Ground Water Analytical Data Map.

Each map should include the following general information:

- Site name and location (i.e., address, city, county);
- North directional arrow;
- Explanation or legend;
- Scale (i.e., 1 in. = 20 ft.);
- Preparation date;
- Signature or initials of the person who prepared the map.

In addition, each map listed below should contain the following specific information.

Topographic Map

- Site location identified on a USGS 7.5-min. topographic map.
(See Figure B-1 for an example of a topographic map.)

Site and Surrounding Area Map

- Property boundaries of the release site;
- The location of the suspected release source;
- Nearby buildings, street names, and business name(s);

- Buried and overhead utility locations on or adjacent to the UST release site;
 - The location of other potential release sources, such as nearby service stations;
 - Locations of drinking-water wells within 2000 ft. of the UST system;
 - Labeled 2000 feet radius surrounding site;
 - Lakes, streams, rivers and surface water bodies within 2000 ft.
- (See Figure B-2 for an example of a site and surrounding area map.)

Site Map

- Property boundaries of release site;
 - UST system locations (i.e., tanks, piping, dispensers) and former UST system locations;
 - The location of the suspected release source;
 - Site structure and surface cover (i.e., buildings, asphalt, concrete, grass);
 - Nearby buildings, street names, and business name(s);
 - Buried and overhead utility locations on or adjacent to the UST release site;
 - The location of other potential release sources, such as nearby service stations;
 - Exact locations of drinking water wells within 50-ft. of the UST system.
- (See Figure B-3 for an example of a site map.)

Sample Location Map

- Property boundaries of release site;
 - UST system locations (tanks, piping, dispensers) and former UST system locations with dimensions noted;
 - The location of the suspected release source;
 - Nearby buildings, street names, and business name(s);
 - Buried and overhead utility locations on or adjacent to the UST release site;
 - The location of other potential release sources, such as nearby service stations;
 - The limits of any excavations;
 - All soil boring, trench, and monitoring well locations, marked and designated appropriately (e.g., monitoring well - MW-1 or soil boring - SB-3);
 - All soil and water sample collection points within an excavation marked and designated appropriately;
 - Exact locations of drinking-water wells within 50 ft. of the UST system.
- (See Figure B-4 for an example of a sample location map.)

Potentiometric Surface Map

- Property boundaries of release site;
- UST system locations (i.e., tanks, piping, dispensers) and former UST system locations with dimensions noted;
- The location of the suspected release source;
- Nearby buildings, street names, and business name(s);
- Buried and overhead utility locations on or adjacent to the UST release site;
- The location of other potential release sources, such as nearby service stations;
- The limits of any excavations;
- All soil boring, trench, and monitoring well locations, marked and designated appropriately (e.g., MW-1 or SB-3);

- All soil and water sample collection points within an excavation marked and designated appropriately;
 - Exact locations of drinking-water wells within 50 ft. of the UST system;
 - Data points and potentiometric surface contour lines.
- (See Figure B-5 for an example of a potentiometric surface map.)

Soil Analytical Data Map

- Property boundaries of release site;
 - UST system locations (i.e., tanks, piping, dispensers) and former UST system locations with dimensions noted;
 - The location of the suspected release source;
 - Nearby buildings, street names, and business name(s);
 - All soil boring, trench, and monitoring well locations, marked and designated appropriately (e.g., MW-1 or SB-3);
 - Buried and overhead utility locations on or adjacent to the UST release site;
 - The location of other potential release sources, such as nearby service stations;
 - The limits of any excavations;
 - All soil and water sample collection points within an excavation marked and designated appropriately;
 - Exact locations of drinking-water wells within 50 ft. of the UST system;
 - Soil analytical results in tabular form for each sample location.
- (See Figure B-6 for an example of a soil analytical map.)

Ground Water Analytical Data Map

- Property boundaries of release site;
 - UST system locations (i.e., tanks, piping, dispensers) and former UST system locations with dimensions noted;
 - The location of the suspected release source;
 - Nearby buildings, street names, and business name(s);
 - All soil boring, trench and monitoring well locations, marked and designated appropriately (e.g., MW-1 or SB-3);
 - Buried and overhead utility locations on or adjacent to the UST release site;
 - The location of other potential release sources, such as nearby gas stations;
 - The limits of any excavations;
 - All water sample collection points within an excavation marked and designated appropriately;
 - Exact locations of drinking-water wells within 50 ft. of the UST system;
 - Ground water analytical results in tabular form for each sampling point.
- (See Figure B-7 for an example of a ground water analytical map.)

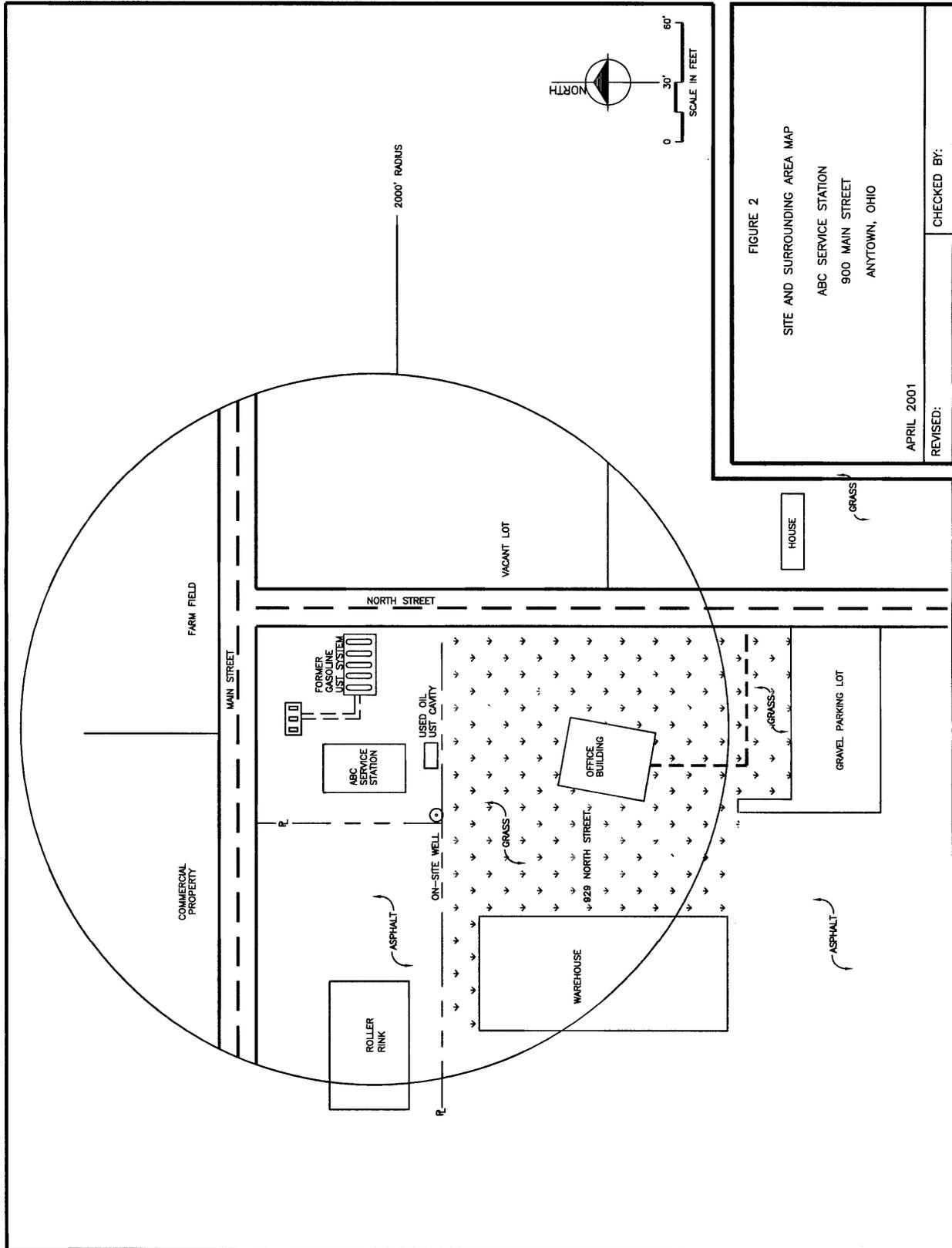


Figure B-2: Site and Surrounding Area

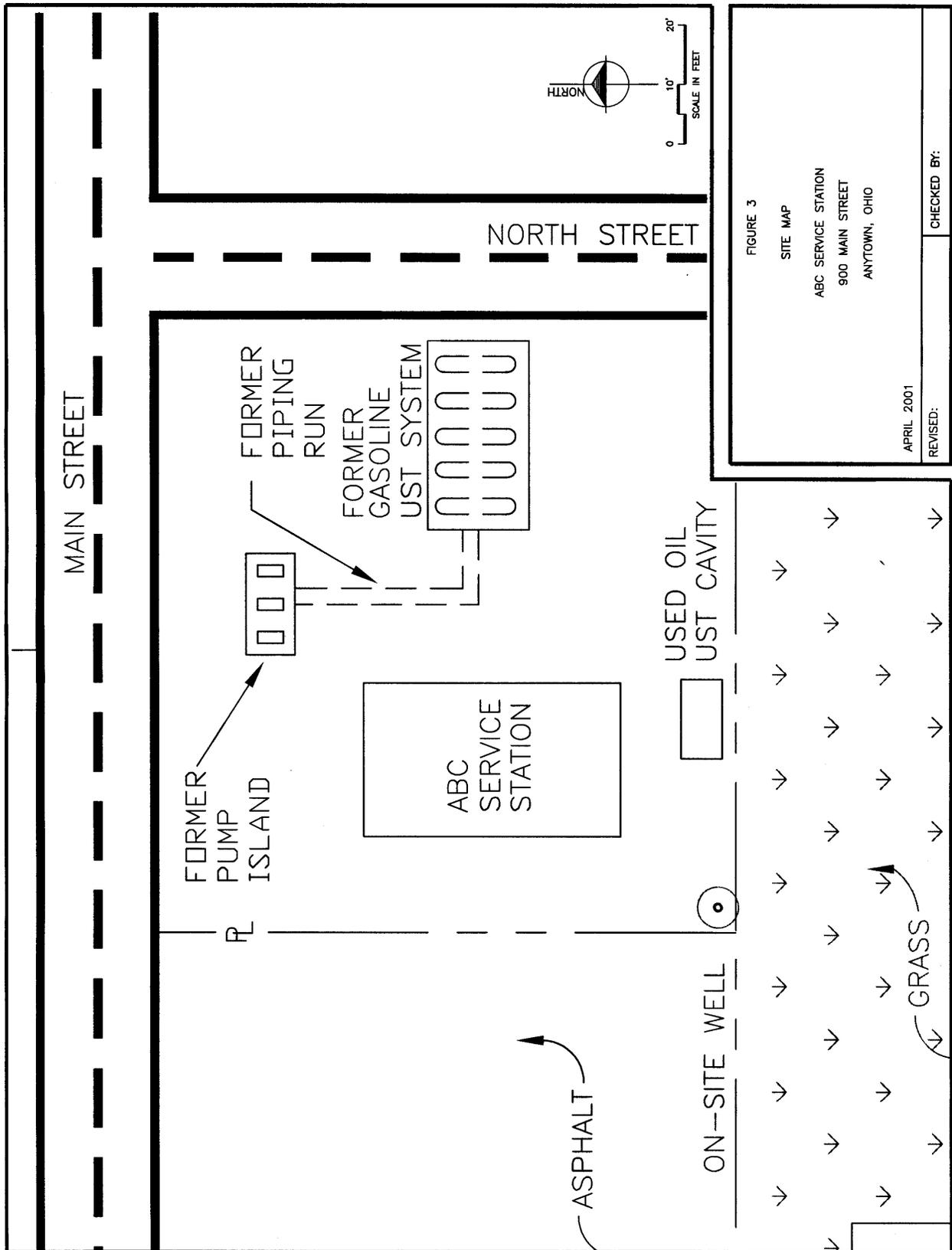


Figure B-3: Site Map

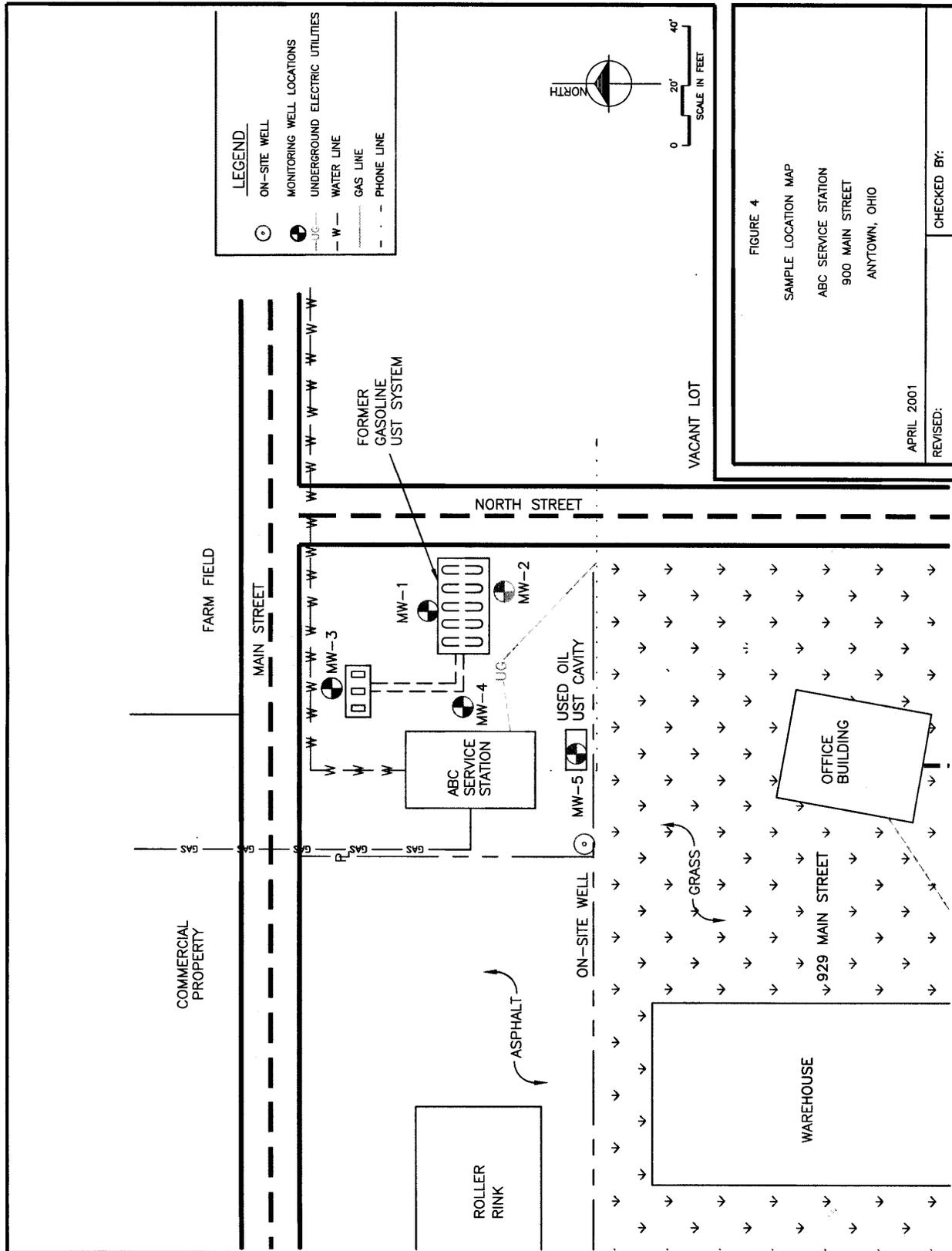


Figure B-4: Location Map

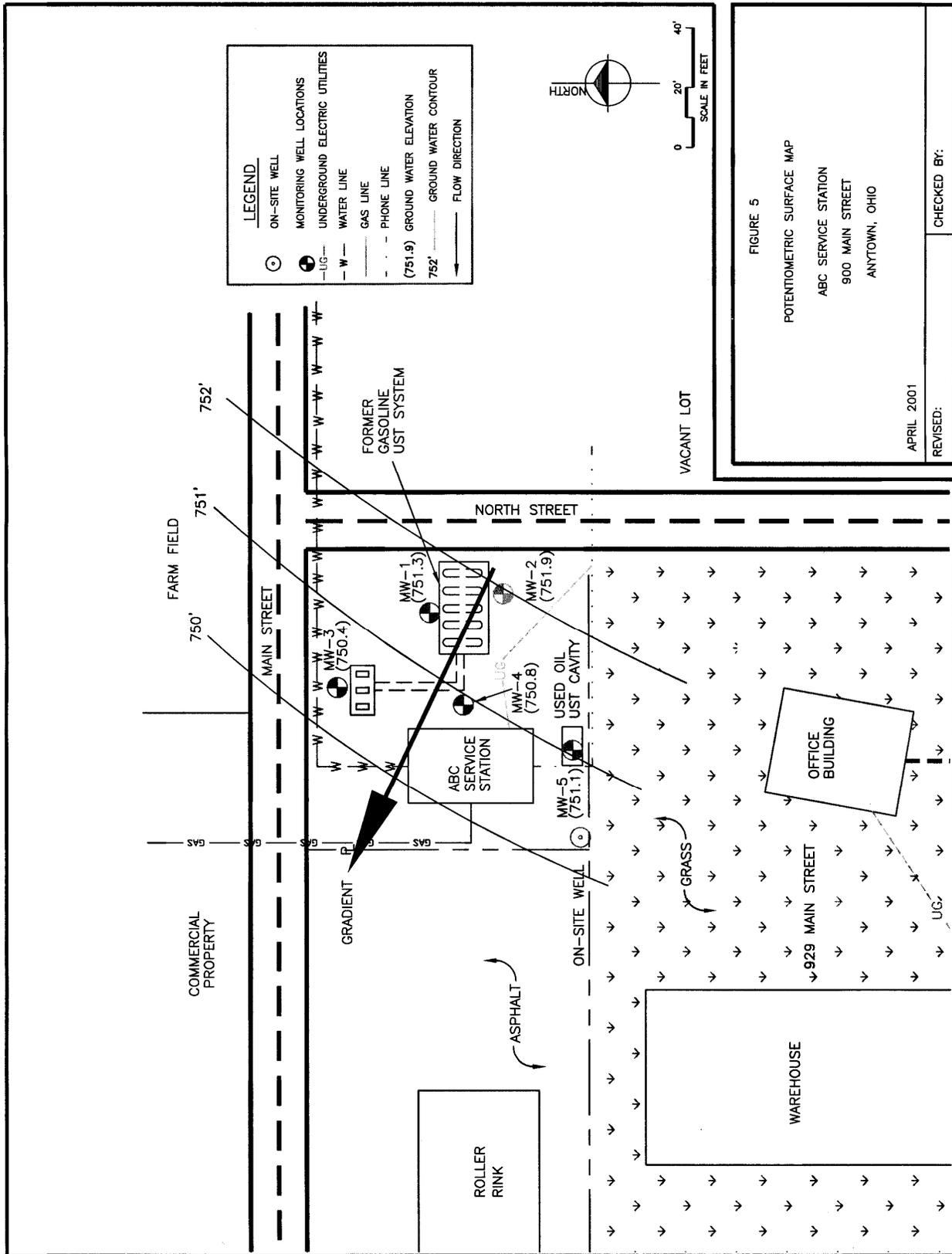


Figure B-5: Potentiometric Surface Map

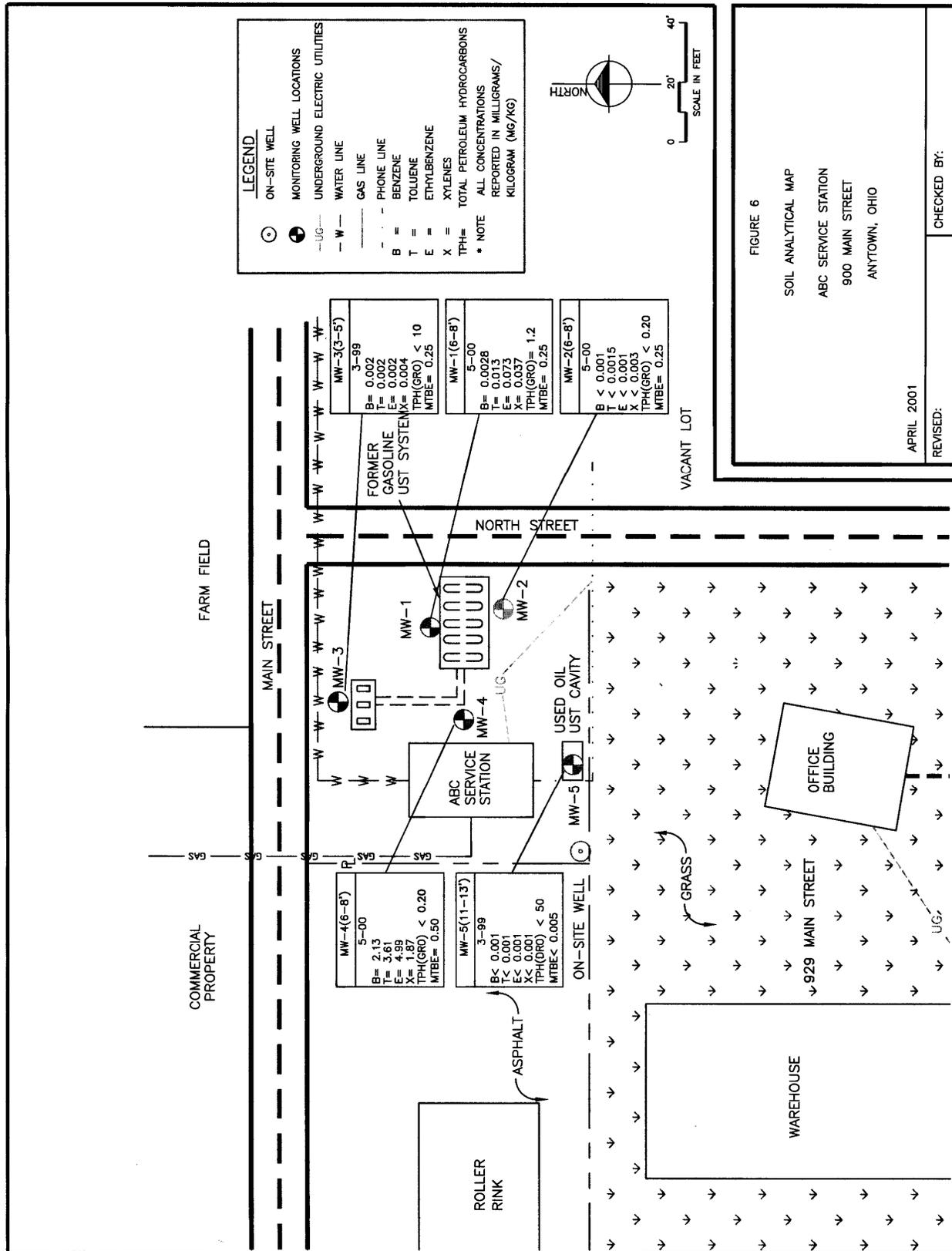


Figure B-6: Soil Analytical Map

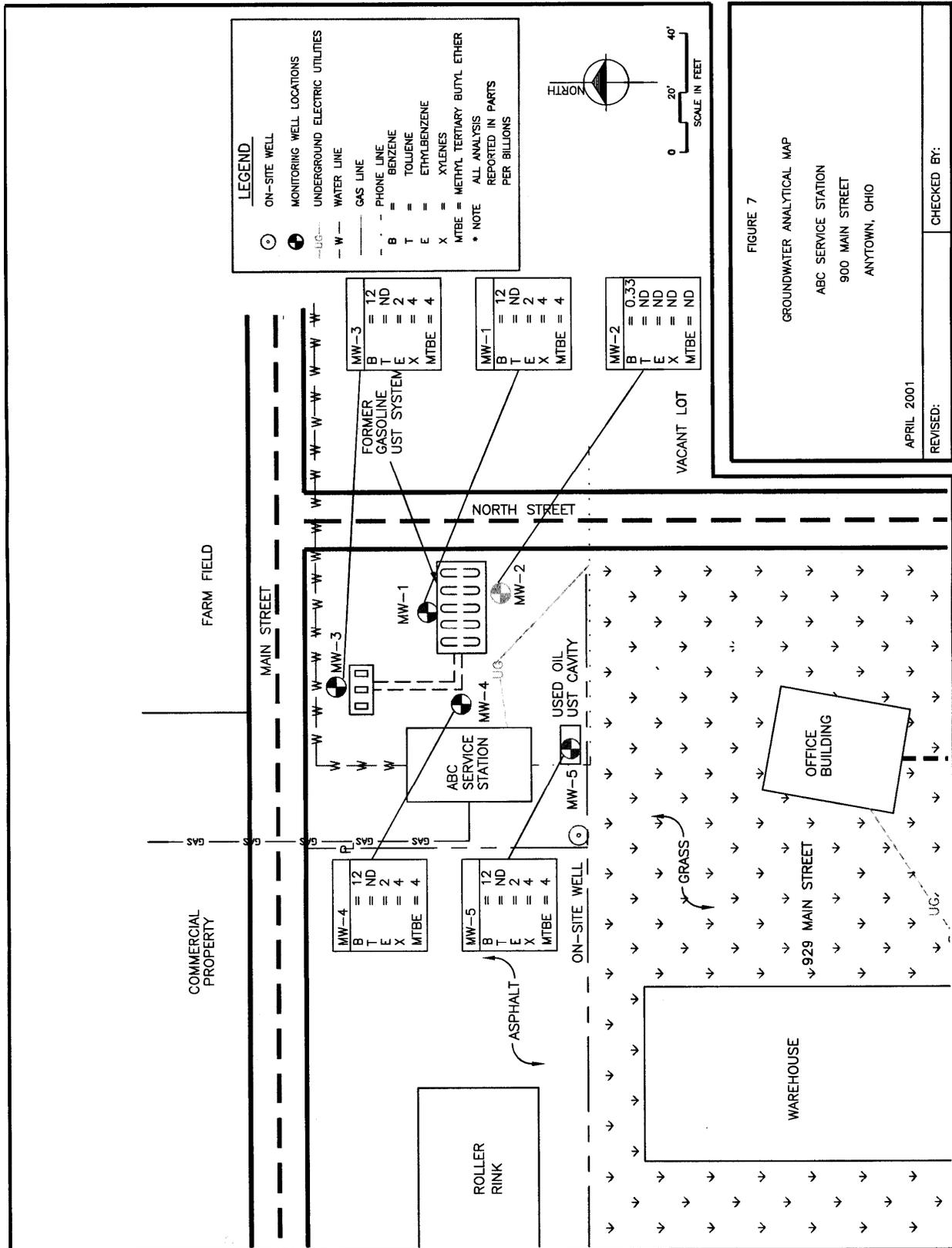


Figure B-7: Ground Water Analytical Map

Soil Boring Logs and Monitoring Well Construction Diagrams

Use detailed diagrams to show soil boring logs and monitoring well construction. (See Figure B-8 for an example.) Soil boring and monitoring well logs should include the following information, as appropriate:

- Boring/well identification number;
- Site name and address;
- Latitude and longitude (e.g., global positioning system - GPS);
- Drilling and well installation dates, including dates started and completed;
- Name of person logging the boring/well;
- Name of drilling company;
- Type and size of drilling/sampling equipment (i.e., 4.25-in. ID hollow-stem augers (HSA), 24-in. split spoons);
- Type and size of well construction material (i.e., 2-in. ID Schedule 40 PVC casing and 0.010-slot PVC screen);
- Type of grout used to backfill the boring/well annulus;
- Detailed description of the soil sample for each interval, including soil type, color, moisture content, presence of fracturing, and any other pertinent observations and comments (i.e., staining, odors);
- Detailed description of bedrock samples collected, including rock type, color, bedding thickness, approximate dip angle and fracturing, moisture content, extent of weathering/competency, and any other pertinent observations or comments;
- Standard penetration test (i.e., blow count) data for each sampling interval;
- Sample recovery from each sampling interval;
- Results of field screening for each sample;
- Depth that ground water was encountered during drilling;
- Static water depth after the well has been developed (including date(s) of measurement);
- Ground surface elevation at the wellhead, and the elevation at the top of the well casing, measured from a marked point on the north side of the well. All monitoring well elevation measurements should be surveyed to within 0.01 ft. Ground surface elevations should be surveyed to within 0.1 ft;
- Graphical representation of well construction details;
- Graphical representation of soil/rock types as encountered;
- Identification of soil sample(s) submitted for laboratory analysis;
- Notable occurrences during drilling (i.e., the presence of heaving sand in the augers, difficult drilling conditions);
- Any information associated with geotechnical soil characterization.

BORING LOG/ WELL CONSTRUCTION DIAGRAM

Depth	Symbol	Description	Depth (ft)	Well Data	Well Const. Info.	SAMPLE INFORMATION				Comments
						Blow Counts	Type	Recovery	PID (ppm vapor)	
		Ground Surface	98.5							
		ASPHALT	98.1		flush mount set in concrete 0-1'					
1		SAND (SM) black, damp, loose, strong gas odor becomes moist, green-gray at 3.5 ft	93.3		2" PVC riser pipe	5,6,4,5			3430	2-4 ft sample submitted to lab
2										
3										
4										
5		SILTY CLAY (CL) light gray w/ black staining, moist, medium stiff, interbeds of thin (<1") sand lenses @ 7.7 becomes gray w/ orange motting, little gravel @ 8.9 becomes very stiff, damp, trace fine gravel	87.3		#4 coarse silica sand 3.5-0-16'	3,3,3,3			5,6,4,5	4-6 ft sample submitted to lab
6										
7										
8										
9										
10		SAND AND GRAVEL (GC) Gray, wet, coarse, some fines, dense	86		2" ID PVC 0.010 slot well screen	2,4,6,11			1833	
11										
12										
13		SILTY CLAY (CL) Gray, slightly moist, medium stiff, trace gravel, becomes very stiff, damp, trace fine	82.5			2,8,6,6			270	
14										
15										
16										
17						4,7,9,12			43.9	
18						6,10,7,15			0.0	
19						6,12,22,20			0.0	
20										

Comments:

Drilling Company: Drilling Co.	Consulting, Inc.	Hole Size: 8.25" OD
Drilling Method: 4.25-inch HSA	Avenue	Casing Elevation: 98.47
Drilling Date: 1-01-01	Anytown, Ohio 42286	Water Elevation: 90.65
	Phone No. (555)555-5555	

SOIL BORING/WELL #:

▽ Depth Water Uncontoured	Client: ABC Service Station
▼ Static Water Level	Location: Main Street, Anytown, Ohio
	Project: Tier 1 Evaluation
	Project Number: 01-01-000000
	Logged By:
	Reviewed By:

Figure 8

Figure B-8: Soil Boring Log/Monitoring Well Construction Diagram

Cross Sections

The term, “cross section”, refers not only to cross sections constructed from boring logs and other information, but also to drawings of trench or tank cavity walls. Figure B-9 is an example of a cross section location map. (See Figure B-10 for an example of a cross section.)

Cross sections should include the following information:

- Site name and address;
- Cross section name (i.e., A-A’);
- An explanation of any symbols used (i.e., legend);
- Graphical representation of soil/bedrock encountered;
- The location of any samples collected;
- Field screen readings corresponding to sample intervals;
- Underground utilities;
- Static and encountered ground water elevations;
- Horizontal and vertical scales.

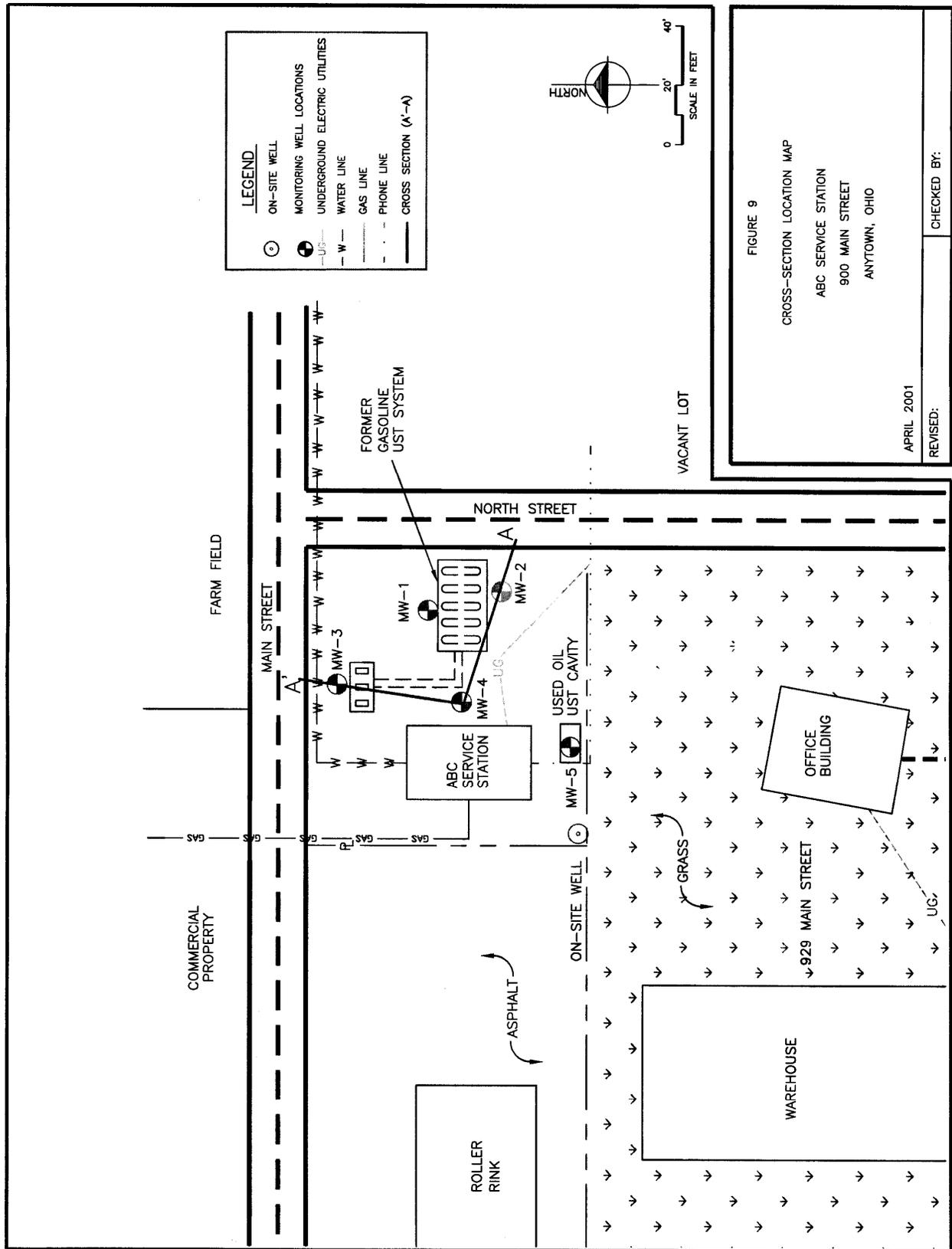


Figure B-9: Cross Section Location Map

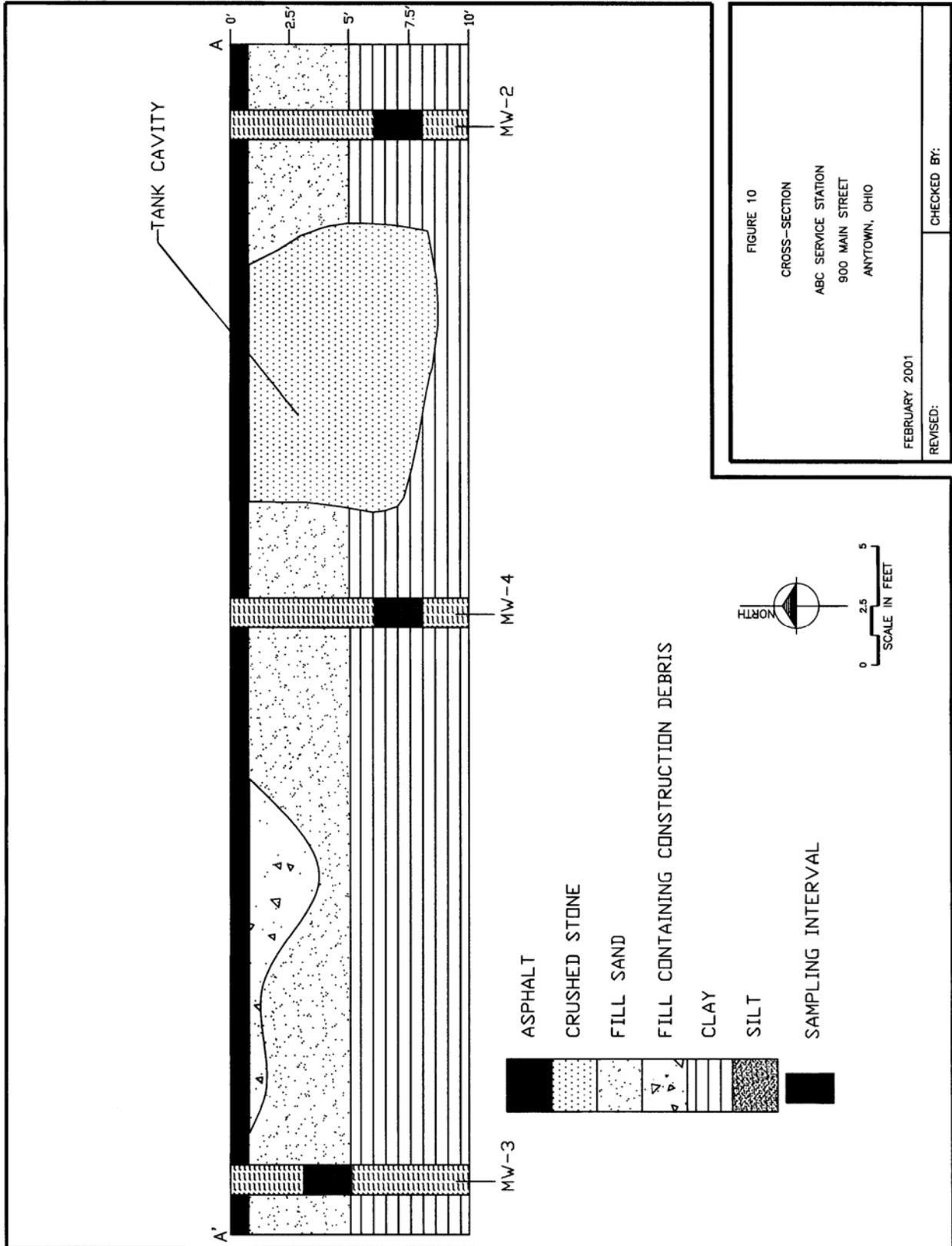


Figure B-10: Cross Section

Tables

Use tables whenever possible to efficiently display analytical data. Include your notes or comments below the table. Present data as an actual concentration or as less than the reporting limit (such as less than 5 ppb – parts per billion). **Do not use notations such as below detection limit (BDL), below quantitation limit (BQL), and not detectable (ND).** (See Tables B-1 and B-2 for examples.)

Tables should include the following information:

- Site name and address;
- Media sampled;
- Date of sampling;
- Sample identification (i.e., MW-3, SB-1);
- Sample depth;
- Actual concentration of contaminants in ppm – parts per million;
- Field screening measurement, if applicable.

Table B-1

Field Screening Results
 ABC Service Station
 900 Main Street
 Anytown, Ohio

Sample Interval	Sampling Date	SB-1 (ppm)	SB-2 (ppm)	SB-3 (ppm)
0-2'	4-10-01	0.0	0.0	0.0
2-4'	4-10-01	75.0	87.0	99.0
4-6'	4-10-01	32.0	35.0	53.0
6-8'	4-10-01	43.0	12.0	18.0
8-10'	4-10-01	22.0	31.0	33.0
10-12'	4-10-01	55.0	67.0	78.0

Bold: Submitted for laboratory analysis.

Table B-2

Soil Analytical Results
 ABC Service Station
 900 Main Street
 Anytown, Ohio

Sample	Depth (ft)	Sampling Date	Benzene mg/kg	Toluene mg/kg	Ethylbenzene mg/kg	Xylenes mg/kg	MTBE mg/kg
SB-1	2-4	4-10-01	0.006	0.035	0.254	0.476	0.062
SB-1	10-12	4-10-01	0.054	0.037	0.027	0.092	0.354
SB-2	2-4	4-10-01	0.140	0.365	0.276	0.486	0.197
SB-2	10-12	4-10-01	0.356	0.476	0.957	0.746	1.376
SB-3	2-4	4-10-01	0.046	0.736	0.366	0.354	0.286
SB-3	10-12	4-10-01	0.098	0.228	0.336	1.900	0.098

Bold: Above action levels

Laboratory Analytical Reports

Submit copies of actual laboratory analytical results with each report. Table B-3 shows an example of an appropriate laboratory analytical report.

Laboratory analytical reports should include the following:

- Site name and address;
- Name, address, and phone number of the laboratory;
- Client name;
- Sample matrix (i.e., soil, water, air);
- Sample identification;
- Date of sample collection;
- Date of sample receipt by laboratory;
- Date of sample analysis;
- Analytical method used to analyze sample;
- Analyte (e.g., benzene, toluene);
- Concentration and units of analyte(s) present;
- Quantitation limit and units;
- Name of analyst.

Table B-3: Laboratory Analytical Report**Water and Soil Labs, Inc.****12345 Elm St., Anytown, OH 12345, (123) 456-7890**

Client Name: ABC Service Station
 Address: 900 Main Street
 Anytown, OH

Client Sample Identification: SGC-019248B
 Sample Matrix: Soil
 Date Sample Collected: 10-April-01
 Date Sample Received: 11-April-01
 Date Sample Analyzed: 12-April-01

Purgeable Aromatics
 Analytical Results

Lab No. 90979A
 Sample ID# SB-1 (10-12')

<u>Analyte</u>	<u>Concentration (mg/kg)</u>	<u>Quantitation Limit (mg/kg)</u>
Benzene	0.054	<0.002
Toluene	0.037	<0.002
Ethylbenzene	0.027	<0.002
Total Xylenes	0.092	<0.002
MTBE	0.354	<0.002
Surrogate- a,a,a-Trifluorotoluene	95%	

Analytical method: SW 846 Method 8021

Analyst: Jane Doe
 Verified: 12-April-01
 Date Reported: 12-April-01

Appendix C Chemicals of Concern

Table of Contents

Chemical(s) of Concern To Be Evaluated	C-1
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Identifying chemicals of concern (COCs) and the appropriate analytical methods must be based on the petroleum product known or suspected to have been released. For released product falling in Analytical Group 3 (e.g., used oil), you must also identify the additional chemicals of concern (ACOCs).

Chemical(s) of Concern To Be Evaluated

Table C-1 below divides COCs into the following 3 analytical groups:

- Analytical Group 1 (light distillate products) includes gasoline and aviation gasoline. Gasoline is evaluated using the aromatic hydrocarbons benzene, toluene, ethyl benzene, and xylenes (BTEX). Methyl tert butyl ether (MTBE) is also evaluated for gasoline releases.
- Analytical Group 2 (middle distillate products) includes diesel, light fuel oils, kerosene, and jet fuels. Middle distillates are evaluated using both BTEX and polynuclear aromatic hydrocarbons (PAH). Group 2 requires only the 8 PAHs listed in the table to be evaluated as COCs. In addition, TPH (C10-C20 and C20-C34) must be evaluated to determine soil saturation. (See Section 4.0 for an explanation of soil saturation.)
- Analytical Group 3 (heavy petroleum products) includes lubricating oils, hydraulic oils, used oils, and other unknown petroleum products or petroleum products not included in Analytical Groups 1 and 2. For Group 3 substances, the full range of chemicals listed in 8260 and 8270 (or 8310) and any other suspected COCs must be analyzed and reported. In addition, TPH (C10-C20 and C20-C34) must be evaluated to determine soil saturation. (See Section 4.0 for an explanation of soil saturation.) Chemicals of concern are further subdivided as volatile organic compounds (VOCs), additives, semi-VOCs, and TPH.) (See Table C-1 for examples.) All substances detected by laboratory analysis, must be evaluated and compared to site-specific target level (s) (SSTLs).

Table C-1 - Chemicals of Concern and Analytical Methods

	Selected Chemicals of Concern				Analytical Methods	
	Materials Stored or Handled				Soil	Ground water
	Analytical Group	1	2	***3		
	Chemical	Gasoline	Middle Distillates	Heavy Products & Unknowns		
Volatile Organic Compounds	Benzene	X	X	X	*8020, 8021, *8240, 8260	*8020, 8021,* 8240, 8260
	Toluene	X	X	X		
	Ethyl benzene	X	X	X		
	Xylenes	X	X	X		
	Other volatile organic compounds			As appropriate		
	Chlorinated organic compounds			As appropriate		
Additives	Methyl tert butyl ether (MTBE)	X		X		
Semi-Volatile Organic Compounds	Benzo(a)anthracene		X	X	8310, 8270	8310, 8270
	Benzo(a)pyrene		X	X		
	Benzo(b)fluoranthene		X	X		
	Benzo(k)fluoranthene		X	X		
	Chrysene		X	X		
	Dibenz(a,h)anthracene		X	X		
	Ideno(1,2,3-cd)pyrene		X	X		
	Naphthalene		X	X		
Other semi-volatile organic compounds			X			
**TPH	Total Petroleum Hydrocarbons		X	X	8015	NA

* Test methods 8020 and 8240 have been superseded by methods 8021 and 8260, respectively.

** TPH by method 8015 (C-10 to C-34) is required.

*** Group 3 products require analysis for the full range of VOCs.

Send soil and ground water samples to a laboratory for analysis of the appropriate COCs. If an alternative analytical method is more appropriate for a particular COC, you must submit that alternative method to BUSTR for approval.

Additional Chemical(s) of Concern

If the release is a petroleum product in Analytical Group 3, you must make a determination to identify any ACOCs likely to be present. This determination must identify impurities, additives, or degradation products of the petroleum product stored or released. At a minimum, Analytical Group 3 products must be sampled for the COCs identified in Table C-1. In addition, where an Analytical Group 3 product is known or suspected to contain ACOCs (e.g., chlorinated compounds), choose an analytical method that can detect these ACOCs. Unless you suspect a specific ACOC, direct the laboratory to report all chemicals found. Consult BUSTR before selecting an analytical method for an ACOC. You may need to submit a Material Safety Data Sheet (MSDS) for the substance. Assume that any chemical(s) identified by the analytical method, and that has available toxicological data (e.g., slope factors, reference doses), is an ACOC. Toxicological data references include U.S. Environmental Protection Agency's (EPA's) Integrated Risk Information System (IRIS), Health Effects Assessment Summary Tables (HEAST), VAP,

and Region 9 USEPA Preliminary Remediation Goals (PRGs). Calculate action levels for all ACOCs, and compares them to the highest concentrations of the ACOCs identified. (See Appendix F for physical, chemical and toxicological properties for ACOCs.)

Appendix D Action Level Determination and Tables

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Determining Action Levels

Determine action levels for each environmental media and exposure pathway at the underground storage tank (UST) site. To do so, you must evaluate the following site-specific information, as appropriate:

- Identify the chemical(s) of concern (COCs) based on the petroleum product released;
- Select a soil type that best represents the soil under the UST site and is most appropriate to the specific exposure pathway. For purposes of the Tier 1 evaluation, classify bedrock as a sand/gravel soil type;
- Determine if the saturated zone is ground water. If you don't make a determination, assume that the saturated zone is ground water;
- Determine if ground water is drinking water. If you don't make a determination, then assume that the ground water is drinking water;
- Determine the depth to ground water for the upper most saturated zone. If you encounter bedrock prior to extending the boring to 50-ft. and the boring has not been extended into the bedrock, assume that the depth to ground water equals the depth to the top of bedrock.

Drinking Water Scenario

If you determine that the ground water is drinking water, then you must compare the highest concentration of each COC in soil and ground water to the action levels in the following tables:

- Ground Water Ingestion;
- Direct Contact;
- Soil to Drinking Ground Water Leaching;
- Soil to Indoor Air;
- Ground Water to Indoor Air.

Non-Drinking Water Scenario

If you determine that the ground water is not drinking water, then you must compare the highest concentration of each COC in soil and ground water to the action levels in the following tables:

- Direct Contact;
- Soil to Non-Drinking Ground Water Leaching;
- Soil to Indoor Air;
- Ground Water to Indoor Air.

No Ground Water Scenario

If you encounter no ground water, then compare the highest concentration of each COCs in soil to the action levels in the following tables:

- Direct Contact;
- Soil to Indoor Air.

Action Level Tables

The following tables contain the generic action levels for closure assessment and corrective actions:

Closure and Site Check Action Levels (Summary)

Drinking Water Action Levels	Chemical of Concern	Soil Action Levels*		
		Sand/Gravel	Silty/Clayey Sand	Clay/Silt
.005	Benzene	.150	.240	.910
1.000	Toluene	58.7	112	520
.700	Ethylbenzene	71.1	131	230
10.000	Total Xylenes	1500	1500	1500
.040	MTBE	.530	.890	3.8
-	Benzo(a)anthracene	5.5	5.5	5.5
.0002	Benzo(a)pyrene	.550	.550	.550
-	Benzo(b)fluoranthene	5.50	5.5	5.5
-	Benzo(k)fluoranthene	55	55	55
-	Chrysene	550	550	550
-	Dibenz(a,h)anthracene	.550	.550	.550
-	Indeno(1,2,3-cd) pyrene	5.5	5.5	5.5
.570	Napthalene	1800	1800	1800

*Contaminant levels in ppm

*Soil action levels include direct contact and soil to ground water leaching action levels

Note: For the purpose of closure assessment and site check, assume that the ground water underlying the UST site and surrounding area is a drinking water source.

Soil Saturation Values

Analytical Group	Chemical of Concern	Soil Classification Group		
		Sand/Gravel	Silty/Clayey Sands	Silt/Clay
Analytical Group 1	Benzene	444.5	491.6	592.2
	Toluene	268.2	313.7	374.6
	Ethylbenzene	149.3	178.8	213.0
	Total Xylenes	124.7	147.4	175.8
	MTBE	5483.0	6111.0	8493.0
Analytical Group 2	TPH (C10-C-20)	2,000	10,000	20,000
Analytical Group 3	TPH (C20-C34)	5,000	20,000	40,000

Contaminant levels in ppm

Action Levels by Soil Type

Action Levels for Sandy/Gravel Soil

PCS*	Drinking Water	Chemicals of Concern	Direct Contact	Soil to Ground Water Leaching			
				Depth to Ground Water			
				< 15 Feet	15-30 Feet	31-50 Feet	>50 Feet
.015	.005	Benzene	8.2	.15	.15	.15	.15
5.86	1	Toluene	520	58.7	58.7	58.7	62.1
7.11	.7	Ethylbenzene	230	71.1	71	71	71.9
72.4	10	Total Xylenes	1500	-	-	-	-
.053	.04	MTBE	130	.53	.53	.53	.53
5.5	-	Benzo(a)anthracene	5.5	-	-	-	-
.55	.0002	Benzo(a)pyrene	.55	-	-	-	-
5.5	-	Benzo(b)flouranthene	5.5	-	-	-	-
1.97	-	Benzo(k)flouranthene	55	-	-	-	-
1.27	-	Chrysene	550	-	-	-	-
.55	-	Dibenz(a,h)anthracene	.55	8.63	8.63	-	-
.15	-	Indeno(1,2,3-c,d)pyrene	5.5	-	-	-	-
127	.57	Naphthalene	1800	-	-	-	-
Soil to Non-Drinking Water Leaching				117	118	118	120
Soil to Indoor Air				.950	.950	.950	.950
Ground Water to Indoor Air				3.98	3.98	4.03	4.1

Contaminant levels in ppm

- (dash) – no applicable action level

*PCS – petroleum contaminated soil

Action Levels for Silty/Clayey Sand Soil

PCS*	Drinking Water	Chemicals of Concern	Direct Contact	Soil to Ground Water Leaching			
				Depth to Ground Water			
				< 15 Feet	15-30 Feet	31-50 Feet	>50 Feet
.015	.005	Benzene	8.2	.24	.24	.27	.30
5.86	1	Toluene	520	112	112	-	-
7.11	.7	Ethylbenzene	230	131	131	-	-
72.4	10	Total Xylenes	1500	-	-	-	-
.053	.04	MTBE	130	.89	.89	1.0	1.19
5.5	-	Benzo(a)anthracene	5.5	-	-	-	-
.55	.0002	Benzo(a)pyrene	.55	-	-	-	-
5.5	-	Benzo(b)fluoranthene	5.5	-	-	-	-
1.97	-	Benzo(k)fluoranthene	55	-	-	-	-
1.27	-	Chrysene	550	-	-	-	-
.55	-	Dibenz(a,h)anthracene	.55	-	-	-	-
.15	-	Indeno(1,2,3-c,d)pyrene	5.5	-	-	-	-
127	.57	Naphthalene	1800	-	-	-	-
Soil to Non-Drinking Water Leaching		Benzene		196	197	216	251
Soil to Indoor Air		Benzene		1.05	1.05	1.05	1.05
Ground Water to Indoor Air		Benzene		3.99	3.99	4.06	4.16

Contaminant levels in ppm

- (dash) – no applicable action level

*PCS – Petroleum contaminated soil

Action Levels for Clay/Silt Soil

PCS*	Drinking Water	Chemicals of Concern	Direct Contact	Soil to Ground Water Leaching			
				Depth to Ground Water			
				< 15 Feet	15-30 Feet	31-50 Feet	>50 Feet
.015	.005	Benzene	8.2	.91	.91	1.08	.15
5.86	1	Toluene	520	-	-	-	-
7.11	.7	Ethylbenzene	230	-	-	-	-
72.4	10	Total Xylenes	1500	-	-	-	-
.053	.04	MTBE	130	3.8	3.8	4.75	6.43
5.5	-	Benzo(a)anthracene	5.5	-	-	-	-
.55	.0002	Benzo(a)pyrene	.55	-	-	-	-
5.5	-	Benzo(b)flouranthene	5.5	-	-	-	-
1.97	-	Benzo(k)flouranthene	55	-	-	-	-
1.27	-	Chrysene	550	-	-	-	-
.55	-	Dibenz(a,h)anthracene	.55	-	-	-	-
.15	-	Indeno(1,2,3-c,d)pyrene	5.5	-	-	-	-
127	.57	Naphthalene	1800	-	-	-	-
Soil to Non-Drinking Water Leaching		Benzene		-	-	-	-
Soil to Indoor Air		Benzene		1.29	1.29	1.29	1.29
Ground Water to Indoor Air		Benzene		4.09	4.09	4.45	4.88

Contaminant levels in ppm

- (dash) - no applicable action level

*PCS – petroleum contaminated soil

Petroleum Contaminated Soil

If excavated soil does not exceed the following action levels, you may use the soil for any lawful purpose. Do not interpret this statement as authorizing the use of such soil for any purpose prohibited or otherwise restricted by applicable federal, state, or local laws and regulations.

Chemical of Concern	Action Level
Benzene	.015 PPM
Toluene	5.86 PPM
Ethylbenzene	7.11 PPM
Total Xylenes	72.4 PPM
Methyl Tertiary Butyl Ether (MTBE)	.053 PPM
Benzo (a) - anthracene	5.50 PPM
Benzo (a) - pyrene	.550 PPM
Benzo (b) - fluoranthene	5.50 PPM
Benzo (k) - fluoranthene	1.97* PPM
Chrysene	1.27* PPM
Dibenz (a,h) - anthracene	.550 PPM
Indeno (1, 2, 3, - cd) pyrene	.150* PPM
Naphthalene	127* PPM

*Calculated saturation values in sand/gravel soil

Landfarming Petroleum Contaminated Soil

If landfarmed, petroleum contaminated soil must not have COCs concentrations that exceed the following:

Chemical of Concern	Action Level
Benzene	35.00 PPM
Toluene	109.00 PPM
Ethylbenzene	32.00 PPM
Total Xylenes	65.00 PPM
Methyl Tertiary Butyl Ether (MTBE)	75.00 PPM
Benzo (a) - anthracene	7.50 PPM
Benzo (a) - pyrene	3.30 PPM
Benzo (b) - fluoranthene	3.69 PPM
Benzo (k) - fluoranthene	1.97 PPM
Chrysene	1.27 PPM
Dibenz (a,h) - anthracene	18.90 PPM
Indeno (1, 2, 3, - cd) pyrene	150.00 PPM
Naphthalene	127.00 PPM

Appendix E Statistically Representative Concentration Calculation

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Introduction

This Appendix provides guidance for statistically deriving representative concentrations of chemicals of concern (COCs) in soil by calculating the ninety-five percent upper confidence level (UCL) of the arithmetic mean as provided in Ohio Administrative Code (OAC) 1301-7-9-13(M)(3), Tier 2 Options. It is not intended to address general data quality and statistical analysis issues. There are a number of textbooks and U.S. Environmental Protection Agency (USEPA) guidance documents that address statistical data analysis and comparison of sampling results to target levels. (See the reference list at the end of this Appendix.)

To help you design a scientific and resource-efficient sampling program, USEPA provides guidance on developing Data Quality Objectives (DQO) (USEPA, 1998). The DQO process allows you to define the data requirements and acceptable levels of decision errors before any data are collected. A determination of sample size using this process is also acceptable to BUSTR, keeping in mind that the purpose of this Appendix is to provide a simplified procedure for a standard underground storage tank (UST) site using DQO principles.

Basic Sampling Requirements

Soil samples collected for use in determining representative concentration values must come from the source area. Statistical analysis assumes samples are representative of the source area and are obtained by using either random sampling or another statistically valid sampling plan. If there is more than one source area on the site, then separate the data by source area. In addition, if you plan separate analyses of exposures to surface soils and subsurface soils, then separate the analytical results accordingly.

To simplify the process of determining a statistically representative concentration of COCs in soil, you can use the following criterion to select your sample size. BUSTR requires a minimum of 8 samples for soil impacted volumes less than 125 yd³. For larger impacted volumes, a minimum of 12 samples per 3000 yd³ are required. BUSTR requires that non-detect values comprise no more than 15% of the total number of measurements. If there are more than 15% non-detects in the data set the EPA provides guidance for modified analysis methods that may be used in place of the methods described in this appendix (USEPA, 1992)

For each chemical and source area, you need the following data:

- All analysis results (including analytical method references);
- Number of samples (detects/non-detects);
- Detection limits;
- Sampling and analysis dates.

Calculating Summary Statistics

In a spreadsheet, or by hand, order the data from lowest to highest concentration. If the laboratory results are below the detection limits, use a value of one-half of the detection limit in-place of the non-detect values. Typically for evaluating source area data non-detects will not appear in the data set or will be a very small proportion, since by definition the source area is the area of highest concentration.

You must determine summary statistics for each sample set. These include:

- Sample median (i.e., middle value, half of the values are lower and half are higher);
- Sample range (i.e., highest value, lowest value);
- Sample mean (average);
- Sample variance;
- Standard error of the mean;
- Skewness;
- Coefficient of variation.

Calculate the summary statistics for both the original data and for log-transformed data. See the examples below for summary statistics calculations:

Calculate the arithmetic mean of the sample data using this equation:

$$mean(x) = \bar{x} = \frac{1}{n} \sum_{i=1}^n x_i$$

Equation E-1 - Sample Mean

Calculate the variance of the sample data as follows:

$$variance(x) = s^2 = \frac{1}{(n-1)} \sum_{i=1}^n (x_i - \bar{x})^2$$

Equation E-2 - Sample Variance

If you are using random sampling, the sample mean is an unbiased estimate of the population mean. The sample mean is a random variable, meaning it will equal the value of the population mean plus or minus some error. The expected size of that error is measured by the variance of the mean. The variance of the mean is:

$$variance(\bar{x}) = \frac{s^2}{n}$$

Equation E-3 - Variance of the Sample Mean

Note that the above equations assume your sampling is random and from the same population. This is why it is important to ensure your data is representative of the source area, and that data from different source areas is separated.

The standard error of the mean is the square root of the variance of the sample mean:

$$s(\bar{x}) = \frac{\sqrt{\text{variance}(x)}}{\sqrt{n}}$$

Equation E-4 - Standard Error of the Mean

By using more sample data you can reduce the size of the standard error of the mean. There is an inverse relationship between the standard error of the mean and the square root of the number of samples (e.g., increasing n from 4 to 16 reduces the standard error by 50%).

The skewness and the coefficient of variation are useful values for determining the distribution of your sample data. Skewness is an indicator of whether the data are distributed symmetrically around the mean. If the skewness is equal to zero then the data are distributed symmetrically. If the skewness is less than zero, the values below the mean are more dispersed than the values above the mean. The opposite is true when the skewness is greater than zero.

$$\text{skewness}(x) = \frac{\frac{1}{n} \sum (x_i - \bar{x})^3}{\left(\frac{n-1}{n}\right)^{\frac{3}{2}} * s^3}$$

Equation E-5 – Skewness

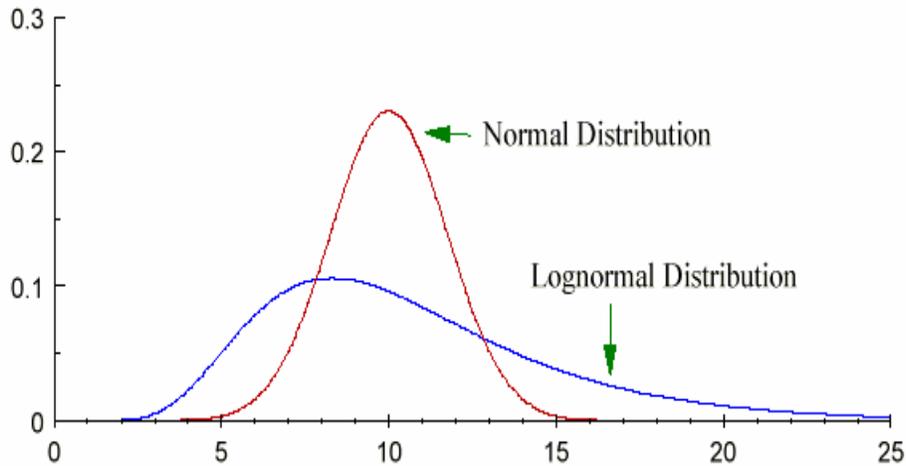
The coefficient of variation (δ) is also an indicator of the dispersion of the data around the mean value:

$$\delta = \frac{s}{\bar{x}}$$

Equation E-6 - Coefficient of Variation

Estimating the Distribution of the Data

As noted before, we assume that sample results are from a random sampling taken from the same source area. In order to calculate a 95% upper confidence level for the mean we also have to assume a sampling distribution. Two of the most common frequency distributions are the normal distribution (or “bell curve”) and the lognormal distribution. Other sampling distributions that may exist are beyond the scope of this Appendix. A histogram of sample data from a population with a normal or a lognormal distribution will look something like the following example:



To decide whether a normal or lognormal distribution is more appropriate for your data analysis, conduct the following qualitative and simple quantitative tests:

Qualitative Tests

Prepare a histogram of both the sample concentration data and the log-transformed data. The x-axis must be divided into groups (or bins) of concentration values. If the data appear to be symmetrically distributed about the mean value, then you probably have a normal distribution. If the log-transformed data appear to be symmetrically distributed around the (log transformed) mean value, then you probably have a lognormal distribution. (See samples of histograms in Examples 1 and 2 at the end of this Appendix.)

Next, compare the mean and the median values of the data. If these values are similar, this also indicates the data are symmetrically distributed about the mean value.

The coefficient of variation must be less than 1.0 for the data to be considered normally distributed (see Equation E-6). This is a less powerful indicator than the skewness value, or the probability plots presented in the next section, but it is a simple statistic to calculate and is included in the analyses.

Simple Quantitative Tests

The coefficient of skewness test evaluates the skewness value (see Equation E-5). The skewness value will be close to zero if the data are normally distributed. If the skewness value is greater than 1.0, or if it is less than -1.0 then the data is too highly skewed to be from a normal distribution. If the skewness value of the data is larger than zero, but the skewness value for the log-transformed data is near zero, then you probably have a lognormal distribution.

Probability plots are a convenient way to demonstrate normality of the data. Construct your probability plots on distribution-specific probability paper (similar to semi-logarithmic graph paper). There are also software packages included on standard spreadsheets that display probability plots. (See a sample of a probability plot in Example 2 at the end of this Appendix.)

In a probability plot, the data are ranked from lowest to highest. Prepare separate probability plots for the sample concentration data and the log-transformed concentration

data. Plot the concentration data on the y-axis versus the standard normal variate, on the x-axis (see graph at the end of Example 2). If the plot results in a relatively straight line (allowing for variations due to natural variability and measurement error), then the data follow the normal distribution. Similarly, a relatively straight line on the log concentration plot results in a lognormal distribution.

Evaluating the Results

If the original concentration data pass all of the qualitative tests and the simple quantitative tests, then you can assume your data is normally distributed. If the log-transformed data pass all of the qualitative tests and the simple quantitative tests then you can assume your data is log-normally distributed. In these cases, you can use the following formulas (e.g., Equations E-7 & E-8) to determine your 95% UCL. The distribution may also be used in further data analyses (e.g., calculating the value of collecting additional information for a Tier 3 evaluation or using Monte Carlo simulation of the source area concentration in Tier 3 fate and transport modeling).

In the cases where one or more tests are successful but others fail, it may not be appropriate to assume a normal or lognormal distribution for your data. If a quantitative evaluation fails, do not use the assumed distributions for the data sets. Instead, collect additional sampling data, and use a non-parametric procedure, or use the maximum concentration value for Tier 2.

95% UCL for the Mean

The UCL for the mean will be greater than or equal to the true mean with a probability of 0.95. Derive the UCL by taking the sample mean and adding a value determined by: the variance of the sample mean; the desired confidence level (95%); and the characteristics of the assumed distribution.

$$\text{upper confidence limit } [\mu]_{1-\alpha} = \left(\bar{x} + \Phi^{-1}(1-\alpha) * \frac{s}{\sqrt{n}} \right)$$

Equation E-7 - UCL on Mean for Normal Distribution

Statistics textbooks provide tabulated values of $\Phi^{-1}(z)$ for the normal distribution. These values are also available in spreadsheet programs as standard functions. These are known as one-sided confidence limits, since the lower confidence limit is not needed.

If the sample size is small (defined as ~ 20 samples or less), then use the t-distribution to calculate the upper confidence limit:

$$\text{upper confidence limit } [\mu]_{1-\alpha} = \left(\bar{x} + t_{\alpha, n-1} * \frac{s}{\sqrt{n}} \right)$$

Equation E-8 - UCL on Mean for Small Sample Set

Statistics textbooks, and some spreadsheet programs, provide tabulated t-distribution values. The shape of the t-distribution is symmetric and depends on the number of samples (n). At low values of (n) the t-distribution is flatter (more spread-out) than the normal distribution, so the 95% UCL value will be higher using the t-statistic than the standard

normal value. As the number of samples increases the t-distribution tends towards the normal distribution. Therefore, there will be no difference in the calculated values of the 95% UCL.

Non-Parametric Evaluations

If you cannot use a normal or lognormal distribution to analyze your data, non-parametric methods can be used to further evaluate the available data. The non-parametric methods use the ranks of the data values, rather than the values themselves. Because the test statistics require larger data sets than those used for normal or lognormal data distributions, using non-parametric data evaluations is generally reserved for Tier 3 analyses. Before using non-parametric evaluations for UST site data, submit your data analysis to BUSTR for approval.

Examples

The following numerical examples illustrate some of the data analysis concepts presented in the preceding text:

Example 1

Representative Concentration Values

For a soil source area at a UST site, these are the benzene concentration data identified as source area sample results. Order concentrations from lowest to highest (include calculated natural logarithms) of the data values:

Sample ID	Concentration (mg/kg)	Ln (Conc)
S1	0.078	-2.5510
S7	0.17	-1.7720
S3	0.25	-1.3863
S2	0.45	-0.7985
S5	0.55	-0.5978
S8	0.55	-0.5978
S4	0.62	-0.4780
S6	1.60	0.4700

Miscellaneous information:

Number of samples (n) 8
 Soil Concentrations of Benzene mg/kg
 Sample Date 3/1/2000
 Analysis Method 8260
 Detection Limit 0.05
 Soil type clay/shale
 Depth to water 30
 Water type drinking
 Action Level **1.06**

Statistical Descriptors

Since we have 8 sample results, initially we will determine that sufficient data have been collected. If the data cannot be described by the normal or log normal distribution, then you may need to collect additional data. The maximum concentration (used in the Tier 1 comparison) is 1.6 mg/kg, which is above the action level of 1.06 mg/kg.

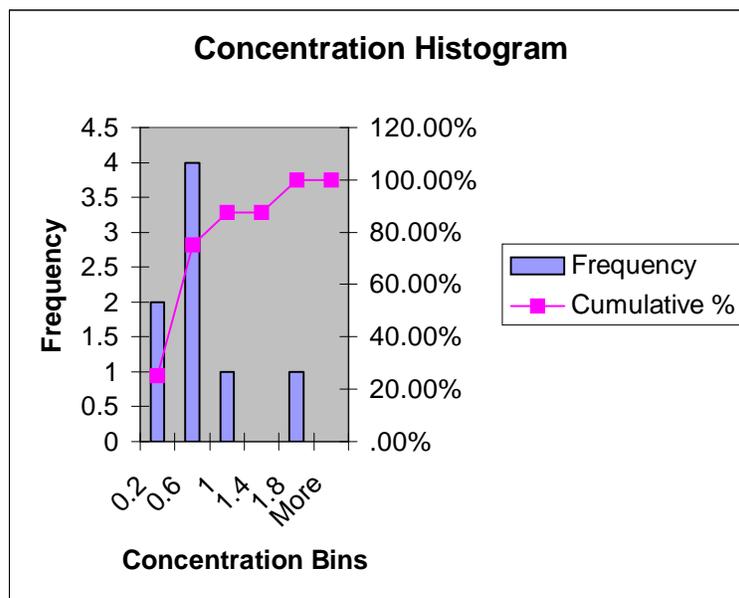
Here are the basic sample statistics for the concentration data and the logarithms of the concentration data:

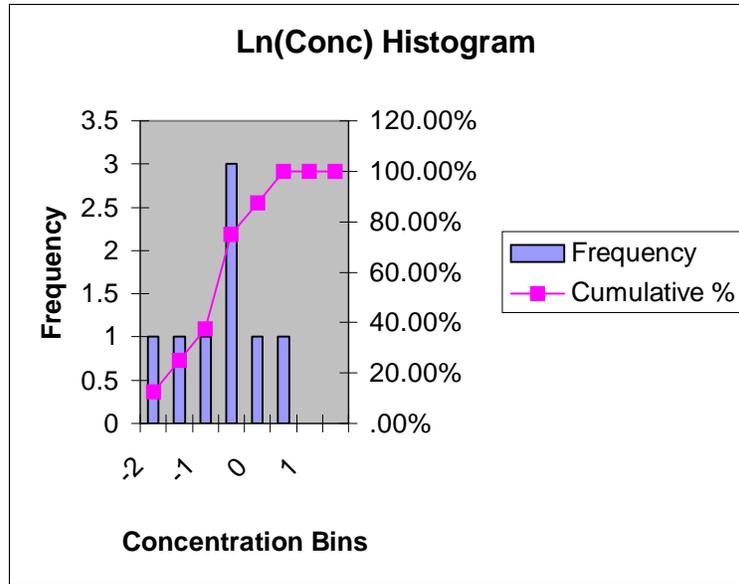
	Conc	Ln(Conc)
Mean	0.5335000	-0.9639389406
Std dev	0.4739509	0.9210172323
Variance	0.2246294	0.8482727423
COV	0.8883803	-0.9554725860
Skew	1.8746668	-0.3498130938
Median	0.5000000	-0.6981723485
t(0.95, 7)	1.8950000	1.8950000000
*		-0.3468724304
95%UCL	0.8510393	0.7068955009
Var(mean)	0.0280787	0.1060340928
Std Error	0.1675669	0.3256287653

* Indicates the 95% UCL for the log transformed data. The 95% UCL must be obtained by taking the inverse log of this value.

Histograms

Here are histograms of the data:





The histograms show that the ln (conc) distribution is more symmetric than the original concentration data.

95% UCL

Comparing the mean and median shows that they are fairly close for both distributions. However, for the original concentration data the skewness = 1.8, while the skewness and the COV for the ln (conc) data both meet the normality test criteria. A probability plot would also be appropriate for this data set (see Example 2 for procedures).

The log transformed data are more nearly normally distributed and the 95% UCL is calculated based on the ln (conc) data (using Equation E-8 for small data sets):

$$95\%UCL \ln(\text{conc}) = -0.9639 + t\{0.95, 7\} * 0.3256$$

The value for the 95th percentile of a t statistic with 7 degrees of freedom is $t\{0.95, 7\} = 1.895$

$$95\%UCL \ln(\text{conc}) = -0.3466$$

$$95\%UCL \text{ Benzene} = \exp(-0.3466) = 0.71 \frac{\text{mg}}{\text{kg}}$$

Since 0.71 mg/kg is below the action level of 1.06 mg/ kg additional evaluation of benzene for this pathway is not necessary.

Example 2

Probability Plots and Probability That the Concentration Exceeds Action Level

For a soil source area at another UST site, you have the following benzene concentration data. The results are in rank order from lowest to highest concentration; and the natural logarithms of the values are calculated.

Sample ID	Concentration (mg/kg)	ln(Conc)	Rank	m/(N+1)	Std Normal Variate
S1	ND (use 0.05)	-2.9957	1	0.0909	-1.3352
S6	0.12	-2.1202	2	0.1818	-0.9085
S10	0.15	-1.8970	3	0.2727	-0.6046
S5	0.35	-1.0498	4	0.3636	-0.3488
S8	0.5	-0.6932	5	0.4545	-0.1142
S4	0.75	-0.2877	6	0.5455	0.1142
S9	0.89	-0.1165	7	0.6364	0.3488
S3	1.56	0.4447	8	0.7273	0.6046
S2	1.6	0.4700	9	0.8182	0.9085
S7	5.19	1.6467	10	0.9091	1.3352

Since there is one value at non-detect, you can replace this concentration with one-half the detection limit, since the percentage of non-detects (10%) is below the guidance level of 15%. For this example the detection limit is 0.10, half the detection limit is 0.05.

Miscellaneous information:

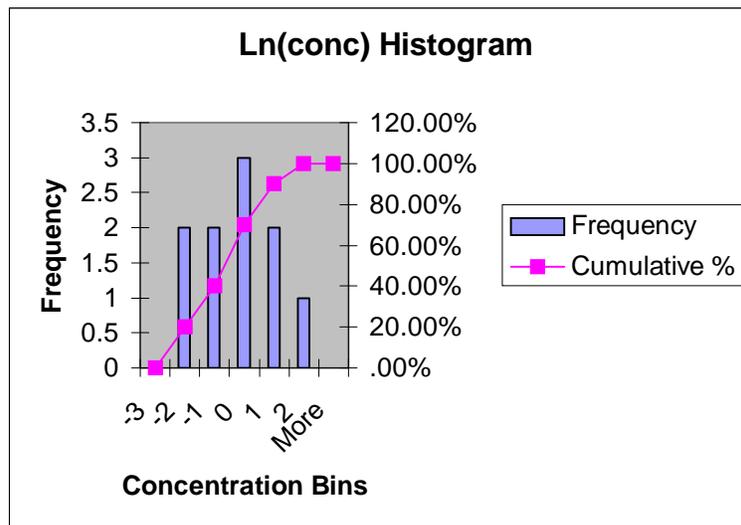
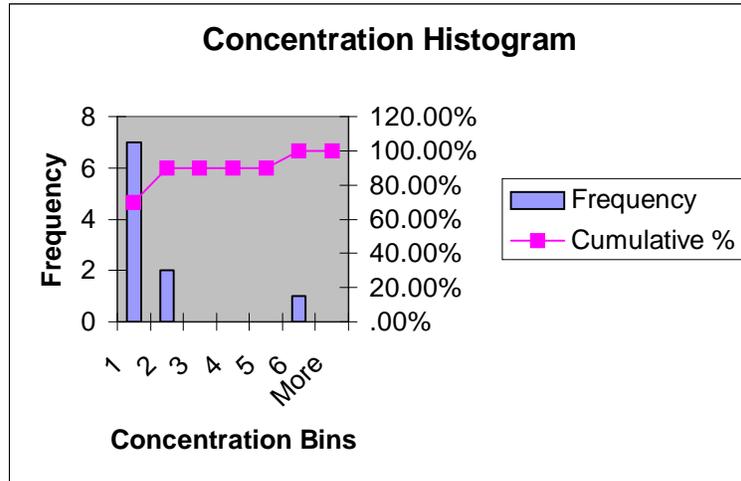
Number of samples (n) 10
 Soil Concentrations of Benzene mg/kg
 Sample Date 12/3-5/1999
 Analysis Method 8260
 Detection Limit 0.01
 Soil type clay/shale
 Depth to water 30
 Water type drinking
 Action Level 1.06

With 10 data points, initially we will determine that sufficient data has been collected. Here are the basic sample statistics for the concentration data and the logarithms of the concentration data:

	Conc	Ln(Conc)
Mean	1.116000	-0.6598878
Std dev	1.536288	1.3953803
Variance	2.360182	1.9470862
COV	1.376603	-2.1145721
Skew	2.450505	-0.1297420
Median	0.625000	-0.4904146
t(0.95, 9)	1.833000	1.8330000
*		0.1489381
95%UCL	2.006503	1.1606012
Var(mean)	0.236018	0.1947086
Std Error	0.485817	0.4412580

* Indicates the 95% UCL for the log transformed data. The 95% UCL must be obtained by taking the inverse log of this value.

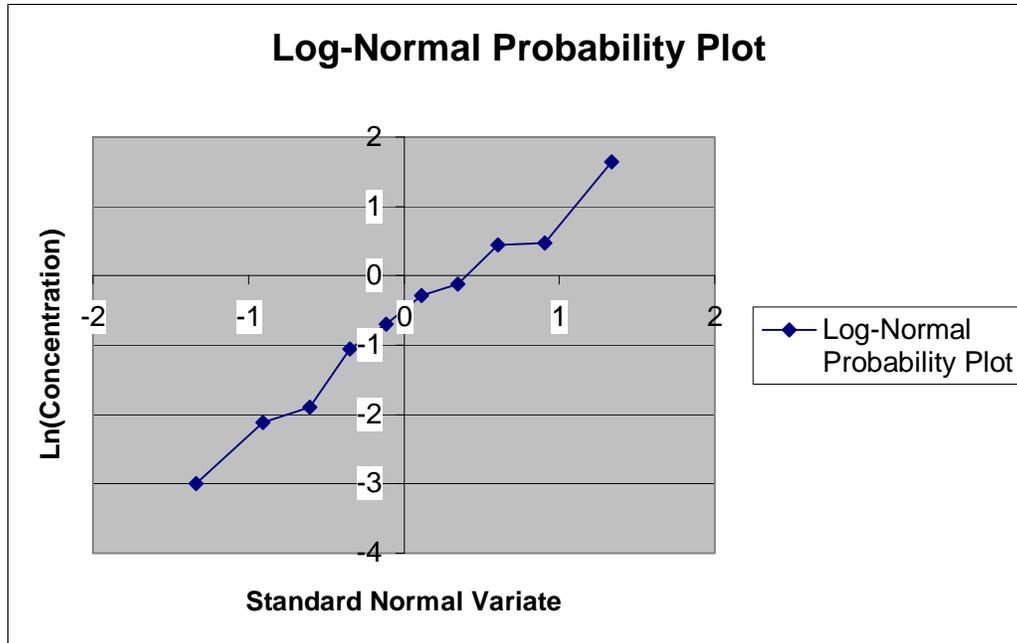
Here are the histograms of the data:



The histogram of the ln(conc) is more symmetric than the original concentration data.

The difference between the mean and the median data are similar for both distributions. However, the original concentration data has skewness = 2.45, while the skewness and the COV for the ln(conc) data both meet the normality test criteria.

Construct the probability plot using a spreadsheet with the ln(conc) values (on the y-axis) and the standard normal variate values (on the x-axis):



The plot was constructed using a spreadsheet. If you use probability graph paper, you would plot the cumulative probability values on the x-axis.

The log-transformed data shows a nearly normal distribution and the 95% UCL is calculated based on the $\ln(\text{conc})$ data (using Equation E-12 for small data sets):

95% UCL Benzene Concentration = 1.16 mg/kg

This value is above the action level of 1.06 mg/ kg. For this example, the sample results are insufficient to show that the statistically representative concentrations are below the action level. Collecting additional data points in the source area may help lower the 95% UCL.

References

Ang, H-S., Tang, W. H., 1975. *Probability Concepts in Engineering Planning and Design, Volume 1 Basic Principles*. John Wiley & Sons, Inc. New York.

Benjamin, J. R., Cornell, C. A., 1970. *Probability, Statistics and Decision for Engineers*. McGraw-Hill Book Company. New York.

DeVore, J. L., 1995. *Probability and Statistics for Engineering and the Sciences*, Fourth Edition. Duxbury Press. Belmont, CA.

Gilbert, R. O., 1987. *Statistical Methods for Environmental Pollution Monitoring*. Van Nostrand Reinhold. New York.

PADEP 1997. *Pennsylvania's Land Recycling Program Technical Guidance Manual*. Final Draft. Pennsylvania Department of Environmental Protection.

USEPA (Environmental Protection Agency), 1998. *Guidance for Data Quality Assessment, Practical Methods for Data Analysis*. EPAQA/G-9. Office of Research and Development. EPA/600/R-96/084.

USEPA, 1992. *Statistical Methods for Evaluating the Attainment of Cleanup Standards. Volume 3. Reference-based Standards for Soil and Solid Media*. Office of Policy, Planning and Evaluation. EPA/230/R-94/004.

Appendix F Action Level Development

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Tier 1 Action Levels

The action levels (ALs) published in Ohio Administrative Code (OAC) 1301:7-9-13 were developed using the assumptions, parameters, and algorithms provided in this Appendix. In general, ALs developed for common chemical(s) of concern (COC) use the most conservative assumptions for the exposure pathways typically encountered at a UST site. Specifically, ALs assume that the receptors will be children and adults living at the site and that all exposures will occur at the source of the highest COC concentrations.

Tier 2 Site-Specific Target Levels

During further tier evaluation, the owner/operator may consider current and future land use when developing site-specific target levels (SSTLs). However, when developing SSTLs, you must also develop a site conceptual exposure model to identify all of the complete and potentially complete exposure pathways. Based on the site conceptual exposure model, the use of alternative exposure factors and site-specific physical characteristics may be appropriate. In addition, you may be required to evaluate exposure pathways, such as soil to outdoor air and/or excavation worker scenarios, if you have not been able to eliminate all other associated pathways.

For exposure pathways that have not been eliminated, evaluate **one or a combination** of the following under Tier 2:

4. Statistically derive the representative concentration by calculating the 95% upper confidence level (UCL) of the arithmetic mean and compare them to Tier 1 action levels;
5. Develop Tier 2 SSTLs (i.e., using BUSTR Tier 2 spreadsheets) by replacing the assumptions for the geological, hydrogeological, and physical parameters used in the algorithms for the action levels in Tier 1 with site-specific values;
6. Apply the Tier 1 action level at the site-specific point of exposure (POE) and back calculate the Tier 2 SSTL for environmental media in the source area(s) using fate and transport modeling.

Statistically Representative Concentrations (Option 1)

During the Tier 1 evaluation, action levels are compared to the highest measured concentration of each COC in the environmental media. When using statistically derived concentrations of COCs, the action levels identified for the UST site during the Tier 1 Evaluation are compared to the 95% UCL of the arithmetic mean for each identified COC. In addition, as was the case in the Tier 1 evaluation, the POE is assumed to be located in the source area(s). Statistically derived ground water concentrations of COCs cannot be used in fate and transport modeling.

Apply statistically representative concentrations of COCs only to soil source areas. Calculate the 95% UCL of the arithmetic mean using techniques for sampling normal or log normal distributions based on appropriate peer-reviewed statistical methodology. Your data sets must contain a sufficient number and quality of samples for deriving a normal, log normal, or other applicable frequency distribution. (See Appendix E for an example calculation of the statistically representative concentration of COCs in soil.)

Calculating SSTLs Using Site-Specific Parameters (Option 2)

You can also calculate the SSTL by replacing the default geological, hydrogeological and physical parameters used in the Tier 1 action level calculations with site-specific geological, hydrogeological, and physical parameters. In addition, you may substitute non-residential exposure factors where a non-residential land use determination has been made. However, residential exposure factors cannot be changed from the default exposure factors used to develop the action levels. If you want to use residential or non-residential exposure factors other than those identified in Appendix F, then you must submit a Tier 3 Evaluation Plan. (See Appendix F below for algorithms and default parameters used in action level calculations.)

When using SSTLs calculated this way, assume that the exposure pathways identified in the Tier 1 evaluation apply, and compare the SSTL to the highest concentration for each COC for each exposure pathway. As in the Tier 1 evaluation, assume that the SSTLs are located at the POE. This approach is also appropriate for calculating SSTLs for chemicals that have no calculated Tier 1 action levels.

Back Calculating SSTLs Based on Site-Specific Point(s) of Exposure (Option 3)

Another option for calculating SSTLs is using modeling to evaluate the fate and transport of COCs in the environmental media for the complete exposure pathways identified in the site conceptual exposure model.

Fate and transport modeling is generally used to calculate COC concentration at the source area that will not cause COC concentrations at the POE to exceed appropriate action levels. If an action level does not exist for an exposure pathway, calculate that action level using another publicly available default value.

Default Parameters

The following tables provide the default input and exposure parameters used in developing the Tier 1 action levels and the recommended parameters for developing Tier 2 SSTLs. You may substitute less conservative, site-specific values for many of these default parameters. **Whenever you substitute a site-specific input parameter for a default parameter, you must provide supporting documentation to BUSTR.** Do not modify the residential default exposure parameters, such as the parameters listed below.

Default Exposure Parameters

Parameter	Symbol	Units	Residents		Workers		Excavation			
			child	Adult	Commercial	Excavation				
Target Risk	TR	unitless	1.00E-05	a	1.00E-05	a	1.00E-05	a		
Target Hazard Quotient	THQ	unitless	1	a	1	a	1	a		
Averaging Time (carcinogens)	AT _c	years	70	a	70	a	70	a		
Averaging Time (non-carcinogens)	AT _n	years	6	a	17	a	25	b	1	c
Body Weight	BW	kg	15	a	70	a	70	b	70	c
Exposure Duration	ED	years	6	a	17	a	25	b	1	c
Exposure Frequency	EF	days	350	a	350	a	250	b	120	c
Skin surface area	SA	cm ²	NA	f	NA	f	NA	f	5000	c
Soil to skin adherence factor	M	unitless	NA	f	NA	f	NA	f	1	d
Ingestion Rate	IR _{soil}	mg/day	NA	f	NA	f	NA	f	138	c
Inhalation Rate (indoor)	IR _{air}	m ³ /hr	0.625	a	0.625	a	0.833	b	NA	f
Inhalation Rate (outdoor)	IR _{air}	m ³ /hr	0.833	b	0.833	b	0.833	b	1.34	c
Exposure time (indoor)	ET	hours	16	a	16	a	8	e	NA	f
Exposure time (outdoor)	ET	hours	2	e	2	e	8	e	8	c,e

Notes:

- a Values used in development of Tier 1 action levels
- b ASTM RBCA standard default exposure
- c VAP Voluntary Action Program (construction worker guidance)
- d U.S. EPA Supplemental Risk Assessment Guidance for Superfund
- e U.S. EPA Exposure Factors Handbook
- f Not applicable

Default Soil Parameters

Parameter	Symbol	Units	Sand & Gravel	Silty/Clayey Sands	Clay/Silt
Total Porosity in vadose zone	Θ_T	cm ³ /cm ³	0.43	0.43	0.43
Volumetric water content in vadose zone	Θ_{ws}	cm ³ /cm ³	0.12	0.15	0.25
Volumetric air content in vadose zone	Θ_{as}	cm ³ /cm ³	0.31	0.28	0.18
Volumetric air content in capillary fringe soil	Θ_{acap}	cm ³ /cm ³	0.043	0.043	0.043
Volumetric water content in capillary fringe soil	Θ_{wcap}	cm ³ /cm ³	0.387	0.387	0.387
Thickness of capillary fringe	h_{cap}	cm	5	5	5
Fraction organic carbon	F_{oc}	g oc/ g soil	0.002	0.0025	0.003
Bulk density	ρ_s	g/cm ³	1.4	1.6	1.8
Saturated hydraulic conductivity	K_s	cm/sec	5.83E-03	4.17E-05	1.67E-05
Wetting front suction head	Ψ	cm	-4.95	-21.85	-31.63
Infiltration rate	I	cm/year	31.75	20.32	6.35
Ponding depth	h	cm	0	0	0

Default Building Parameters

Parameter	Symbol	Units	Residential	Commercial
Enclosed space air exchange rate	ER	1/sec	1.39E-04	2.30E-04
Enclosed space volume/infiltration area ratio	L_B	cm	487.68	487.68
Enclosed space foundation or wall thickness	L_{crack}	cm	15	15
Areal fraction of cracks in foundation/walls	\square	cm ² /cm ²	0.001	0.001
Volumetric air content in foundation/wall cracks	\square_{acrack}	cm ³ /cm ³	0.25	0.25
Volumetric water content in foundation/wall cracks	\square_{wcrack}	cm ³ /cm ³	0.19	0.19

Default Ground Water and Atmospheric Parameters

Parameter	Symbol	Units	Value
Ground water darcy velocity	U_{gw}	cm/yr	2500
Ground water mixing zone thickness	\square_{gw}	cm	200
Ambient air mixing zone height	\square_{air}	cm	200
Wind speed above ground surface in ambient mixing zone	U_{air}	cm/sec	225
Width of source area parallel to wind direction	W	cm	1500

Default Physical and Chemical Properties for COCs

The table below provides COC-specific input parameter values for deriving action levels; additional COCs also are provided below. If a COC-specific input parameter value is not provided on these tables or in these references, then you may use another publicly available reference.

Reference Table of Physical and Chemical Properties

Chemical of Concern	Molecular Weight	Reference	Solubility 20°-25°	Reference	Vapor Pressure 20°-25°	Reference	Henry's Law Constant	Reference	Soil-Water Partition Coe	Reference
	g/mol		mg/L		mmHg(sat)		Dimensionless		K _{oc} (L/kg)	
Aromatic Hydrocarbons										
benzene	78.1	a	1.75E+03	b	9.52E+01	h	2.28E-01	b	5.89E+01	b
toluene	92.1	a	5.26E+02	b	2.84E+01	h	2.72E-01	b	1.82E+02	b
ethyl benzene	106.2	a	1.69E+02	b	9.60E+00	h	3.23E-01	b	3.63E+02	b
xylene, total	106.2	e	1.98E+02	e	8.84E+00	h	2.90E-01	e	2.40E+02	e
Additives										
1,2 dibromoethane, EDB	187.9	a	4.30E+03	a	1.12E+01	h	2.89E-02	f	4.37E+01	j
1,2 dichloroethane, EDC	99.0	a	8.52E+03	b	7.89E+01	h	4.01E-02	b	1.74E+01	b
methyl tert butyl ether, MTBE	88.2	g	4.80E+04	e	2.49E+02	h	2.04E-02	g	1.20E+01	e
Polynuclear Aromatic Hydrocarbons										
acenaphthene	154.2	a	4.24E+00	b	2.30E-03	a	6.36E-03	b	7.08E+03	b
acenaphthylene	152.2	a	3.93E+00	a	9.12E-04	h	4.67E-03	f	4.79E+03	j
anthracene	178.2	a	4.34E-02	b	2.67E-06	h	2.67E-03	b	2.95E+04	b
benzo(a)anthracene	228.3	a	9.40E-03	b	3.05E-08	h	1.37E-04	b	3.98E+05	b
benzo(b)fluoranthene	252.3	a	1.50E-03	b	5.00E-07	h	4.55E-03	b	1.23E+06	b
benzo(k)fluoranthene	252.3	a	8.00E-04	b	9.65E-10	h	3.40E-05	b	1.23E+06	b
benzo(g,h,i)perylene	276.3	a	2.60E-04	a	1.01E-10	a	1.09E-05	f	7.76E+06	j
benzo(a)pyrene	252.3	a	1.62E-03	b	5.49E-09	a	4.63E-05	b	1.02E+06	b
chrysene	228.3	a	1.60E-03	b	6.23E-09	h	3.88E-03	b	3.98E+05	b
dibenz(a,h)anthracene	278.4	a	2.49E-03	b	1.00E-10	h	6.03E-07	b	3.80E+06	b
fluoranthene	202.3	a	2.06E-01	b	1.23E-08	h	6.60E-04	b	1.07E+05	b
fluorene	166.2	a	1.98E+00	b	8.42E-03	h	2.61E-03	b	1.38E+04	b
indeno(1,2,3-cd)pyrene	276.3	a	2.20E-05	b	1.00E-10	h	6.56E-05	b	3.47E+06	b
naphthalene	128.2	a	3.10E+01	b	8.50E-02	h	1.98E-02	b	2.00E+03	b
phenanthrene	178.2	a	1.29E+00	a	1.12E-04	h	1.60E-03	f	2.29E+04	j
pyrene	202.3	a	1.35E-01	b	2.45E-06	h	4.51E-04	b	1.05E+05	b
Volatile Organics										
carbon tetrachloride	153.8	a	7.93E+02	b	1.15E+02	a	1.25E+00	b	1.74E+02	b
chlorobenzene	112.6	a	4.72E+02	b	1.20E+01	h	1.52E-01	b	2.19E+02	b
chloroform	119.4	a	7.92E+03	b	1.97E+02	h	1.50E-01	b	3.98E+01	b
1,1 dichloroethane	99.0	a	5.06E+03	b	2.27E+02	a	2.30E-01	b	3.16E+01	b
1,1 dichloroethylene	96.9	a	2.25E+03	b	6.00E+02	h	1.07E+00	b	5.89E+01	b
cis 1,2 dichloroethylene	96.9	c	3.50E+03	b	2.01E+02	h	1.67E-01	b	3.55E+01	b
trans 1,2 dichloroethylene	96.9	a	6.30E+03	b	3.31E+02	h	3.85E-01	b	5.25E+01	b
methylene chloride	84.9	a	1.30E+04	b	4.35E+02	h	8.98E-02	b	1.17E+01	b
styrene	104.2	a	3.10E+02	b	6.40E+00	h	1.13E-01	b	7.76E+02	b
1,1,1,2 tetrachloroethane	167.9	a	2.97E+03	b	4.62E+00	h	1.41E-02	b	9.33E+01	b
tetrachloroethylene (PCE)	165.8	a	2.00E+02	b	1.86E+01	a	7.54E-01	b	1.55E+02	b
1,1,1 trichloroethane	133.4	a	1.33E+03	b	1.24E+02	a	7.05E-01	b	1.10E+02	b
1,1,2 trichloroethane	133.4	a	4.42E+03	b	2.30E+01	h	3.74E-02	b	5.01E+01	b

Reference Table of Physical and Chemical Properties

Chemical of Concern	Molecular Weight	Reference	Solubility 20°-25°	Reference	Vapor Pressure 20°-25°	Reference	Henry's Law Constant	Reference	Soil-Water Partition Coe	Reference
trichloroethylene (TCE)	131.4	a	1.10E+03	b	6.90E+01	a	4.22E-01	b	1.66E+02	b
vinyl chloride	62.5	a	2.76E+03	b	2.98E+03	h	1.11E+00	b	1.86E+01	b
Metals										
arsenic	74.9	c	no data		0.00E+00		no data		no data	
barium	137.3	c	no data		0.00E+00		no data		no data	
cadmium	112.4	c	no data		0.00E+00		no data		no data	
chromium (III)	52.0	c	no data		0.00E+00		no data		no data	
chromium (VI)	52.0	c	no data		0.00E+00		no data		no data	
lead	207.2	c	no data		0.00E+00		no data		no data	
mercury	200.6	c	no data		1.30E-03	i	4.67E-01	b	no data	
selenium	79.0	c	no data		0.00E+00		no data		no data	
silver	107.9	c	no data		0.00E+00		no data		no data	

References:

- a. Montgomery, J. H., 1996. *Ground water Chemicals Desk Reference, 2nd. Edition*. CRC Press, Inc. Boca Raton, FL.
- b. US EPA, 1996. *Soil Screening Guidance*, EPA540/R-96/018.
- c. Windholz, M. (ed.), 1976. *The Merck Index, 9th Edition*, Merck and Co., Inc. Rahway, N.J.
- d. Howard, P., et al., 1991. *Handbook of Environmental Degradation Rates*, Lewis Publishers Inc., Chelsea, MI. Half-life values are given in days for ground water and include a high-end range and low-end range. Decay rate (days⁻¹) is calculated by $.693/\text{half-life (days)}$. of the user should select the most conservative rates for chemical degradation for Tier 1 and Tier 2 evaluations.
- e. American Society for Testing & Materials, *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites*, E 1739-95
- f. Henry's Law Constant (HLC) (atm-m³/mol) is calculated from HCL (dimensionless) by dividing by 41. HLC (dimensionless) is calculated from HLC (atm-m³/mol) by multiplying by 41 (Soil Screening Guidance).
- g. BP Oil and Spence, L.R., October, 1996. *Risk-Integrated Software for Cleanups (RISC)*, , Version 3.0.
- h. Howard and Meylan, 1997. *Handbook of Physical Properties of Organic Chemicals*.
- i. Wheast, R.C. (ed.), 1997-8. *CRC Handbook of Chemistry and Physics, 58th ed.*, CRC Press, Inc. Boca Raton, FL, D-182.
- j. K_{oc} value is converted from log K_{oc} given in Reference a.

Reference Table of Physical and Chemical Properties

Chemical of Concern	Octanol/Water Partition Coe	Reference	Degradation Rate (Half-Life) high end to low end range	Reference	Air Diffusivity D _{i,a} (25°C)	Reference	Water Diffusivity D _{i,w} (25°C)	Reference
	log K _{ow} (L/kg)		day ⁻¹ , (days)		cm ² /s		cm ² /s	
Aromatic Hydrocarbons								
benzene	2.13E+00	b	7.00E-02(10) to 9.60E-04(720)	d	8.80E-02	b	9.80E-06	b
toluene	2.75E+00	b	.1(7)-.025(28)	d	8.70E-02	b	8.60E-06	b
ethyl benzene	3.14E+00	b	.1(6)-.00304(228)	d	7.50E-02	b	7.80E-06	b
xylenes, total	3.26E+00	e	.050(14)-.0019(360)	d	7.20E-02	e	8.50E-06	e
Additives								
1,2 dibromoethane, EDB	1.76E+00	a	.0354(19.6)-.0058(120)	d	5.00E-02	g	9.60E-06	a
1,2 dichloroethane, EDC	1.47E+00	b	.007(100)-.0019(360)	d	1.04E-01	b	9.90E-06	b
methyl tert butyl ether, MTBE	1.30E+00	e	.012(56)-.0019(360)	d	7.10E-02	g	9.04E-06	g
Polynuclear Aromatic Hydrocarbons								
acenaphthene	3.92E+00	b	.0282(24.6)-.00340(204)	d	4.21E-02	b	7.69E-06	b
acenaphthylene	3.94E+00	a	.0082(85)-.0058(120)	d	5.40E-02	g	6.60E-06	a
anthracene	4.55E+00	b	.007(100)-.00075(920)	d	3.24E-02	b	7.74E-06	b
benzo(a)anthracene	5.70E+00	b	.00340(204)-.000510(1360)	d	5.10E-02	b	9.00E-06	b
benzo(b)fluoranthene	6.20E+00	b	.00096(720)-.000568(1220)	d	2.26E-02	b	5.56E-06	b
benzo(k)fluoranthene	6.20E+00	b	.0003898(1778)-.000162(4280)	d	2.26E-02	b	5.56E-06	b
benzo(g,h,i)perylene	7.10E+00	a	.000587(1180)-.00053(1300)	d	4.10E-02	g	4.90E-06	a
benzo(a)pyrene	6.11E+00	b	.00608(114)-.000654(1060)	d	4.30E-02	b	9.00E-06	b
chrysene	5.70E+00	b	.000934(742)-.0003(2000)	d	2.48E-02	b	6.21E-06	b
dibenz(a,h)anthracene	6.69E+00	b	.000960(722)-.000369(1880)	d	2.02E-02	b	5.18E-06	b
fluoranthene	5.12E+00	b	.0025(280)-.00079(880)	d	3.02E-02	b	6.35E-06	b
fluorene	4.21E+00	b	.011(64)-.0058(120)	d	3.63E-02	b	7.88E-06	b
indeno(1,2,3-cd)pyrene	6.65E+00	b	.00058(1200)-.000475(1460)	d	1.90E-02	b	5.66E-06	b
naphthalene	3.36E+00	b	.7(1)-.00269(258)	d	5.90E-02	b	7.50E-06	b
phenanthrene	4.57E+00	a	.022(32)-.002(400)	d	5.17E-02	g	5.90E-06	a
pyrene	5.11E+00	b	.0017(420)-.00018(3800)	d	2.72E-02	b	7.24E-06	b
Volatile Organics								
carbon tetrachloride	2.73E+00	a	.1(7)-.0019(360)	d	7.80E-02	b	8.80E-06	b
chlorobenzene	2.86E+00	b	.0051(136)-.002(300)	d	7.30E-02	b	8.70E-06	a
chloroform	1.92E+00	b	.012(56)-.0004(1800)	d	1.04E-01	b	1.00E-05	b
1,1 dichloroethane	1.79E+00	a	.011(64)-.0019(360)	d	7.42E-02	b	1.05E-05	b
1,1 dichloroethylene	2.13E+00	a	.012(56)-.005(132)	d	9.00E-02	b	1.04E-05	b
cis 1,2 dichloroethylene	1.86E+00	b	no data		7.36E-02	b	1.13E-05	b
trans 1,2 dichloroethylene	2.07E+00	b	no data		7.07E-02	b	1.19E-05	b
methylene chloride	1.25E+00	a	.050(14)-.012(56)	d	1.01E-01	b	1.17E-05	b
styrene	2.94E+00	b	.025(28)-.003(210)	d	7.10E-02	b	8.00E-06	b
1,1,2,2 tetrachloroethane	2.39E+00	a	1.550(446)-.015(45)	d	7.10E-02	b	7.90E-06	b
tetrachloroethylene (PCE)	2.67E+00	b	.0019(360)-.00096(720)	d	7.20E-02	b	8.20E-06	b
1,1,1 trichloroethane	2.48E+00	a	.005(140)-.0013(546)	d	7.80E-02	b	8.80E-06	b

Reference Table of Physical and Chemical Properties

Chemical of Concern	Octanol/Water Partition Coe	Reference	Degradation Rate (Half-Life) high end to low end range	Reference	Air Diffusivity D _{i,a} (25°C)	Reference	Water Diffusivity D _{i,w} (25°C)	Reference
	log K _{ow} (L/kg)		day ⁻¹ , (days)		cm ² /s		cm ² /s	
1,1,2 trichloroethane	2.05E+00	b	.0051(136)-.00095(730)	d	7.80E-02	b	8.80E-06	b
trichloroethylene (TCE)	2.71E+00	b	.0022(321)-.0004(1653)	d	7.90E-02	b	9.10E-06	b
vinyl chloride	1.50E+00	b	.012(56)-2.41E-04(2875)	d	1.06E-01	b	1.23E-06	b
Metals								
arsenic	no data		no data		no data		no data	
barium	no data		no data		no data		no data	
cadmium	no data		no data		no data		no data	
chromium (III)	no data		no data		no data		no data	
chromium (VI)	no data		no data		no data		no data	
lead	no data		no data		no data		no data	
mercury	no data		no data		3.07E-02	b	6.30E-06	b
selenium	no data		no data		no data		no data	
silver	no data		no data		no data		no data	

References:

- a. Montgomery, J. H., 1996. *Ground water Chemicals Desk Reference, 2nd. Edition*. CRC Press, Inc. Boca Raton, FL.
- b. US EPA, 1996. *Soil Screening Guidance*, EPA540/R-96/018.
- c. Windholz, M., (ed.), 1976. *The Merck Index, 9th Edition*, Merck and Co., Inc. Rahway, N.J.
- d. Howard, P., et al., 1991. *Handbook of Environmental Degradation Rates*, Lewis Publishers Inc., Chelsea, MI. Half-life values are given in days for ground water and include a high-end range and low-end range. Decay rate (days⁻¹) is calculated by .693/half-life (days). of the user should select the most conservative rates for chemical degradation for Tier 1 and Tier 2 evaluations.
- e. American Society for Testing & Materials, *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites*, E 1739-95
- f. Henry's Law Constant (HLC) (atm-m³/mol) is calculated from HCL (dimensionless) by dividing by 41. HLC (dimensionless) is calculated from HLC (atm-m³/mol) by multiplying by 41 (Soil Screening Guidance).
- g. BP Oil and Spence, L.R., October, 1996. *Risk-Integrated Software for Cleanups (RISC)*, , Version 3.0.
- h. Howard and Meylan, 1997. *Handbook of Physical Properties of Organic Chemicals*.
- i. Wheast, R.C. (ed.), 1997-8. *CRC Handbook of Chemistry and Physics, 58th ed.*, CRC Press, Inc. Boca Raton, FL, D-182.
- j. K_{oc} value is converted from log K_{oc} given in Reference a.

Default Toxicological Properties of COCs

Reference Table of Toxicological Properties

Chemical of Concern	Slope Factor Ingestion	Reference	Slope Factor Inhalation (p)	Reference	Reference Dose Ingestion	Reference	Reference Dose Inhalation (p)	Reference
	1/(mg/kg-d)		1/(mg/kg-d)		mg/kg-d		mg/kg-d*	
Aromatic Hydrocarbons								
benzene	2.90E-02	k	2.90E-02	k	no data		no data	
toluene	no data		no data		2.00E-01	k	1.14E-01	l
ethyl benzene	no data		no data		1.00E-01	k	2.86E-01	k
xylenes, total	no data		no data		2.00E+00	k	2.00E-01	o
Additives								
1,2 dibromoethane, EDB	8.50E+01	k	7.70E-01	k	5.70E-05	m	5.71E-05	l
1,2 dichloroethane, EDC	9.10E-02	k	9.10E-02	k	2.90E-03	m	2.86E-03	n
methyl tert butyl ether, MTBE	no data		no data		5.00E-03	n	8.57E-01	k
Polynuclear Aromatic Hydrocarbons								
acenaphthene	no data		no data		6.00E-02	k	6.00E-02	m
acenaphthylene	no data		no data		no data		no data	
anthracene	no data		no data		3.00E-01	k	3.00E-01	m
benzo(a)anthracene	7.30E-01	n	7.30E-01	m	no data		no data	
benzo(b)fluoranthene	7.30E-01	n	7.30E-01	m	no data		no data	
benzo(k)fluoranthene	7.30E-02	n	7.30E-02	m	no data		no data	
benzo(g,h,i)perylene	no data		no data		no data		no data	
benzo(a)pyrene	7.30E+00	k	7.30E+00	m	no data		no data	
chrysene	7.30E-03	n	7.30E-03	m	no data		no data	
dibenz(a,h)anthracene	7.30E+00	n	7.30E+00	m	no data		no data	
fluoranthene	no data		no data		4.00E-02	k	4.00E-02	m
fluorene	no data		no data		4.00E-02	k	4.00E-02	m
indeno(1,2,3-cd)pyrene	7.30E-01	n	7.30E-01	m	no data		no data	
naphthalene	no data		no data		4.00E-02	l	4.00E-02	m
phenanthrene	no data		no data		no data		no data	
pyrene	no data		no data		3.00E-02	k	3.00E-02	m
Volatile Organics								
carbon tetrachloride	1.30E-01	k	5.30E-02	k	7.00E-04	k	5.71E-04	n
chlorobenzene	no data		no data		2.00E-02	k	5.70E-03	l
chloroform	6.10E-03	k	8.10E-02	k	1.00E-02	k	1.00E-02	m
1,1 dichloroethane	no data		no data		1.00E-01	l	1.40E-01	l
1,1 dichloroethylene	6.00E-01	k	1.80E-01	k	9.00E-03	k	9.00E-03	m
cis 1,2 dichloroethylene	no data		no data		1.00E-02	l	1.00E-02	m
trans 1,2 dichloroethylene	no data		no data		2.00E-02	k	2.00E-02	m
methylene chloride	7.50E-03	k	1.60E+03	k	6.00E-02	k	8.60E-01	l
styrene	no data		no data		2.00E-01	k	2.86E-01	k
1,1,1,2, tetrachloroethane	2.00E-01	k	2.00E-01	k	no data		no data	

Reference Table of Toxicological Properties

Chemical of Concern	Slope Factor Ingestion	Reference	Slope Factor Inhalation (p)	Reference	Reference Dose Ingestion	Reference	Reference Dose Inhalation (p)	Reference
	1/(mg/kg-d)		1/(mg/kg-d)		mg/kg-d		mg/kg-d*	
tetrachloroethylene (PCE)	no data		no data		1.00E-02	k	1.00E-02	m
1,1,1 trichloroethane	no data		no data		3.50E-02	n	2.90E-01	o
1,1,2 trichloroethane	5.70E-02	k	5.60E-02	k	4.00E-03	k	4.00E-03	m
trichloroethylene (TCE)	no data		no data		6.00E-03	n	6.00E-03	m
vinyl chloride	1.90E+00	l	3.00E-01	l	no data		no data	
Metals								
arsenic	1.50E+00	k	1.51E+01	k	3.00E-04	k	no data	
barium	no data		no data		7.00E-02	k	1.43E-04	l
cadmium	no data		6.30E+00	k	5.00E-04	k	5.71E-05	o
chromium (III)	no data		no data		1.00E+00	k	5.70E-07	o
chromium (VI)	no data		2.90E+02	k	5.00E-03	k	no data	
lead	no data		no data		no data		no data	
mercury	no data		no data		3.00E-04	l	8.57E-05	k
selenium	no data		no data		5.00E-03	k	no data	
silver	no data		no data		5.00E-03	k	no data	

References:

k . Integrated Risk Information System (IRIS)

l. Health Effects Assessment Summary Tables (HEAST)

m. route extrapolation

n. National Center for Environmental Assessment (NCEA)

o. withdrawn from IRIS or HEAST

p. Inhalation reference dose (RfD) values in this table have been converted from a given reference concentration (RfC). The RfC (in mg/m³) is converted to a RfD (in mg/kg/d) by multiplying the RfC by 20m³/d (inhalation rate) and dividing by 70kg (body weight).

Note: Other toxicity data may be available; however, when failing to confirm the data or identify it as provisional, "no data" was entered. Have the consultant review current toxicity data sources to confirm information presented here. The toxicity values may be periodically updated or withdrawn as new toxicity data are developed.

Ground Water Ingestion

Tier 1

The ground water ingestion action level for each COC was derived from the maximum contaminant level (MCL) established by the United States Environmental Protection Agency (USEPA) under the National Primary Drinking Water Regulations (40CFR Part 141) and the National Secondary Drinking Water Regulations (40CFR Part 143). USEPA Region 9 preliminary remediation goals (PRG) are used if there were no drinking water action levels. Find the MCL values at <http://www.epa.gov/safewater/mcl.html>.

For naphthalene and methyl tertiary butyl ether (MTBE), the action level is based on a Generic Unrestricted Potable Use Standard calculated by Ohio Environmental Protection Agency (OEPA) under the Voluntary Action Program (VAP). Information on calculating Generic Unrestricted Potable Use Standards (GUPUS) can be found in the *Support Document for the Development of Generic Numerical Standards and Risk Assessment Procedures* prepared by the VAP, Division of Emergency and Remedial Response, OEPA, July 1996. The MTBE value was calculated after the VAP rule promulgation and is not included in Table VII of OAC 3745-300-08 (C)(3)(c).

Where no MCL was available for a COC, no ground water ingestion action level was established for that COC.

Tier 2

Regardless of the land use, assume that a residential adult or child receptor can ingest COCs that are dissolved in ground water (or surface water) used as drinking water.

Therefore, you cannot calculate SSTLs for the ground water ingestion pathway during further tier evaluations. Instead, apply the action level for ground water ingestion at the site-specific point of exposure.

If a MCL is not available for a COC and a Generic Unrestricted Potable Use Standard (GUPUS) has been calculated by the OEPA under the VAP, then use the OEPA Generic Potable Unrestricted Use Standard.

If a MCL or an OEPA GUPUS is not available for a COC, you must provide sufficient justification to eliminate it from the list of COCs being evaluated.

Direct Contact with Soil

Tier 1

Within this exposure pathway, consider these 4 exposure routes for adult or child receptor in a residential setting: 1) incidental ingestion, 2) dermal contact, 3) inhalation of volatile organic compounds, and 4) inhalation of particulates.

Each direct contact COC action level for each COC derives from the OEPA VAP rule OAC 3745-300-08 (B)(3)(c) Table II: *Generic Direct Contact Soil Standards for Carcinogenic and Noncarcinogenic Chemicals of Concern – Residential Land Use Category*.

The MTBE value was calculated after the VAP rule promulgation and is not included in Table VII of OAC 3745-300-08 (C)(3)(c). Find information about calculating the GUPUS in the *Support Document for the Development of Generic Numerical Standards and Risk Assessment Procedures* prepared by the VAP, Division of Emergency and Remedial Response, OEPA, July 1996.

Tier 2

Residential

No site-specific default exposure factors may be substituted during Tier 2.

Commercial

Consistent with the approach used for the Tier 1 action levels, the Tier 2 SSTLs for direct contact also follow the VAP rule. Specifically, the Tier 2 SSTLs may be taken from OAC 3745-300-08 (B)(3)(d) Table III: *Generic Direct Contact Soil Standards for Carcinogenic and Noncarcinogenic Chemicals of*

Concern – Commercial Land Use Category. Tier 2 SSTLs may also be taken from any of the Supplemental Generic Cleanup Values developed through technical assistance by the OEPA.

Additionally, Tier 2 SSTLs may be developed according to the *Support Document for the Development of Generic Numerical Standards and Risk Assessment Procedures*, VAP, Division of Emergency and Remedial Response, OEPA, July 1996.

Excavation Worker

You must evaluate direct contact with soil by excavation workers whenever you have eliminated all soil pathways required in Tier 1. Use the following algorithms.

Algorithms Used for Direct Contact with Soil Sources (from Risk Assessment Guidance for Superfund):

$$SSTL_{DC} = \frac{TR \times BW \times AT_C \times 365 \frac{\text{days}}{\text{year}}}{EF \times ED \left[\left(SF_o \times 10^{-6} \frac{\text{kg}}{\text{mg}} \times (IR_{\text{soil}} \times RAF_o + SA \times M \times RAF_d) \right) + (SF_i \times IR_{\text{air}} \times ET \times (VF_{ss} + VF_p)) \right]}$$

Equation F-9 SSTL Direct Contact with Soil (carcinogenic)

$$SSTL_{DC} = \frac{THQ \times BW \times AT_n \times 365 \frac{\text{days}}{\text{year}}}{EF \times ED \left[\frac{10^{-6} \frac{\text{kg}}{\text{mg}} \times (IR_{\text{soil}} \times RAF_o + SA \times M \times RAF_d)}{RfD_o} + \frac{(IR_{\text{air}} \times ET \times (VF_{ss} + VF_p))}{RfDi} \right]}$$

Equation F-2 SSTL Direct Contact with Soil (non-carcinogenic)

Input Parameters

See the Default Parameters section of the Appendix for input parameters for Equations F-1 and F-2. Input parameters unique to Equations F-1 and F-2 are listed below:

Variable	Description	Units	Value	Source
RAF _o	Relative absorption factor – oral	unitless	COC specific	
RAF _d	Relative absorption factor – dermal	unitless	COC specific	
VF _{ss}	Volatilization factor – surface soil ambient vapors	$\frac{\text{mg/m}^3 - \text{air}}{\text{mg/kg} - \text{soil}}$	Calculated	Equation F-3, F-4
VF _p	Volatilization factor – particulates	$\frac{\text{mg/m}^3 - \text{air}}{\text{mg/kg} - \text{soil}}$	Calculated	Equation F-5

Volatilization Factors for Direct Contact with COCs in Soil (VF_{ss}, VF_p)

The volatilization factors (VFs) for direct contact with COCs in soil relate to volatilization from surface soil or subsurface soil, and suspension of particulates from surface soil or subsurface soil in ambient air. Assume that the excavation worker is in direct contact with soil in the excavation. Inhalation of particulate and/or vapors is based on mixing in ambient air. Surface soil is considered 0 - 10 ft. for the residential scenario and 0 - 2 ft. for the commercial scenario. Assume that excavation workers will be in contact with soil to a default depth of 10 ft.

Algorithms

Calculate the volatilization factors (VF_{ss} and VF_p) for direct contact with COCs using the equations in the *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites*. For determining the VF for surface soil ambient air vapors (VF_{ss}), determine the value via the smaller value calculated by Equation F-3 or Equation F-4.

$$VF_{ss} = \frac{2Wp_s}{U_{air}\delta_{air}} \sqrt{\frac{D_s^{eff}H}{\pi[\Theta_{ws} + k_s p_s + H\Theta_{as}]t}} \times 10^3$$

Equation F-3 Volatilization Factor Surface Soil

$$VF_{ss} = \frac{Wp_s d}{U_{air}\delta_{air}} \times 10^3$$

Equation F-4 Volatilization Factor Surface Soil

Use Equation F-5 to calculate the volatilization factor for soil ambient air particulate (VF_p):

$$VF_p = \frac{P_e W}{U_{air} \delta_{air}} \times 10^3$$

Equation F-5 Volatilization Factor Particulates

Calculating the volatilization factor for soil to ambient air vapors (VF_{ss}) requires that you calculate an effective diffusion coefficient for the vapor phase chemical in soil (D_s^{eff}). Calculate the effective diffusion coefficient in soil (D_s^{eff}) by using Equation F-11.

For the site-specific case, the site data may indicate that you need to identify properties of more than one soil layer in the vadose zone. Here, the effective diffusion coefficient in soil must include separate contributions from each soil layers.

Input Parameters

See the Default Parameters section of this Appendix for the input parameters for Equations F-3, F-4, and F-5. The input parameters that are unique to the equations for direct contact with soil are below.

Variable	Description	Units	Value
d	Lower depth of surficial soil	cm	304.8
t	Averaging time for vapor flux	sec	3.15E+07
P_e	Particulate emission rate	g/cm ² -sec	6.9E-14

When calculating the volatilization factors VF_{ss} , and VF_p , use default input parameter values for the following and modify only with prior approval from BUSTR:

- COC-specific input parameter values (H , K_{oc} , D^{air} , D^{wat});
- Ambient air mixing zone height (δ_{air});
- Average time for vapor flux (t) which is equal to the exposure duration (ED) converted to seconds;
- Lower depth of surficial zone (d) which is equal to 10 feet;
- Particle emission rate (P_e).

Input Parameters That May Be Site-Specific

You may modify 3 groups of site-specific input parameters when calculating the VF_{ss} or VF_p for purpose of developing the SSTL:

1. Physical Dimensions for the Subsurface Source Area

The width of the source area parallel to the wind direction (W) is the only physical dimension required for this volatilization factor. If you do not determine a site-specific input parameter value for W, use the default value of 1500 cm (approximately 49.2 ft.).

2. Characteristics of the Subsurface Soil

You may use site specific characteristics of the subsurface soil in the vadose zone between the top of the source area and the ground surface if sufficient data are collected to demonstrate that the proposed site-specific values are representative of the soil within this zone. Characterize the site-specific subsurface soil characteristics according to:

- Soil bulk density (ρ_s);
- Fraction organic carbon (f_{oc});
- Volumetric water content in the vadose zone (Θ_{ws});
- Volumetric air content in the vadose zone (Θ_{as}) and;
- Total soil porosity in the vadose zone (Θ_t).

Since the sum of the Θ_{ws} , and the Θ_{as} must equal the Θ_T , any changes to one of these values must be reflected by changes in the other two values. If site-specific characteristics for subsurface soil are not determined, use the default soil values in this Appendix.

3. Wind Speed

Determine the wind speed above the ground surface in the ambient mixing zone (U_{air}) based on site-specific or surrounding area information. If a site-specific U_{air} is not available, then use a wind speed of 225 cm/sec.

Indoor Air Inhalation

This indoor air concentration is the acceptable concentration of a COC that a receptor may be exposed to within a home or other building. Use this concentration as the point of exposure concentration to calculate the soil to indoor air and the ground water to indoor air SSTLs.

Assumptions

Calculate the residential indoor air concentrations for carcinogenic COCs with a combined adult and child exposure that averages life spans. This assumption suggests that a resident spends some of that time as a child and the remainder as an adult. The combined approach results in more conservative action levels/SSTLs (as opposed to evaluating adults or children individually).

Calculate the residential indoor air concentrations for non-carcinogenic COCs with only the child's exposure. These assumptions were made for the non-carcinogen case because during the child's exposure, the body weight values are low and the inhalation rates are equal to the adult values, resulting in more conservative action levels/SSTLs.

Calculate the commercial indoor air concentrations for both carcinogenic and non-carcinogenic COCs for the adult worker. Although residents may be exposed at commercial properties, their exposures are assumed to be infrequent and of short duration. Adult workers are the maximally exposed receptor group, resulting in more conservative SSTLs.

Algorithms

Calculate the SSTLs for vapor to indoor air using the equations in the *Risk Assessment Guidance for Superfund*:

$$SSTL_{air-c} = \frac{TR \times BW \times AT_c \times 365 \frac{\text{days}}{\text{year}} \times 10^3 \frac{\text{ug}}{\text{mg}}}{SF_1 \times IR_{air} \times ET \times EF \times ED}$$

Equation F-6 Carcinogenic Chemicals of Concern (Commercial Only)

$$SSTL_{air-h} = \frac{THQ \times RfD \times BW \times AT_c \times 365 \frac{\text{days}}{\text{year}} \times 10^3 \frac{\text{ug}}{\text{mg}}}{IR_{air} \times ET \times EF \times ED}$$

Equation F-7 Non-carcinogenic Chemicals of Concern

$$SSTL_{air-c} = \frac{TR \times AT_c \times 365 \frac{\text{days}}{\text{year}} \times 10^3 \frac{\text{ug}}{\text{mg}}}{SF_i \times ET \times EF \times \left[\frac{ED_{child} \times IR_{child}}{BW_{child}} + \frac{ED_{adult} \times IR_{adult}}{BW_{adult}} \right]}$$

Equation F-8 Carcinogenic Chemicals of Concern (Residential Only)

Input Parameters

See the Default Parameters section of this Appendix for the input parameters for Equations F-6, F-7, and F-8. There are no input parameters unique to these algorithms.

Soil to Indoor Air Pathway

Where a soil source area exists below a building, COCs adsorbed to soil can volatilize into the soil pore spaces, travel through the soil, and into the cracks in a foundation of a building, and mix with the air inside the building.

Algorithms

Calculate the SSTLs for vapor to indoor air from soil sources using the equation in the *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites*:

$$SSTL_{soil-air} = \frac{SSTL_{air}}{VF} \times 10^{-3} \frac{\text{mg}}{\text{ug}}$$

Equation F-9 SSTL Soil to Indoor Air

Input Parameters

$SSTL_{air}$ is the SSTL for indoor air inhalation for a COC used in Equations F-6, F-7, and F-8.

VF (also referenced as VF_{seps}) is the volatilization factor for a COC in subsurface soil migrating to indoor air that is used in Equation F-10.

Volatilization Factor for a COC in Subsurface Soil to Indoor Air (VF_{seps})

The volatilization factor for COCs in subsurface soil to indoor air relates the concentration of a COC in soil vapor to its concentration in soil. It describes the diffusion for COCs through the soil and cracks in a building's foundation.

Assumptions

For the action levels calculated during Tier 1, assume that the house is a one-story structure with a full basement. Locate the house directly over the soil source area. Assume that vapors will infiltrate through the basement floor only. Assume that the house dimensions are 40 ft. (1219.20 cm) by 20 ft. (609.6 cm) by 16 ft. (487.68 cm) in height (i.e., the combined height of the basement and the first floor). (See the illustration, Figure F-1.)

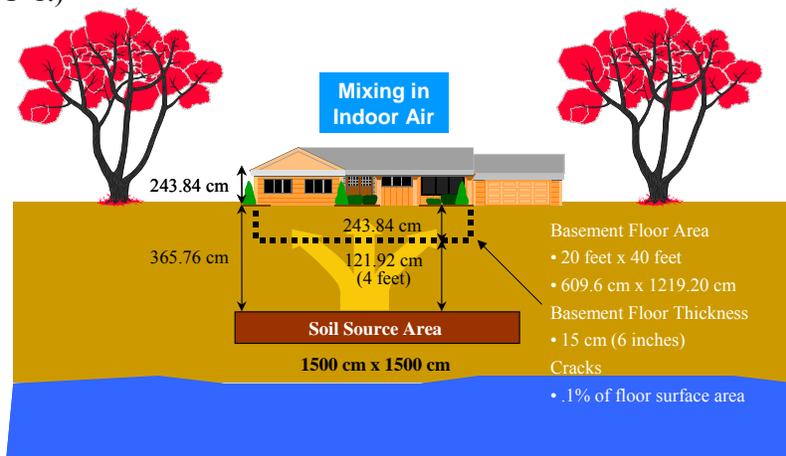


Figure F-1 - Soil to Indoor Air Assumptions

Algorithms

Calculate the volatilization factor (VF_{sesp}) for COCs in subsurface soil to indoor air using the equation from the *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites*. This equation is based on a heuristic model presented by Johnson and Ettinger:

$$VF_{\text{sesp}} = \frac{\frac{H \rho_s}{\theta_{ws} + k_s \rho_s + H \theta_{as}} \left[\frac{D_s^{\text{eff}}}{L_s} \right]}{1 + \left[\frac{D_s^{\text{eff}}}{ER L_B} \right] + \left[\frac{D_{\text{crack}}^{\text{eff}}}{L_{\text{crack}}} \right] n} \times 1000 \frac{\text{cm}^3 - \text{kg}}{\text{m}^3 - \text{g}}$$

Equation F-10 Volatilization Factor for Subsurface Soil to Indoor Air

Calculating the VF requires that you calculate an effective diffusion coefficient for the vapor phase chemical in soil (D_s^{eff}) and an effective diffusion coefficient for the vapor phase chemical through foundation cracks ($D_{\text{crack}}^{\text{eff}}$). The diffusion coefficients are functions of the vadose zone soil porosity (Θ_T), the water-filled porosity of the vadose zone soil (Θ_{ws}) and the air-filled porosity (Θ_{as}). During Tier 2, based on the site data, you may need to identify properties of more than one soil layer in the vadose zone. If this is the case, then the effective diffusion coefficient in soil would include contributions from each of the soil layers.

Calculate the effective diffusion coefficient in soil (D_s^{eff}) using the equation in the *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites*. This equation is based on the semi-empirical model presented by Millington and Quirk:

$$D_s^{eff} = D^{air} \frac{\theta_{as}^{3.33}}{\theta_T^2} + D^{wat} \frac{1}{H} \frac{\theta_{ws}^{3.33}}{\theta_T^2}$$

Equation F-11 Effective Diffusion Coefficient in Soil Based on Vapor-Phase Concentrations

Calculate the effective diffusion coefficient through foundation cracks (D_{crack}^{eff}) using the equation in the *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites*. This equation is based on the semi-empirical model presented by Millington and Quirk:

$$D_{crack}^{eff} = D^{air} \frac{\theta_{acrack}^{3.33}}{\theta_T^2} + D^{wat} \frac{1}{H} \frac{\theta_{wcrack}^{3.33}}{\theta_T^2}$$

Equation F-12 Effective Diffusion Coefficient Through Foundation Cracks

Input Parameters

See the Default Parameters section of this Appendix for default input parameter values for calculating VF_{seep} , D_s^{eff} , and D_{crack}^{eff} . Two parameters unique to these algorithms are L_s and L_B , which derive from Equations F-13 and F-14, respectively.

$$L_s = (\text{depth of subsurface source}) - (\text{depth to bottom of basement})$$

Equation F-13 Depth to Top of Subsurface Source From Bottom of Basement or Foundation

$$L_B = \frac{\text{Length of basement} \times \text{Width of basement} \times (\text{Height of basement} + \text{Height of house})}{\text{Length of basement} \times \text{Width of basement}}$$

Equation F-14 Enclosed Space Volume/Infiltration Ratio

When calculating the VF_{seps} , the following default input parameter values must be used and should only be modified with prior approval from BUSTR:

- Aerial fraction of cracks in foundation/walls (η);
- COC-specific input parameter values (H , K_{oc} , D^{air} , D^{wat});
- Volumetric air content in foundation/wall cracks (Θ_{acrack});
- Volumetric water content in foundation/wall cracks (Θ_{wcrack}).

Many common COC-specific input parameters can be found in the Default Parameters section of this Appendix. First, consult these tabulated values and the references used to define the default COCs for any additional COCs. If a COC-specific input parameter value is not there, then use another publicly available reference.

Input Parameters That May Be Site-Specific

There are 4 groups of site-specific input parameters that may be modified when calculating the VF_{seps} during Tier 2:

1. Physical Dimensions of the Building

You must accurately estimate the length, width, and height of the building because the model used to calculate indoor air concentration assumes that concentrations of COCs are evenly mixed throughout the building. Never assume that the height of the building is more than 1 story or 8 ft. (243.84 cm). If there is no basement for the building, then assume that the basement height is zero. Additionally, the enclosed space foundation/wall thickness (L_{crack}) may also be modified based on the actual thickness of the basement floor or building slab (if no basement exists). Modifications to the physical dimensions of the building may require a re-calculation of the volume/infiltration area ratio (L_B) **and/or** institutional controls (i.e., deed restriction) to ensure that the building configuration is maintained and protective of future land use.

2. Physical Dimensions of the Subsurface Source Area

You may change only the soil thickness between the bottom of the basement and top of the source (L_s). If the depth to the bottom of the basement is below the top of the subsurface soil source, then use a value of 1 cm for L_s . This assumes that the subsurface foundation of the building could be placed directly onto the source of COCs.

3. Characteristics of the Subsurface Soil

You may use site-specific characteristics of the subsurface soil in the vadose zone between the top of the source area and the bottom of the basement if sufficient data are collected to demonstrate that these values represent soil within this zone. You may modify these site-specific subsurface soil characteristics:

- Soil bulk density (ρ_s);
- Fraction organic carbon (f_{oc});
- Volumetric water content in the vadose zone (Θ_{ws});
- Volumetric air content in the vadose zone (Θ_{as});
- Total soil porosity in the vadose zone (Θ_t).

Since the sum of the Θ_{ws} and the Θ_{as} must equal the Θ_t , any changes to one of these values must be reflected by changes in the other two values.

4. Enclosed Space Air Exchange Rate

You may substitute a site-specific enclosed space air exchange rate (ER) for the recommended default parameters. However, you must document the source/assumptions used to derive the ER value.

Ground Water to Indoor Air Pathway

Where a ground water source area exists below a building, COCs dissolved in ground water can volatilize into the soil pore spaces, travel through the soil, and into the cracks in a foundation of a building, and mix with the air inside the building. An adult or child receptor can inhale COCs that have volatilized into the air.

Algorithms

Calculate the SSTLs for vapor to indoor air from a ground water source using the equation in the *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Site*:

$$\text{SSTL}_{\text{water-air}} = \frac{\text{SSTL}_{\text{air}}}{\text{VF}} \times 10^{-3} \frac{\text{mg}}{\text{ug}}$$

Equation F-15 COCs in Ground Water Vapor to Indoor Air

Input Parameters

SSTL_{air} is the SSTL for indoor air inhalation for the COCs shown in Equations F-6, F-7, and F-8.

VF (also referred to as VF_{wesp}) is the volatilization factor for a COC in ground water migrating to indoor air as presented in Equation F-16.

Volatilization Factor for a COC in Ground Water to Indoor Air - (VF_{wesp})

The VF for COCs in ground water to indoor air relates the COC concentration in indoor air to its concentration in ground water, and accounts for diffusion through the soil and cracks in the foundation of a building.

Assumptions

For the action levels calculated during Tier 1, assume that the house is a one-story structure with a full basement directly over the ground water source area. Vapors are assumed to infiltrate through the basement floor only. The house is assumed to be 40 ft. (1219.20 cm) in length by 20 ft. (609.6 cm) in width by 16 ft. (487.68 cm) in height (i.e., the combined height of the basement and the first floor). In Tier 1, the variable depth to ground water would fall into one of these categories:

- Less than 15 ft. uses 14 ft. (426.72 cm);
- 15 to 30 ft. uses 15 ft. (457.20 cm);
- 31 ft. to 50 ft. uses 31 ft. (944.88 cm);
- Greater than 50 ft. uses 50 ft. (1524.0 cm).

(See the illustration, Figure F-2.)

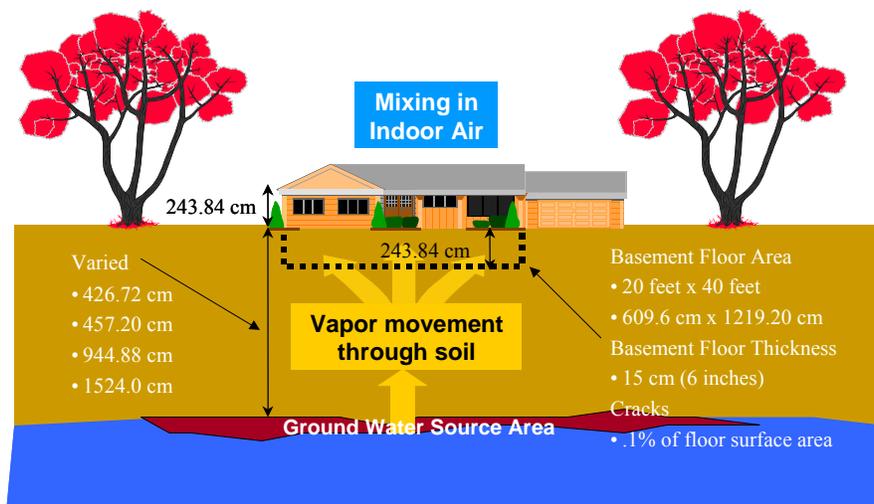


Figure F-2 Ground Water to Indoor Air Assumptions

Algorithms

Calculate the volatilization factor (VF_{wesp}) for COCs in ground water migrating to indoor air using the equation from the *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites*. This equation is based on a model developed by Johnson and Ettinger:

$$VF_{wesp} = \frac{H \left[\frac{D_{ws}^{eff}}{L_{GW}} \right]}{ER \times L_B} \times 10^3 \frac{L}{m^3} \times \left[1 + \frac{\left[\frac{D_{ws}^{eff}}{L_{GW}} \right]}{\left[\frac{D_{crack}^{eff}}{L_{crack}} \right] \eta} \right]$$

Equation F-16 Volatilization Factor for Ground Water to Indoor Air

Calculating the VF factor requires that you calculate an effective diffusion coefficient (D_{ws}^{eff}) for the vapor phase chemical from the ground water surface through the capillary fringe (h_{cap}) and through the vadose zone (h_v) soil, and an effective diffusion coefficient (D_{crack}^{eff}) for the vapor phase chemical through foundation cracks. The diffusion coefficients are functions of the vadose zone soil porosity (Θ_T), the water-filled porosity of the vadose zone soil (Θ_{ws}), the air-filled porosity (Θ_{as}), the water-filled porosity of the capillary fringe (Θ_{wcap}), and the air-filled porosity of the capillary fringe (Θ_{acap}). Assume that the total soil porosity in the capillary fringe is the same as the vadose zone, but with different assumptions for the air-filled fractions and water-filled fractions. In the capillary fringe, the water content is higher than in the remainder of the vadose zone. The capillary fringe is thicker in finer grained soil, with smaller pore sizes than in coarser grained soil. This provides a greater resistance to vapor phase movement.

Calculate the effective diffusion coefficient for the vapor phase chemical from the ground water surface through the capillary fringe and through the vadose zone soil (D_{ws}^{eff}) using the equation found in *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites*. This equivalent diffusion coefficient (D_{ws}^{eff}) for the resistances in series is given by the harmonic average of the effective diffusion coefficients for the individual layers weighted by their thicknesses:

$$D_{ws}^{eff} = (h_{cap} + h_v) \left[\frac{h_{cap}}{D_{cap}^{eff}} + \frac{h_v}{D_s^{eff}} \right]^{-1}$$

Equation F-17 Effective Diffusion Coefficient Between Ground Water and Bottom of the Basement or Foundation

D_s^{eff} is the effective diffusion coefficient in the vadose zone soil based on vapor-phase concentration (See Equation F-11). For the site-specific case, based on the site data, you may need to identify properties of more than one soil layer in the vadose zone. If this is the case, then include the separate contributions from each of the soil layers.

D_{cap}^{eff} is the effective diffusion coefficient through the capillary fringe; calculate it using the equation in the *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites*. This equation is based on the semi-empirical model presented by Millington and Quirk:

$$D_{cap}^{eff} = D^{air} \frac{\Theta_{acap}^{3.33}}{\Theta_T^2} + D^{wat} \frac{1}{H} \frac{\Theta_{wcap}^{3.33}}{\Theta_T^2}$$

Equation F-18 Effective Diffusion Coefficient in the Capillary Fringe

Calculate the effective diffusion coefficient through foundation cracks (D_{crack}^{eff}) using Equation F-18.

Input Parameters

See the Default Parameters section of this Appendix for the input parameter values used in Equations F-16, F-17, and F-18. The parameters L_{GW} and h_v are unique to these equations and can be found in Equations F-19 and F-20, respectively.

$$L_{GW} = (\text{Depth to top of groundwater}) - (\text{Depth to bottom of basement})$$

Equation F-19 Depth to Top of Ground Water From the Bottom of Basement or Foundation

$$h_v = L_{GW} - h_{cap}$$

Equation F-20 Thickness of Vadose Zone Below Basement or Foundation

When calculating the VF_{wesp} , use the following default input parameter values and modify them only with prior approval from BUSTR:

- Aerial fraction of cracks in foundation/walls (η);
- COC-specific input parameter values (H , D^{air} , D^{wat});
- Volumetric air content in foundation/wall cracks (Θ_{crack}) and the volumetric water content in foundation/wall cracks (Θ_{wcrack}).

See the Default Parameters section of this Appendix for input parameter values for some common COCs. Use any publicly available reference for any COC-specific input parameter value not in this Appendix.

Input Parameters That May Be Site-Specific

There are 4 groups of site-specific input parameters that may be modified when calculating the VF_{wesp} during Tier 2:

1. Physical Dimensions of the Building

You must accurately estimate the length, width, and height of the building because the model used to calculate indoor air concentration assumes that concentrations of the COCs are evenly mixed throughout the building. Never assume the height of the building to be more than 1 story or 8 ft. (243.84 cm). If there is no basement for the building, then assume that the basement height is zero. Additionally, the enclosed space foundation/wall thickness (L_{crack}) may also be modified based on the actual thickness of the basement floor or building slab (if no basement exists). Modifications to the physical dimensions of the building may require a re-calculation of the volume/infiltration area ratio (LB) and/or **institutional controls (i.e., deed restriction) to ensure that this building configuration is maintained and protective of future land use.**

2. Depth to Ground Water

The depth to the top of the ground water (dtw) and the thickness of the capillary fringe (h_{cap}) are the only physical dimensions required for this volatilization factor. You must calculate the depth to top of ground water from bottom of basement (L_{GW}) based on the depth to the top of the ground water from the ground surface. You can calculate the thickness of the vadose zone (h_v) based on the thickness of the capillary fringe (h_{cap}). If the depth of the bottom of the basement is below the depth of the top of ground water, then use a value of 30.48 cm for L .

3. Characteristics of the Subsurface Soil

You may use site-specific characteristics of the subsurface soil in the vadose zone between the top of the source area and the bottom of the basement if sufficient data are collected to demonstrate that these values represent the soil within this zone. You may modify these site-specific subsurface soil characteristics:

- Soil bulk density (ρ_s);
- Fraction organic carbon (F_{oc});

- Volumetric water content in the vadose zone (Θ_{ws});
- Volumetric air content in the vadose zone (Θ_{as});
- Total soil porosity in the vadose zone (Θ_T);
- Volumetric water content in the capillary fringe (Θ_{wcap});
- Volumetric air content in the capillary fringe (Θ_{acap}).

Since the sum of the Θ_{ws} and the Θ_{as} must equal the Θ_T , any changes to one of these values must be reflected by changes in the other two values.

4. Enclosed Space Air Exchange Rate

You may substitute a site-specific enclosed space air exchange rate (ER) for the recommended default parameters. However, you must document the source/assumptions used to derive the ER value.

Soil to Ground Water Leaching

Where a soil source exists above ground water, COCs adsorbed to soil can dissolve in infiltrating water, migrate to ground water and mix with ground water. There are two potential endpoints for this pathway. The first is based on soil leaching to drinking water, which is calculated using the drinking water action levels (MCLs) as the target concentrations for the COCs in ground water. Or, you may use the USEPA Region 9 preliminary remediation goals (PRGs), or GUPUS, if no drinking water action level exists. The second is based on the action levels or SSTLs calculated for the ground water to indoor air pathway as the target concentration for COCs in ground water.

Tier 1 action levels assume a horizontal dilution factor of 10 for a well located 30 ft. from the center of the source area. The Tier 2 model, however, does not include this dilution factor and assumes the well is located directly in the center of the source area. Therefore, COC concentrations must be modeled to a site-specific point of exposure.

Assumptions

Assume that the thickness of the soil source area varies according to the soil type:

- 6 ft. (182.88 cm) for sand/gravel;
- 4 ft. (121.92 cm) for silty clayey sand;
- 2 ft. (60.96 cm) for clay/silt.

The depth to ground water is categorized to one of these:

- Less than 15 ft. uses 14 ft. (426.72 cm);
- 15 - 30 ft. uses 15 ft. (457.20 cm);
- 31 - 50 ft. uses 31 ft. (944.88 cm);
- Greater than 50 ft. uses 50 ft. (1524.0 cm).

The distance between the bottom of the source area and the top of the ground water is calculated using:

$$L = L_{gw} - L_{sss} - L_{tsss}$$

Equation F-21 The Distance Between the Bottom of the Soil Source and the Top of the Ground Water

L_{gw} is the depth to ground water, L_{sss} is the depth to the top of the soil source area, and L_{tsss} is the thickness of the soil source area. Where L is less than 1 ft. (30.48 cm), L is set equal to 1 ft. (30.48 cm). (See in the illustration, Figure F-3.)

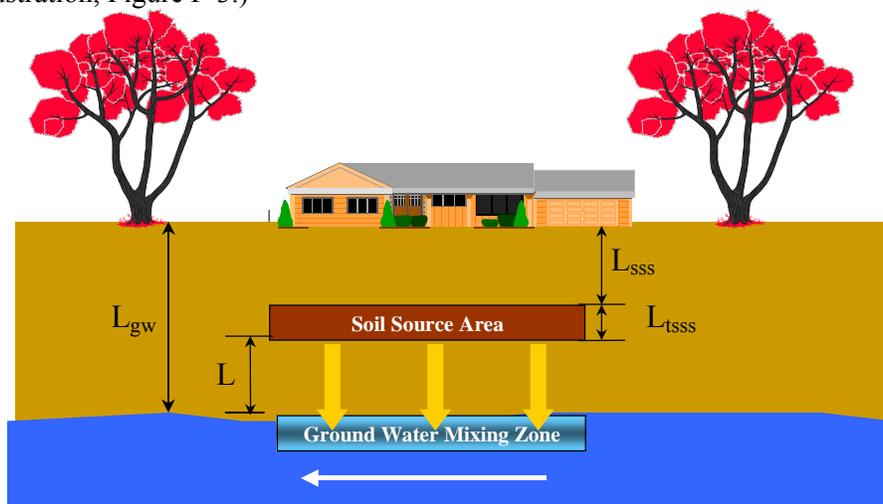


Figure F-3 Leaching from Soil to Ground Water Assumptions

Algorithms

The first step in calculating the SSTL for soil leaching COCs to ground water is to calculate the soil leaching to ground water SSTL without degradation. Do this by dividing the applicable action level (MCL for drinking water) or SSTL (ground water to indoor air) by a soil to ground water leaching factor.

$$SSTL_{no\ deg} = \frac{AL_w}{LF_{sw}}$$

Equation F-22 Soil to Ground Water SSTL without Degradation

AL_w is the action level/SSTL for a COC in water, and LF_{sw} is the soil to ground water leaching factor. Specifically, this leaching factor includes both partitioning and mixing; calculate it using the equation in the *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites*.

$$LF_{sw} = \frac{P_s}{(\Theta_{ws} + K_d P_s + \Theta_{as} H) \left(1 + \frac{U_{gw} \times \delta_{gw}}{I \times W} \right)} \times 10^0 \frac{cm^3 - kg}{L - g}$$

Equation F-23 Soil to Ground Water Leaching Factor

Determine the degradation of COCs by calculating the time for water to infiltrate through soil from the bottom of the soil source area to the top of the ground water. Then apply that travel time to a first order degradation rate. This process, based on the Green-Ampt model, assumes that infiltration is responsible for the mobilization of hydrocarbons in the vadose zone.

Determine the time needed for the infiltrating water to move from the location of the highest concentration of a COC to the ground water with the following equation:

$$t = \left(\frac{\Theta_{as}}{K_u} \right) \times \left[L - (h - \Psi) \times \ln \left(\frac{h + L - \Psi}{(h - \Psi)} \right) \right] \times \frac{1 \text{ day}}{86400 \text{ seconds}}$$

Equation F-24 Time for Infiltrating Water to Move From the Source to the Water Table

Calculate the seepage velocity of the ground water using this equation:

$$V_w = \frac{L}{t}$$

Equation F-25 Vertical Seepage Velocity of Water

Use this equation to calculate the travel velocity of the COCs in the soil:

$$V_c = \frac{V_w}{\left[1 + \left(\frac{P_s \times K_d}{\Theta_t} \right) \right]}$$

Equation F-26 COCs Velocity

Calculate the partitioning coefficient between soil pore water and the soil using this equation:

$$K_d = K_{oc} \times F_{oc}$$

Equation F-27 Partitioning Coefficient Between Soil Pore Water and Soil

For determining the time required for the COCs to reach the ground water, use this equation:

$$t_c = \frac{L}{V_c}$$

Equation F-28 Travel Time for COCs to Reach Water Table

Calculate the ratio of the final COC concentration in the soil pore relative to the original concentration using this equation:

$$\frac{C_f}{C_w} = e^{(-kt_c)}$$

Equation F-29 Ratio of Final COCs Concentration in Soil Pore to Original Concentration

Then you can calculate the SSTL for soil leaching to ground water this way:

$$SSTL = \frac{SSTL_{no\ deg}}{C_f/C_w}$$

Equation F-30 SSTL for Soil Leaching to Ground Water

Input Parameters

L is the depth to ground water from the bottom of the source. The Default Parameters section of this Appendix contains the remaining input parameters for Equations F-22 - F-30.

You must use the following default input parameters and may modify them only with prior approval from BUSTR:

1. The COC-specific input parameter values (H, K_{oc}).
2. Ground water mixing zone thickness (δ_{gw}).

Input Parameters That May Be Site-Specific

You may modify these 2 groups of site-specific input parameters in equations used for developing SSTLs:

1. Physical Dimensions of the Subsurface Source Area

These parameters include the width of the source area parallel to the ground water flow direction (W) and the depth to ground water from the bottom of the source area (L).

2. Site Specific Characteristics of the Subsurface Soil

You may consider site-specific characteristics of the subsurface soil in the vadose zone if sufficient data are collected to show that site-specific values represent the soil within this zone. You may modify these site-specific subsurface soil characteristics:

- Soil bulk density (ρ_s);
- Fraction organic carbon; (Foc),
- Volumetric water content in the vadose zone (Θ_{ws});
- Volumetric air content in the vadose zone (Θ_{as});
- Total soil porosity in the vadose zone (Θ_T);
- Ground water Darcy velocity (U_{gw});
- Infiltration rate (I);

- Saturated hydraulic conductivity of vadose zone (K_s);
- Unsaturated hydraulic conductivity of vadose zone (K_u);
- Wetting front suction (Ψ).

Since the sum of the Θ_{ws} and the Θ_{as} must equal the Θ_T , any changes to one of these values must be reflected by changes in the other two values.

Solubility and Saturation

Solubility

When a calculated action level for ground water is greater than the solubility value for a COC, then no action level is provided for that COC exposure pathway.

Saturation

When calculated action levels for (C_{sat}) are greater than the saturation concentration for a COC, no action level is provided for that COC's exposure pathway.

Calculate soil saturation using the equation in the *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites*. The equation is based on local equilibrium partitioning between all phases (e.g., adsorbed to soil, dissolved in pore water, vapors in soil pores) in the soil matrix:

$$C_{sat} = \frac{S}{\rho_s} \times [H \Theta_{as} + \Theta_{ws} + k_d \rho_s]$$

Equation F-31 Soil Saturation Equation

Input Parameters

S is the solubility of the COC in water. K_d is the soil water partitioning coefficient and is calculated using Equation F-27. See the remaining input parameter values in the Default Parameters section of this Appendix.

Outdoor Air Inhalation

In situations where the indoor air exposure pathway has been eliminated, you must evaluate the outdoor air exposure from subsurface soil or ground water. The direct contact with soil pathway addresses outdoor inhalation of volatiles and particulates from surface soil. Surface soil is considered 0 - 10 ft. for the residential scenario and 0 - 2 ft. for the commercial scenario. Assume that excavation workers are exposed to the area of highest soil contamination to a default depth of 10 ft.

Calculate an outdoor air concentration that is protective of the receptor for each COC. This outdoor air concentration is the acceptable COC concentration that impacts a receptor to exposure outside of a home or other building. Use this concentration to back-calculate the soil to outdoor air and the ground water to outdoor air SSTLs.

Evaluate this pathway for adult and child residential receptors, adult commercial receptors, and adult excavation worker receptors.

Assumptions

For the residential receptor, calculate the SSTL for a carcinogenic COC using a combination of adult and child exposures. For the SSTLs for non-carcinogenic COCs, calculate only the child exposure. Assume the non-carcinogen case because the child's body weight value is low and the inhalation rate is equal to the adult value, resulting in more conservative SSTLs. For the carcinogens, the averaging time spans a lifetime, so assume the receptor spends some of that time as a child and the remainder as an adult, resulting in more conservative SSTLs (when compared to the adult only calculation).

For the commercial and excavation worker receptor, calculate the SSTL for carcinogenic and non-carcinogenic COCs by using only the adult commercial or excavation worker exposure.

Algorithms

Calculate the SSTLs for vapor to outdoor air with Equations F-6, F-7, and F-8. (See the Indoor Air Inhalation section.)

Input Parameters

See the input parameters found in the Default Parameters section of this Appendix.

Subsurface Soil to Outdoor Air Pathway

Where a contaminant source area exists below an outdoor area, COCs adsorbed to soil can volatilize into the soil pore spaces, travel through the soil, and mix with the ambient air. You may need to evaluate this pathway for adult and child residential receptors, adult commercial receptors, and adult excavation worker receptors.

Algorithms

Calculate the SSTL_{soil-air} values for vapor to outdoor air from soil sources by using the equation in the *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites*:

$$\text{SSTL}_{\text{soil-air}} = \frac{\text{SSTL}_{\text{air}}}{\text{VF}} \times 10^{-3} \frac{\text{mg}}{\text{ug}}$$

Equation F-32 Vapor to Outdoor Air from a Soil Source

Input Parameters

SSTL_{air} is the SSTL for outdoor air inhalation for a COC. (See equations F-6, F-7, and F-8).

VF (also referenced as VF_{samb}) is the volatilization factor for a COC in subsurface soil migrating to outdoor air (See Equation F-33).

Volatilization Factor for a COC in Subsurface Soil to Outdoor Air (VF_{samb})

The VF for COCs in subsurface soil to outdoor air relates the COC concentration in soil vapor to its concentration in soil, and accounts for diffusion through the soil and mixing with ambient air.

Assumptions

Assume that the receptor is located directly over the soil source area. Vapors are assumed to migrate through the soil and mix with ambient air. Mixing in ambient air occurs in a box with dimensions defined as the length of the source L_{Source} (L_s) area perpendicular to wind direction by the width of source W_{source} (W) area parallel to wind direction by the height of the mixing zone Delta Air (δ_{air}). (See the illustration, Figure F-4.)

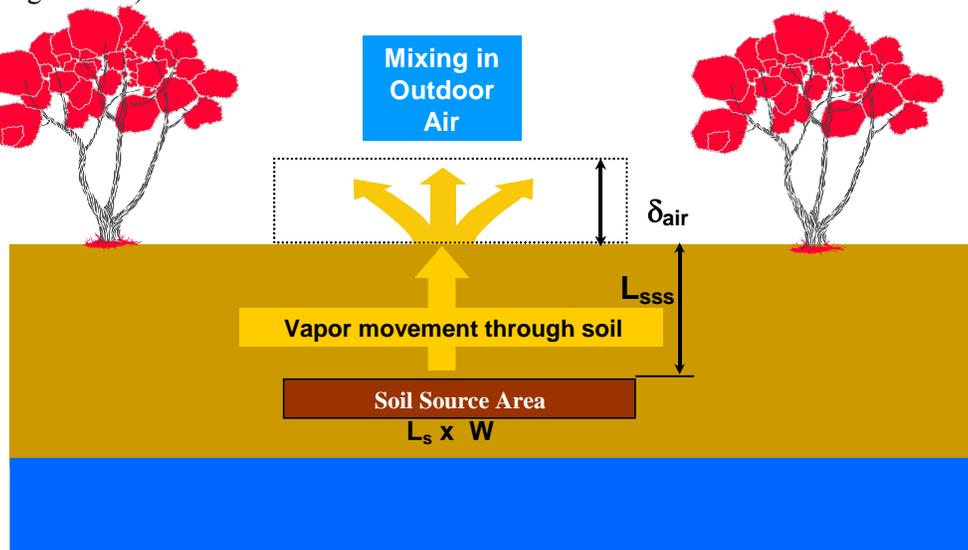


Figure F-4 - Soil to Outdoor Air Dimensions

Algorithms

Calculate the volatilization factor (VF_{samb}) for COCs in subsurface soil to outdoor air using the equation in the *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites*. This equation is based on a model presented by Johnson, Hertz and Byers:

$$VF_{samb} = \frac{H\rho_s}{[\Theta_{ws} + k_s\rho_s + H\Theta_{as}] \left(1 + \frac{U_{air} \delta_{air} L_s}{D_s^{eff} W} \right)} \times 10^3 \frac{cm^3 - kg}{m^3 - g}$$

Equation F-33 Volatilization Factor for COCs in Subsurface Soil to Outdoor Air

Input Parameters

Calculating the volatilization factor requires that you calculate an effective diffusion coefficient for the vapor phase chemical in soil (D_s^{eff}). To do this, use Equation F-11.

When calculating the VF_{samb} , you must use the following default input parameters and may only modify the values for these parameters with prior approval from BUSTR:

- The COC-specific input parameter values (H , K_{oc} , etc.);
- The ambient air mixing zone height (δ_{air}).

See the Default Parameters section of this Appendix for specific input parameter values for COCs. If COC-specific input parameter value is not provided, then use another publicly available reference.

Input Parameters That May Be Site-Specific

You may modify these 3 groups of site-specific input parameters when calculating the VF_{samb} for purposes of developing the $SSTL_{\text{soil-air}}$:

1. Physical Dimensions for the Subsurface Source Area

You need 2 physical dimensions for this VF_{samb} : the depth to the top of the subsurface source area (L_{ss}) and the width of the source area parallel to the wind direction (W_{Source}). If site-specific input parameter values are not determined for these dimensions, use the values in the Default Parameters section of this Appendix. The required dimensions are shown in Figure 4.

2. Characteristics of the Subsurface Soil

You may use site-specific characteristics of the subsurface soil in the vadose zone between the top of the source area and the ground surface if sufficient data are collected to demonstrate that these values represent the soil within this zone. You may modify these site-specific subsurface soil characteristics:

- Soil bulk density (ρ_s);
- Fraction organic carbon (f_{oc});
- Volumetric water content in the vadose zone (Θ_{ws});
- Volumetric air content in the vadose zone (Θ_{as});
- Total soil porosity in the vadose zone (Θ_t).

Since the sum of the Θ_{ws} and the Θ_{as} must equal the Θ_t , any changes to one of these values must be reflected by changes in the other two values. If you do not determine site-specific characteristics for subsurface soil for the site, use the values presented in the Default Parameters section of this Appendix.

3. Wind Speed Above Ground Surface in Ambient Mixing Zone

You may use the wind speed (U_{air}) above the ground surface (i.e., in the ambient mixing zone) to determine site-specific information for the site and the surrounding area. If a site-specific U_{air} is not determined, then use a wind speed of 225 cm/sec.

Ground Water to Outdoor Air Pathway

Where a ground water source area exists below an open area, COCs can volatilize into the soil pore spaces, travel through the soil, and mix with the ambient air. You must evaluate this pathway when the ground water to indoor air pathway has been eliminated.

Algorithms

Calculate the $SSTL_{\text{water-air}}$ for vapor to outdoor air from a ground water source using this equation found in the *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites*:

$$SSTL_{\text{water-air}} = \frac{SSTL_{\text{air}}}{VF} \times 10^{-3} \frac{\text{mg}}{\text{ug}}$$

Equation F-34 - Ground water Vapors to Outdoor Air

Input Parameters

$SSTL_{\text{air}}$ is the SSTL for outdoor air inhalation for a COC. (See Figures F-6, F-7, and F-8.)

VF (also referenced as VF_{wamb}) is the volatilization factor for a COC in ground water migrating to outdoor air. (See Equation F-35.)

Volatilization Factor for a COC in Ground Water to Outdoor Air

The VF_{wamb} for COCs in ground water to outdoor air relates the COC concentration in ground water to its concentration in soil vapor; this VF describes diffusion through the soil and mixing with ambient air.

Assumptions

Assume that the receptor is located directly over the ground water source area. Also assume that vapors migrate through the soil and mix with ambient air. Mixing in ambient air occurs in a box with dimensions defined as the length of the source area perpendicular to wind direction (L_s) by the width of source (W) area parallel to ground water flow direction by the height of the mixing zone (δ_{air}). (See the illustration, Figure F-5.)

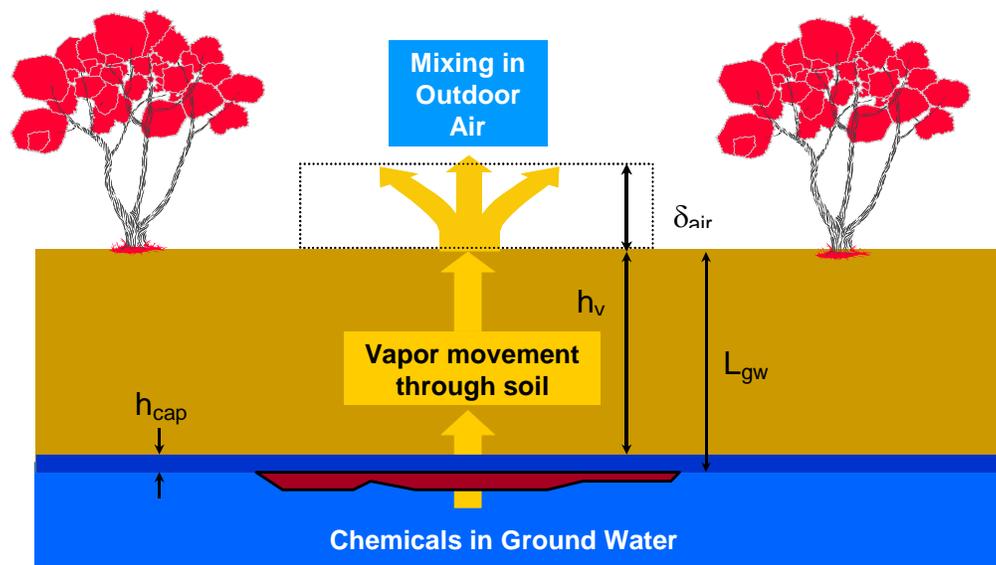


Figure F-5 Ground Water to Outdoor Air Dimensions

Algorithms

Calculate the VF_{wamb} for COCs in ground water to outdoor air using the equation in the *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites*. This equation is based on a model presented in the Superfund Exposure Assessment Manual:

$$VF_{wamb} = \frac{H}{1 + \left[\frac{U_{air} \delta_{air} L_{GW}}{WD_{ws}^{eff}} \right]} \times 10^3 \frac{L}{m^3}$$

Equation F-35 Volatilization Factor for COCs in Ground Water to Outdoor Air

Input Parameters

Calculating the VF_{wamb} requires that you calculate the effective diffusion coefficient for the vapor phase chemical from the ground water surface through the capillary fringe and through the vadose zone soil (D_{ws}^{eff}). This calculation requires an effective diffusion coefficient for the vapor phase chemical in soil (D_s^{eff}) and the effective diffusion coefficient through the capillary fringe (D_{cap}^{eff}), which is derived as follows:

- The effective diffusion coefficient in soil (D_s^{eff}) uses Equation F-11;
- The effective diffusion coefficient through the capillary fringe (D_{cap}^{eff}) uses Equation F-18;
- The effective diffusion coefficient for the vapor phase chemicals from the ground water surface through the capillary fringe and through the vadose zone soil (D_{ws}^{eff}) uses Equation F-17 with the exception that the term h_v is the thickness of the vadose zone from ground surface, instead of from the bottom of the basement.

You must use the following default input parameters when calculating the VF_{wamb} :

- The COC-specific input parameter values (H , D^{air} , D^{wat});
- The ambient air mixing zone height (δ_{air}).

See the Default Parameters section of this Appendix for COC-specific input parameter values. If a COC-specific input parameter value is not provided, then use another publicly available reference.

Input Parameters That May Be Site-Specific

You may modify these 3 groups of site-specific input parameters when calculating the VF_{wamb} :

1. Physical Dimensions of the Subsurface Source Area

Use only the depth to the top of the ground water source area (L_{gw}), the thickness of the capillary fringe (h_{cap}), and the width of the source area (W) parallel to the ground water flow direction to calculate VF_{wamb} . Calculate the thickness of the vadose zone below the ground surface (h_v) by subtracting the thickness of the capillary fringe. If site-specific input parameter values are not determined, then use the values in the Default Parameters section in this Appendix.

2. Characteristics of the Subsurface Soil

You may use the site-specific characteristics of the subsurface soil in the vadose zone, between the top of the source area and the ground surface, if sufficient data are collected to demonstrate that these values present the soil within this zone. You may modify these site-specific subsurface soil characteristics:

- Volumetric water content in the vadose zone (Θ_{ws});
- Volumetric air content in the vadose zone (Θ_{as});
- Total soil porosity in the vadose zone (Θ_t);
- Volumetric water content in the capillary fringe (Θ_{wcap});
- Volumetric air content in the capillary fringe (Θ_{acap}).

Since the sum of the Θ_{ws} and the Θ_{as} must equal the Θ_T and the sum of the Θ_{wcap} and the Θ_{acap} must equal the Θ_T , any changes to one of these values must be reflected by changes in the other two values.

3. Wind Speed above Ground Surface in Ambient Mixing Zone

You may determine the wind speed (U_{air}) above the ground surface (i.e., in the ambient mixing zone) based on the surrounding area and site-specific information. If a site-specific U_{air} is not determined, then use a wind speed of 225 cm/sec.

Fate and Transport in Ground water

When considering a migration of COCs in the ground water, use fate and transport modeling to calculate COC concentrations at various distances from the source. During a Tier 2 Evaluation, use a relatively simple, one-dimensional analytical solution, such as the USEPA's Bioscreen model (based on the transport equation developed by P. A. Domenico).

Assumptions

When using the Domenico solution, remember that it is based on the following assumptions:

- 1-dimensional ground water flow along the centerline of the plume;
- Steady state source concentration;
- Finite size source;
- First-order decay;
- Uniform and constant aquifer properties;
- 3-D dispersion within the plume.

Algorithms

The following equation defines the maximum COC concentration allowable in the ground water at the source area ($SSTL_{source_area}$) for meeting the action level or SSTL at the point of exposure:

$$SSTL_{source_area} = \frac{AL_{poe}}{DAF_{gw}}$$

Equation F-36 Maximum Concentration at Source Area to Meet SSTL or Action Level at the Point of Exposure

The AL_{poe} is the action level or SSTL applied at the point of exposure.

The DAF_{gw} is the dilution attenuation factor calculated by the Domenico solution:

$$DAF_{gw} = EXP \left\{ \frac{sPod}{2 \times Ldisp} \left[1 - \sqrt{1 + \left(\frac{4 \times \text{deg rade}_{lo} \times Ldisp \times Rf}{V_{seep}} \right)^2} \right] \right\} \times ERF \left[\frac{GWSource}{4 \times \sqrt{Tdisp \times sPod}} \right] \times ERF \left[\frac{GDSource}{2 \times \sqrt{Vdisp \times sPod}} \right]$$

Equation F-37 Dilution Attenuation Factor

Calculate the retardation factor (Rf) with the following equation:

$$Rf = 1 + \frac{Rhobsat \times FOC_{gw} \times Koc}{PorSat}$$

Equation F-38 Retardation Factor

Use the follow equation to derive the seepage velocity (V_{seep}):

$$V_{Seep} = \frac{K_{ssat} \times I_{grad}}{PorSat}$$

Equation F-39 Seepage Velocity

Input Parameters

Here are the input parameters for the Domenico solution:

Variable	Description	Units	Value
Koc	Organic carbon partitioning factor	ml/g	Chemical of concern specific
Rhobsat	Soil bulk density in saturated zone	g/cm ³	Site-specific
Porsat	Total soil porosity in the saturated zone	cm ³ /cm ³	Site-specific
F _{oc} sat	Fraction organic carbon in saturated zone	g-oc/g soil	Site-specific
GWSource	Width of source area parallel to ground water flow direction	cm	Site-specific
GDSource	Depth of source area parallel to ground water flow direction	cm	Site-specific
Ldisp	Longitudinal dispersivity	cm	Ldisp = 0.1 × sPod

Variable	Description	Units	Value
Tdisp	Transverse dispersivity	cm	$Tdisp = 0.33 \times Ldisp$
Vdisp	Vertical dispersivity	cm	$Vdisp = 0.05 \times Ldisp$
SPod	Saturated zone distance from source area to point of exposure	cm	Site-specific
Vseep	Seepage velocity (See Equation 39)	cm/sec	Site-specific
Degrade_lo	Degradation rate at low end of range	1/day	Chemical of concern specific
Igrad	Ground water gradient	cm/cm	Site-specific
Kssat	Saturated hydraulic conductivity of saturated zone	cm/sec	Site-specific

Input Parameters That Are Default Parameters

When calculating the dilution attenuation factor DAF_{gw} for the $SSTL_{source_area}$, use the following default input parameter values:

- The COC-specific input parameter values (Koc , $degrade_lo$).

See the Default Parameters section of this Appendix for COC-specific input parameter values. If a COC-specific input parameter value is not provided, then use another publicly available reference.

Input Parameters That May Be Site-Specific

All other input parameters may be site-specific.

References

American Society for Testing and Materials (ASTM). *Standard Guide for Risk-Based Corrective Action at Petroleum Release Sites*, ASTM Designation E: 1739-95, ASTM, Conshohocken, PA.

Charbeneau, R.J., 2000. *Ground Water Hydraulics and Pollutant Transport*, Prentice Hall, Upper Saddle River, NJ.

Cowherd, C., Muleski, G. E., Englehart, P. J., Gilbert, D. A., 1985. *Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination Sites*, Midwest Research Institute, PB85-192219.

Domenico, P.A., 1987. "An Analytical Model for Multidimensional Transport of a Decaying Contaminant Species", *Journal of Hydrology*.

Green, W. II., Ampt, G.A., 1911. "Studies in Soil Physics I: The Flow of Air and Water through Soil", *Journal of Agricultural Science*, 4:1-24.

Johnson, P.C. Ettinger, R.A., 1991. "Heuristic Model for Predicting the Intrusion Rate of Contaminant Vapors into Buildings", *Environmental Science and Technology*, 25(8): 1445-1452.

Johnson, P.C., Hertz, M.B., Byers, D.L., 1990. "Estimates for Hydrocarbon Vapor Emissions Resulting from Service Stations Remediations and Buried Gasoline-Contaminated Soil", *Petroleum Contaminated Soil*, 3:295-326, Lewis Publishers, Chelsea, MI.

Jury, W.A., Spencer, W.F., Farmer, W.J., 1983. "Behavior assessment Model for Trace Organics in Soil: I, Model Description," *Journal of Environmental Quality*, 12:558-564.

Millington, R.J., Quirk, J.M., 1961. "Permeability of Porous Solids", *Transactions of the Faraday Society*, 57:1200-1207.

USEPA (Environmental Protection Agency), 1988. *Superfund Exposure Assessment Manual*, EPA/540/1-88/001, USEPA, Washington, DC.

USEPA, 1989. *Risk Assessment Guidance for Superfund, Vol. 1: Human Health Evaluation Manual*, Part A, EPA/540/1-89/002, USEPA, Washington, DC.

Appendix G BUSTR Sensitive Areas

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Introduction

The Bureau of Underground Storage Tank Regulations (BUSTR) rules define certain parts of Ohio as “Sensitive Areas” and establish technical standards for underground storage tanks (USTs) in those areas. Proximity to drinking water sources is the main criterion for designating areas as sensitive.

Defining Sensitive Areas

Ohio Administrative Code (OAC) rule 1301:7-9-09 defines these sensitive areas:

- 1) Located within 50 ft. of a private water supply well or developed spring not located on the same site as the UST system;
- 2) Within 200 ft. of a lake or reservoir with an average surface area of at least 5 acres;
- 3) Located within 100 ft. of a man-made underground structure, tunnel or cavity used primarily for pedestrian traffic or passenger-carrying vehicles;
- 4) Within a semi-circular arc 1,000 ft. upstream of a public water supply water intake, where the base line of the half-circle is perpendicular to the stream at the intake (unless the UST owner or operator demonstrates that the system is located in a drainage area downstream of the intakes);
- 5) Located within one of the following and is not located on the same site as the UST system:
 - 100 ft. horizontal of a water supply well designated by Ohio Environmental Protection Agency (OEPA) as a public water supply and which has a net production rate of less than or equal to 10,000 gal./day; or
 - 200 ft. horizontal of a water supply designated by OEPA as a public supply and which has a net rate of greater than 10,000 gallons per day to less than or equal to 50,000 gal./day; or
 - 300 ft. horizontal of a water supply designated by OEPA as a public water supply and which has a net production rate of greater than 50,000 gal./day.
- 6) Areas associated with sole-source aquifers as defined by USEPA. Parts of the following counties are affected by this provision of the rule:
 Allen, Auglaize, Butler, Champaign, Clark, Clermont, Green, Hamilton, Logan, Mercer, Miami, Montgomery, Ottawa (Catawba Island only), Preble, Putnam, Shelby, Van Wert, and Warren.

OAC rule 1301:7-9-09(B) defines certain sensitive areas associated with sole-source aquifers in these counties by reference to township sections and/or survey tracts. To determine if an UST is located within one of these sensitive areas, check the property

deed or survey to identify the township section(s) and/or survey tract(s) where the UST is located. Then reference the appropriate county in OAC rule 1301:7-9-09(B) to see if the UST is located in one of the township section(s) and/or survey tract(s) listed as a sensitive area. If you are unable to find the number of the township section(s) and/or survey tract(s) for the property in question, consult Sensitive Area Maps prepared by BUSTR and the Ohio Department of Natural Resources. You can purchase these maps at the BUSTR office.

Appendix H Petroleum Contaminated Soil

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Introduction

Ohio Administrative Code (OAC) 1301:7-9-16 and 17 (effective January 23, 1995) rules govern petroleum-contaminated soil (PCS) generated from underground storage tanks (UST) regulated by BUSTR. These PCS rules, updated in 1999, correspond to the 1999 Corrective Action rule (OAC 1301:7-9-13). Rule 16 establishes standards for reporting, characterizing, storing, transporting, handling, treating, disposing of, and re-using PCS. Rule 17 establishes standards for sampling and analyzing excavated soil. To fully comply with these rules, you must read and meet the requirements in OAC 1301:7-9-16 and -17.

Soil Regulated by the PCS Rules

The PCS rules apply to soil generated at petroleum UST sites regulated by BUSTR under OAC Chapter 1301:7-9. PCS may be generated during the following activities:

- UST removals;
- UST upgrades;
- Soil boring and monitoring well installations;
- Immediate and interim response actions;
- Corrective action activities (e.g., excavating, remedial system trenching).

Manage excavated soil as PCS (unless otherwise proven), and sample and analyze the soil according to the analytical methods prescribed in PCS rules. The minimum number of samples needed to characterize excavation soil is shown in Table H-1. Assume that the soil is PCS if the laboratory analysis reveals that petroleum contamination exceeds the action levels. (See Table H-2: Re-Use of Excavated Soil.) If soil analysis reveals results at or below the action levels in Table H-2, the soil is not considered PCS and its use is not regulated by BUSTR.

Soil Exempt from the PCS Rules

Soil generated from the tanks listed in Section 1.0 of this Technical Guidance Manual (TGM) is exempt from the PCS rules.

The following PCS situations are exempted from the PCS rules because their petroleum contamination did not originate from the UST systems:

- Automobile and combustion engines;
- Rail cars and tanker trucks that have a release during transport;
- Oil/water separators

- Petroleum dispensers above the shear valve;
- Industrial processes such as those cutting oils that are part of a flow through process system or an open collection system as a pit or a trench;
- Electric transformers;
- Any source that cannot be attributed to an UST system regulated by BUSTR under OAC Chapter 1301:7-9.

Responsibility for Complying with the PCS Rules

An owner and/or operator (O/O) who generates soil from any activity associated with a regulated UST system must comply with the PCS rules.

Evaluating Excavated Soil

You must sample soil within 48 hrs. of completing an excavation. Sampling methods are prescribed in PCS rule 17. If all excavated soil is transported to a licensed disposal facility, then the soil must be sampled and analyzed according to both BUSTR rules and the facility's requirements. PCS rule 17 allows for segregating the soil based on the "apparent degree of contamination." By segregating the soil into separate piles (i.e., clean or contaminated), you may be able to reduce the amount of soil disposed of or treated. However, all piles must be sampled and analyzed. In situations when 2 or more laboratory results are required from 1 soil pile, use the highest result to determine the proper disposition for the entire stockpile.

Additionally, an O/O must determine whether the soil is PCS or a hazardous waste. To evaluate whether or not soil is a hazardous waste, contact the Ohio Environmental Protection Agency (OEPA) Division of Hazardous Waste Management regarding Ohio's hazardous waste regulations.

Calculating Stockpile Volume

Use one of the following methods for calculating stockpile volume:

Method 1 (Rectangular Shape)

- Measure the size of the excavation;
- Calculate the total volume of material removed from the cavity (yd³);
 - Length x width x depth = volume of cavity;
- Calculate the total volume of the USTs in yd³.
- Subtract the total volume of all USTs removed from the excavation;
 - Volume of cavity – total volume of all USTs = volume of stockpile;
- Total volume removed x 1.25 (expansion factor) = total stockpile volume.

Conversion Factors

$$27 \text{ ft}^3 = 1 \text{ yd}^3$$

$$1 \text{ U.S. gal} = 0.1337 \text{ ft}^3$$

$$1 \text{ U.S. gal} = 0.00495 \text{ yd}^3$$

Method 2 (Conical Shape)

- Calculate the stockpile volume based on its shape and convert to yd³;
- Volume = radius in ft. at the base of the stockpile (squared) x height of the stockpile.
- Volume in yd³ = volume in ft³ divided by 27.

Determining the Number of Samples to Collect

Step 1

After calculating the volume of the soil stockpile, use Table H-1 (below) to determine the number of soil samples to collect, field screen, and submit to the laboratory for analysis.

Step 2

To determine the locations of the samples to be collected, visually divide the stockpile into sections equal to the number of soil samples required in Row 1 of Table H-1. Collect individual soil samples from the center of each section, at a minimum depth of 12 in. below the surface of the stockpile.

Table H-1 – Stockpile Sampling Requirements

	<i>Cubic yards of soil generated</i>				
	0-25	26-100	101-500	501-1000	>1000
1. Minimum number of grab samples to collect and field screen	2	6	8	10	10 + 1 sample per each additional 100 yd ³ (or fraction thereof)
2. Minimum number of grab samples to submit to the laboratory if field screened	1	1	2	3	4 + 1 sample per each additional 500 yd ³ (or fraction thereof)

Step 3

If field screening the stockpile (per the procedures outlined in Appendix A), you must submit for laboratory analysis the highest field screened samples corresponding to the appropriate number in Row 2 of Table H-1.

If field screening is not conducted, you must submit all samples for laboratory analysis.

Evaluating the Analytical Results

Action levels for stockpiled soil are obtained from OAC 1301: 7-9-13 and the Re-Use of Excavated Soil levels. (See Table H-2.)

- If the concentration for any analyte (e.g., benzene, toluene) **exceeds** the site action level, further treatment/disposal is required:
- If the analytical results for all analytes are **below** the action levels in Rule 13, but above the Re-Use levels, then no additional treatment is required, if returned to the excavation. However, you must cover the soil with a minimum of 1 ft. of clean soil.
- If soil will be spread above ground on-site for cover, the PCS must be at or below the Re-Use of Excavated Soil levels in Table H-2.

Table H-2 Re-Use of Excavated Soil

Chemical of Concern	Action Level
Benzene	.015 PPM
Toluene	5.86 PPM
Ethyl-benzene	7.11 PPM
Total Xylenes	72.4 PPM
Methyl Tertiary Butyl Ether (MTBE)	.053 PPM
Benz (a) – anthracene	5.50 PPM
Benzo (a) – pyrene	.550 PPM
Benzo (b) – fluoranthene	5.50 PPM
Benzo (k) – fluoranthene	1.97 PPM
Chrysene	1.27 PPM
Dibenz (a, h) – anthracene	.550 PPM
Indeno (1, 2, 3 – cd) pyrene	.150 PPM
Naphthalene	127 PPM

PCS Storage

The O/O may choose to store PCS either on or off the UST site. Once excavated, you may store PCS on-site in properly-labeled, portable containers for no more than 180 days, or in properly protected stockpiles for no more than 90 days. You may store PCS off-site, for no more than 90 days from the date of excavation.

The O/O must inspect all PCS storage areas monthly for damage to or unauthorized removal of drums, drum lids, labels, covers, berms, fences, barriers or signs used to deter unauthorized entry. You must keep a written log of these inspections and be able to produce it within 24 hrs., if requested by BUSTR. As O/O, you must also maintain for 1 yr. a record of the estimated excavated soil volume being stored and the date the soil was originally containerized or placed in a stockpile.

Options Available for PCS Treatment

As O/O, you may choose to remediate PCS either on- or off-site. PCS with Analytical Group 3 contaminants cannot be land farmed. However, the rule contains treatment techniques that may be cost-effective alternatives to landfilling, (e.g., involving soil placed upon controlled treatment

zones where natural or enhanced biodegradation and volatilization remediates the soil). Treating soil this way is limited to land that is not open to the public. On-site treatment is limited to any contiguous parcels of land owned or under the control of the UST O/O. Off-site treatment must occur at a “designated facility,” defined as land not open to the public, and which is owned or under the control of the UST O/O.

Prior to treatment, BUSTR must receive written notification of your proposed treatment method, along with a diagram of important features of the property (e.g., boundaries, set backs, well locations). Unless the one-time land farming method is used, you must demonstrate through sampling and analysis that contamination has been reduced below the levels listed in the Re-Use of Excavated Soil table (H-2), within 24 mo. of beginning treatment.

Obtain any necessary air and/or wastewater permits from OEPA prior to initiating any of the treatment options listed below. In addition to the BUSTR and OEPA requirements, other local, regional, state, or federal requirements may affect managing the PCS. The UST O/O must contact all relevant government agencies and satisfy their requirements.

Treatment options described in detail in the PCS rules include on- or off-site:

- One-time land farming;
- Multiple application land farming;
- Confined treatment area or process.

In general, the criteria for off-site treatment methods are more restrictive than for on-site methods. Beyond the treatment methods specified in the PCS rules, you may use alternate techniques if you can demonstrate to BUSTR that the technique is at least as safe and effective as those specified in PCS rule 16. Upon written approval from BUSTR, you may use technologies such as thermal treatment, road base and asphalt batching, and soil washing for cleanup.

Appendix I Checklists and Forms

Table of Contents

Checklists and forms are in this order:

- Closure Form
- Petroleum Contaminated Soil (PCS) Form
- BUSTR Soil Classification Form
- Immediate Response Actions Checklist
- Suspected Release Investigation (Site Check) Checklist
- Free Product Removal Checklist
- Tier Evaluation Notification Checklist
- Interim Response Actions Notification Checklist
- Tier 1 Evaluation Checklist
- Tier 2 Evaluation Checklist
- Remedial Action Plan Checklist

Introduction

This Appendix includes checklists and forms that should be included with the appropriate reports and notifications required by Ohio Administrative Code (OAC) rules 1301:7-9 (12 and 13). They appear in the order shown above.

Closure Form

Owner/Operator and Facility Data:

Owner/Operator Information:

Name: _____
 Address: _____
 City, State: _____
 Zip: _____
 Contact Person: _____
 Phone #: _____
 Permit #: _____

Facility Information:

Name: _____
 Address: _____
 City: _____
 County: _____
 Operator: _____
 Phone #: _____
 Facility ID#: _____
 Fire Department: _____
 FDID #: _____

Site History and Visual Site Evaluation:

Underground Storage (UST) System Data:

Tank	Age	Capacity	Product	Const. Material	Tank Status	Holes Yes/No	Pipe Status	Holes Yes/No	Disp.	Date Removed

*Status= TC-Temporary Closure RE-Replace R-Removed CIU-Currently in Use
 NA-Not Applicable CIS-Change in Service A-Abandoned In Place*

Sample Data:

Sample Collection Procedures:

Sample Preservation: _____

Sampling Equipment: _____

Sampling Method: _____

Field Screening:

Instrument Used: _____

Methodology Used _____

Calibration Procedures:

Name and Affiliation of Person Collecting Samples: _____

Attach copies of the Chain-of-Custody and the Laboratory Data Sheets

Laboratory Data:

Laboratory Name: _____
 Address: _____
 Phone #: _____
 Laboratory Analyst Name: _____
 Date Samples Received by Lab: _____
 Date Samples Analyzed by Lab: _____

Excavation Analytical Results:

Sample ID:	Water	Soil	Soil	Soil	Soil	Soil	Soil	

Chemical Of Concern:								Test Method
Benzene								
Toluene								
Ethylbenzene								
Total xylenes								
MTBE								
Benzo (a) anthracene								
Benzo (a) pyrene								
Benzo (b) fluoranthene								
Benzo (k) fluoranthene								
Chrysene								
Dibenz (a,h) anthracene								
Indeno (1,2,3,-cd) pyrene								
Napthalene								
TPH (C10-C20)	N/A							
TPH(C20-C34)	N/A							
Other :								

If action levels are exceeded, conduct a Tier 1 investigation according to OAC 1301:7-9-13(h).

Stockpile Analytical Results:

Stockpile ID:								
Cubic Yards:								
Stockpile Disposition*								

*R=Returned to cavity L=In landfill S=In stockpile T=Treated by O/O

CHEMICAL OF CONCERN:

Benzene								
Toluene								
Ethylbenzene								
Total xylenes								
Mtbe								
Benzo (a) anthracene								
Benzo (a) pyrene								
Benzo (b) fluoranthene								
Benzo (k) fluoranthene								
Chrysene								
Dibenz (a,h) anthracene								
Indeno (1,2,3,-cd) pyrene								
Napthalene								
TPH (C10-C20)								
TPH(C20-C34)								
Other :								

Waste Disposal Data:

UST System Disposition:

Name: _____
 Address: _____
 City/State/Zip: _____

Product Disposition:

Name: _____
 Address: _____
 City: _____
 State/Zip: _____
 Volume/Gallons: _____

Wastewater Disposition:

Name: _____
 Address: _____
 City: _____
 State/Zip: _____
 Volume/Gallons: _____

Complete the Petroleum Contaminated Soil (PCS) Form. (See Closure Packet, call SFM/BUSTR, or visit our web site.)

Attach the PCS laboratory data sheets to the PCS Form.

Miscellaneous Data:

Submit (i.e., attach to this report) additional information that clarifies closure activities.

Copy of Permit and Field Inspection Report:

Must be attached

Site Map: Attach site maps drawn to scale. Maps should include property boundaries, street locations, underground storage tank (UST) cavity dimensions, above ground structures, UST systems, adjacent properties, sample locations, water wells within 2000 ft. of the site, any utilities, and the location(s) of previously closed UST systems.

Certified Fire Safety Inspector:

Name: _____

Company/FD: _____

Address: _____

Phone #: _____

Inspector ID#: _____

Certified Installer:

Name: _____

ID#: _____

The UST O/O must sign the Closure Form. The O/O must ensure that all data are accurate, and the closure form is legible and complete.

Owner/Operator Signature: _____

Print Name: _____

Date: _____

Petroleum Contaminated Soil (PCS) Form

Complete and submit within 90 days of generating a stockpile, within 180 days of placing the soil in portable containers, or prior to treatment, whichever comes first.
Complete a separate PCS Form for each stockpile generated.

Owner/Operator Information:

° Owner/Operator Name		Contact Person	Area Code-Telephone No.
City		State	Zip Code
Facility Information Facility ID#:		Facility Where Soils Will Be Disposed of or Treated:	
Facility Name		Facility Name	
Address		Address	
City	State	Zip Code	City State Zip Code
Telephone	County	Stockpile Designation (e.g., Pile #1, from waste oil cavity)	

Date stockpile was generated: _____

- | <u>Cubic Yards</u> | (Check applicable) |
|--|------------------------------|
| _____ One time land farming (OTL)..... | _____ on-site _____ off-site |
| _____ Multiple application land farming (MAL)..... | _____ on-site _____ off-site |
| _____ Confined treatment area process (CAT)..... | _____ on-site _____ off-site |
| _____ Alternative treatment method (ALT)..... | _____ on-site _____ off-site |
| _____ Soil analysis falls below Rule 16 re-use levels (RUL)..... | _____ on-site _____ off-site |
| _____ Returned to excavation (below site specific action levels) (RTE BAL) | |
| _____ Returned to excavation (above site specific action levels) (RTE AAL) | |
| _____ Disposal at a landfill (LFL) | |
| _____ Disposal at a treatment facility (COM) | |
| _____ Stockpile remains on-site (provide written explanation) (SOS) | |

If the Owner/Operator Will Be Treating the PCS:
--

Complete this page and provide the following:

1. Map of the location where treatment will take place. The map should depict property boundaries, street locations, above ground structures, etc. (See Ohio Administrative Code (OAC) 1301:7-9-16.)

2. Brief description of the treatment method to be used (include additional pages if needed)

3. Signed waiver form from off-site owner pursuant to OAC 1301:7-9-16 as provided by the State Fire Marshal if any of the following apply:

- Off-site treatment less than 100 ft. from off-site domicile;
- On-site treatment less than 50 ft. from off-site domicile;
- One time land farming less than 50 ft. from off-site domicile.

4. Written statement signed by the UST owner or operator and sworn to or acknowledged by the ust owner or operator before a notary public:

"I state under penalty of perjury that to the best of my knowledge and belief: (please check one)

_____ the on-site treatment at the UST site described above

_____ the off-site treatment at the location described above

Has and shall be conducted according to all applicable provisions of Chapter 1301:7-9 of the OAC, including, but not limited to, OAC rules 1301:7-9-16 and 1301:7-9-17."

Owner/Operator's name _____ Signature _____ Date _____
(Typed or printed)

Subscribed and duly sworn before me according to law, by the above named applicant
this _____ day of _____, 20____ at _____,

County of _____ and State of _____

Signature of notary public _____

Official _____ Title _____

BUSTR Soil Classification Form

Major Divisions		Letter Symbol	Typical Description	BUSTR Class
Coarse Grained Soils (More than 50% of material is GREATER than #200 sieve)	Gravel and Gravelly Soils (More than 50% of coarse fraction RETAINED on #4 sieve)	Clean Gravels (Little or no fines)	GW Well-graded gravels, gravel-sand mixtures, little or no fines	Sand/ Gravel Soil
		Gravels With Fines (Appreciable amount of fines)	GP poorly-graded gravels, gravel-sand mixtures, little or no fines	
			GM Silty gravels, gravel-sand-silt mixtures	
		Sand and Sandy Soils (More than 50% of coarse fraction PASSING on #4 sieve)	Clean Sand (Little or no fines)	
	SP Poorly-graded sands, gravelly sands, little or no fines			
	Sands with Fines (Appreciable amount of fines)		SM Silty-sands, sand-silt mixtures	
			SC Clayey sands, sand-clay mixtures	
	Fine Grained Soils (More than 50% of material is SMALLER than #200 sieve)	Silts and Clays Liquid limit <50	ML Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity	
CL Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays				
OL Organic silts and organic silty clays of low plasticity				
Silts and Clays Liquid limit >50		MH Inorganic silts, micaceous or diatomaceous fine sand or silty soils	Clay/ Silt Soils	
		CH Inorganic clays of high plasticity, fat clays		
		OH Organic clays of medium to high plasticity, organic silts		
Highly Organic Soils		PT Peat, humus, swamp soils with high organic contents		

Pathway	Symbol	Pathway	Symbol
Direct contact with soil		GW to indoor air	
Soil to DW leaching		GW ingestion	
Soil to indoor air		Soil to non-DW leaching	

I have inspected the soil at: _____ Ohio.

(Address) (city)

Name (Printed): _____ Date: _____

(Name of Classifier, Title, Firm Name)

Signature: _____

Immediate Response Actions Checklist

Submit to BUSTR within 20 days of discovering or confirming the release.

Contact Person: _____

Phone Number: _____

Facility Name: _____

Facility Address: _____

County: _____

Facility Number: _____

Site Longitude/Latitude: _____

Indicate page number for each item below.

Overview of the release scenario and any immediate response action measures:

_____ Date and time when release was discovered and reported to BUSTR;

_____ Person who discovered and reported the release to BUSTR;

_____ Type of product released and the approximate volume;

_____ Relative location and media(s) affected;

_____ Description of the UST system and status;

_____ Description of all Immediate Response Action activities completed;

_____ Description of other Immediate Response Action activities planned;

_____ Other information that may assist BUSTR in investigating the release;

_____ Site map, plans, photographs, etc.;

_____ The amount and disposition of any materials generated (e.g., soil and liquids), including any supporting documentation (e.g., copies of disposal receipts).

Preparer Name _____

Preparer Signature _____ Date _____

O/O Name _____

O/O Signature _____ Date _____

Suspected Release Investigation (Site Check) Checklist

Submit to BUSTR within 60 days of reporting release.

Contact Person: _____
 Phone Number: _____
 Facility Name: _____
 Facility Address: _____

 County: _____
 Facility Number: _____
 Site Longitude/Latitude: _____

Indicate page number for each item below.

Suspected Release Investigations Must Include:

- Tank tightness test if underground storage tank(s) (USTs) on property:
 _____ TTT performed on _____ (within 7 days of the suspected release);
 _____ TTT submitted on _____ (within 10 days of release).
- Drinking water well analysis if impact suspected:
 _____ Drinking water well sampled on _____ (within 3 days of suspected release);
 _____ Drinking water analysis reported to BUSTR on _____ (within 24 hours);
 _____ Drinking water analysis submitted to BUSTR on _____ (within 7 days).

Site Check Report Must Include:

- _____ Nature of the suspected release;
- _____ Brief description of the property and UST ownership;
- _____ Overview of activities to date; if free product encountered, submit FPR reports;
- _____ Explanation of why soil boring or trenching option and locations were chosen;
- _____ If trenching chosen, name of BUSTR personnel who approved the option;
- _____ Description of how the trenches or borings were installed;
- _____ Diagrams of all trenches or borings, including sample locations and logs;
- _____ Description of subsurface conditions, including whether water was encountered;
- _____ Description of the sampling methodology;
- _____ Area map and site plan;
- _____ Soil and water field screening, and analytical results in table format;
- _____ Conclusions and recommendations;
- _____ All applicable attachments (e.g., data sheets, logs, lab report, disposal documentation).

Preparer Name _____

Preparer Signature _____ Date _____

O/O Name _____

O/O Signature _____ Date _____

Free Product Removal (FPR) Checklist

Submit the initial FPR Report to BUSTR within 20 days of beginning FPR and monthly thereafter.
(If the FPR is terminated, declare it in a FPR Report.)

Contact Person: _____
 Phone Number: _____
 Facility Name: _____
 Facility Address: _____

 County: _____
 Facility Number: _____
 Site Longitude/Latitude: _____

Indicate page number for each item below.

_____ Date and time of free product discovery _____

_____ Verbal notification to BUSTR on _____ (within 24 hours of initiation)

_____ Initial FPR Report submitted to BUSTR on _____ (within 20 days of initiation)

FPR Report Must Include:

- _____ Overview of activities leading to the discovery of free product
- _____ Name, address and phone number of the person responsible for FPR activities
- _____ Details of the FPR system (drawing, location, discharge, operations, effluent)
- _____ Copies of installation, operation, treatment/discharge permits applied for/granted
- _____ Mention of any FPR system malfunctions (verbally to BUSTR within 24 hours)
- _____ Product thickness in wells, boreholes, and excavations
- _____ Depth to water in wells, boreholes, and excavations
- _____ Quantity of free product (in gallons) recovered per month and to date
- _____ Quantity of water discharged per month and to date
- _____ Disposition of the recovered product
- _____ Disposition of recovered water (if applicable).
- _____ List of attachments containing additional information (e.g., lab reports, logs).

Preparer Name _____ Preparer Signature _____ Date _____

O/O Name _____ O/O Signature _____ Date _____

Tier Evaluation Notification Checklist

Submit to BUSTR within 180 days of a confirmed release.

Contact Person: _____
 Phone Number: _____
 Facility Name: _____
 Facility Address: _____

 County: _____
 Facility Number: _____
 Site Longitude/Latitude: _____

Indicate page number for each item below.

Tier 1 decisions.

Chemicals of Concern (COC) Determination:

_____ Analytical Group 1 (i.e., gasoline, aviation gasoline);
 _____ Analytical Group 2 (i.e., diesel, kerosene, stoddard solvent, jet fuel);
 _____ Analytical Group 3 (i.e., used oil, new oil, unknown).
 • Depth to ground water (in feet):
 _____ <15 _____ 15-30 _____ 30-50 _____ >50.

Soil Type:

_____ Sand/gravel;
 _____ Silty/clayey sands;
 _____ Clay/silt.

Action Level Category Determination:

_____ Drinking water;
 _____ Non-drinking water;
 _____ Not ground water.

Additional Required Information:

_____ Laboratory data;
 _____ Boring logs/well construction diagrams;
 _____ Ground water flow direction;
 _____ Site map;
 _____ Site longitude and latitude;
 _____ Site history;
 _____ Land use determination:
 _____ Source area identified;
 _____ Geologic and hydrogeologic characteristics of the site and surrounding area;
 _____ Immediate response actions;
 _____ Interim response action (IRA).

Preparer Name _____ Preparer Signature _____ Date _____
 O/O Name _____ O/O Signature _____ Date _____

Interim Response Action Notification Checklist

Submit to BUSTR 10 days prior to initiating IRA.

Contact Person: _____
 Phone Number: _____
 Facility Name: _____
 Facility Address: _____

 County: _____
 Facility Number: _____
 Site Longitude/Latitude: _____

Indicate page number for each item below.

IRA Report Must Include:

_____ Description of IRA;**
 _____ Anticipated length of time to complete IRA;**
 _____ Site map indicating limits of proposed excavation (if applicable);
 _____ Anticipated volume of soil to be removed in cubic yards (if applicable);**
 _____ Proposed confirmatory sampling plan (if applicable).

** Obtain prior approval from BUSTR if:

- The total volume of soil is estimated to exceed 800 yd³;
- The anticipated time for completion is greater than 3 mo.;
- More than 1 (one) IRA must be conducted during any tier evaluation.

Preparer Name _____

Preparer Signature _____ Date _____

O/O Name _____

O/O Signature _____ Date _____

Tier 1 Evaluation Checklist (Page 1 of 4)

Submit within 180 days of confirmed release, unless moving to Tier 2.

Contact Person: _____
 Phone Number: _____
 Facility Name: _____
 Facility Address: _____

 County: _____
 Facility Number: _____
 Site Longitude/Latitude: _____

Indicate page number for each item below.

Describing the UST Site:

Include current and historical descriptions of the UST site and surrounding area:

- _____ Applicable 7.5 Min. U.S. Geological Service quadrangle map including the UST site location; map number, longitude, latitude, and location of the quadrangle within the state boundaries;
- _____ Site and surrounding area map;
- _____ Site map;
- _____ Regional geology and hydrogeology; documentation of all information sources, including site cross-sections based on boring logs;
- _____ Information on current UST systems at the site or out-of-service UST systems still existing on the UST site, including age, materials of construction, size, contents, and available precision test results;
- _____ Any immediate response actions performed, including free product removal, soil excavation, and any actions taken to abate vapors or address safety concerns; include date(s) of each action, methods/techniques used, amount of material recovered, and current or most recent UST site conditions;
- _____ Appropriate documentation of recycling or disposal of any material recovered, including sampling data, analytical data, and lists summarizing the disposal manifests and weigh tickets.

Collecting Data:

Summarize data collection activities and the resulting data, including, as appropriate (See Appendix B for additional information on data presentation):

- _____ A summary of the rationale for sampling and testing activities;
- _____ Sample location map.

Tier 1 Evaluation Checklist (Page 2 of 4)

Field methodologies employed including instrument calibration techniques, including the make and model of equipment used;

_____ Documentation from soil boring logs/well construction diagrams, including the type of sampler used (e.g., Shelby tube, California sampler, split-spoon):

- COCs identified by field readings and visual techniques (no olfactory techniques should be used);
- Depth at which saturated conditions were first encountered during drilling and the depth of the static water level;
- Complete description of the soil sample for each interval including moisture content, color, gradation consistency, denotation of horizontal and/or vertical fracturing, type and description of bedrock with differentiation between weathered and competent bedrock, denotation of any voids or significant pressure changes observed (in rock drilling), and graphic illustration of each interval;
- Denotation of which soil sample interval(s) were sent to the laboratory for analysis;
- Sample recovery for each interval.

_____ Well sampling and development logs, including the number and quantity of well purging volumes, purging conditions, date, time, and duration of collection and development;

_____ Ground water elevations and free product thickness namely:

- Depth-to-fluid, depth-to-water, free product thickness measurements, and top-of-casing and groundwater elevations in tabular form for each well; when available, include historical data in the table and reference the source(s) of all information presented
- Corrected ground water elevations for free product thickness per American Petroleum Institute (API) Publication 1628.

_____ Ground water elevations:

- Potentiometric surface map using all relevant monitoring wells to establish ground water contour and flow direction; clearly indicate the collection date(s) for ground water measurements;
- Justification for the exclusion of specific monitoring wells in determination of flow direction, if any
- The calculation of the hydraulic gradient in an Appendix.

_____ Analytical laboratory results:

- Results in tabular form, by medium; on a separate table, present the most recent results along with historical results, when available; indicate sample collection date(s) and reference source(s) of all data points;
- Include the corresponding method detection limit for each analyte that was below detection limits (i.e., use of NA is not acceptable; show actual detection level);
- Soil and ground water analytical maps.

Tier 1 Evaluation Checklist (Page 3 of 4)

_____ Concentrations of chemical(s) of concern (COCs) including:

- Concentration maps for soil (in mg/kg) and ground water (in µg/L); soil maps must also include sample interval depth, and date of sample collection;
- UST site maps indicating the source area(s) locations, point(s) of exposure and concentrations, and spatial distribution of COCs.

_____ Current & future ground water use determination:

- All water well logs within a 2,000 ft. radius of the UST site;
- References for all information source(s) used to determine the current and future ground water use classification.

_____ Saturated zone characterization tests:

- Documentation of any models and calculations used to evaluate data;
- Test data (include at end of the report).

_____ Geotechnical tests:

- Geotechnical test results for soil properties; present in tabular form referencing the ASTM method used for each test.

Site-Conceptual Exposure Model:
--

Summarize the exposure pathway analysis:

_____ The site conceptual exposure model including current and future land use scenarios;

_____ Land, ground water and surface water use determinations;

_____ Identification of complete exposure pathways to be evaluated in Tier 2 (if applicable);

_____ Results of exposure pathway evaluation:

- Exposure pathway evaluation, including identification of potential receptors, source areas, transport mechanisms, points of exposure, routes of exposure; potential receptors considering current and reasonably potential land use; fully document all information sources;
- Justification of exposure pathway elimination and site-specific exposure duration.

Tier Evaluation:

Summarize Tier 1 evaluation results, including identifying exposure pathways that require further tier evaluation (if applicable):

_____ Discussion of the tier evaluation results, including recommendations for NFA;

_____ Action level determination.

Tier 1 Evaluation Checklist (Page 4 of 4)

- _____ Present action level in tabular form;
 _____ Details of any field vapor sampling (e.g., soil gas survey) or any other investigations to collect site-specific data.

Interim Response Action:

- _____ Summary of any interim response actions including the volume of soil removed or ground water treated.

Tier 1 Evaluation-Conclusions/Recommendations:

- _____ Remedial action, if appropriate (details to be included on the Remedial Action Plan);
 _____ Further tier evaluation (if appropriate);
 _____ Justification for NFA recommendation (if appropriate).

Supporting Information:

Attachments of supporting documentation, including:

- _____ Drilling logs;
 _____ Equipment and standard procedures used;
 _____ Chain-of-custody forms, analytical results, QA/QC procedures, and data quality objectives including all laboratory certificates of analysis (data sheets), completed chain-of-custody forms indicating soil boring/monitoring well numbers and laboratory sample numbers;
 _____ Bibliography of references.

Preparer Name _____

Preparer Signature _____ Date _____

O/O Name _____

O/O Signature _____ Date _____

Tier 2 Evaluation Checklist (Page 1 of 4)

Submit to BUSTR within 2 yrs. of submitting the Tier Evaluation Notification.

Contact Person: _____
 Phone Number: _____
 Facility Name: _____
 Facility Address: _____

 County: _____
 Facility Number: _____
 Site Longitude/Latitude: _____

Indicate page number for each item below.

Describing the UST Site:

Include current and historical descriptions of the UST site and surrounding area as:

- _____ Applicable 7.5 Min. U.S. Geological Service quadrangle map including the UST site location; map number, longitude, latitude, and location of the quadrangle within the state boundaries;
- _____ Site and surrounding area map;
- _____ Site map;
- _____ Site longitude and latitude;
- _____ Regional geology and hydrogeology; documentation of all information sources, including site cross-sections based on boring logs;
- _____ Information on current UST systems at the site or out-of-service UST systems still existing on the UST site, including age, materials of construction, size, contents, and available precision test results;
- _____ Any immediate response actions performed, including free product removal, soil excavation, and any actions taken to abate vapors or address safety concerns; include date(s) of each action, methods/techniques used, amount of material recovered, and current or most recent UST site conditions;
- _____ Appropriate documentation of recycling or disposal of any material recovered, including sampling data, analytical data, and lists summarizing the disposal manifests and weigh tickets.

Collecting Data:

Summarize data collection activities and the resulting data, including, as appropriate (See Appendix B for additional information on data presentation):

- _____ Rationale for sampling and testing activities;
- _____ Sample location map;
- _____ Description of the field methodologies including instrument calibration techniques, and the make and model of equipment used.

Tier 2 Evaluation Checklist (Page 2 of 4)

_____ Field methodologies employed including instrument calibration techniques, including the make and model of equipment used;

_____ Documentation from soil boring logs/well construction diagrams, including the type of sampler used (e.g., Shelby tube, California sampler, split-spoon):

- COCs identified by field readings and visual techniques (no olfactory techniques should be used);
- Depth at which saturated conditions were first encountered during drilling and the depth of the static water level;
- Complete description of the soil sample for each interval including moisture content, color, gradation consistency, denotation of horizontal and/or vertical fracturing, type and description of bedrock with differentiation between weathered and competent bedrock, denotation of any voids or significant pressure changes observed (in rock drilling), and graphic illustration of each interval;
- Denotation of which soil sample interval(s) were sent to the laboratory for analysis;
- Sample recovery for each interval.

_____ Well sampling and development logs, including the number and quantity of well purging volumes, purging conditions, date, time, and duration of collection and development;

_____ Ground water elevations and free product thickness namely:

- Depth-to-fluid, depth-to-water, free product thickness measurements, and top-of-casing and groundwater elevations in tabular form for each well; when available, include historical data in the table and reference the source(s) of all information presented;
- Corrected ground water elevations for free product thickness per American Petroleum Institute (API) Publication 1628.

_____ Ground water elevations:

- Potentiometric surface map using all relevant monitoring wells to establish ground water contour and flow direction; clearly indicate the collection date(s) for ground water measurements;
- Justification for the exclusion of specific monitoring wells in determination of flow direction, if any;
- The calculation of the hydraulic gradient in an Appendix.

_____ Analytical laboratory results:

- Results in tabular form, by medium; on a separate table, present the most recent results along with historical results, when available; indicate sample collection date(s) and reference source(s) of all data points;
- Include the corresponding method detection limit for each analyte that was below detection limits (i.e., use of NA is not acceptable; show actual detection level);
- Soil and ground water analytical maps.

Tier 2 Evaluation Checklist (Page 3 of 4)

_____ Concentrations of chemical(s) of concern (COCs) including:

- Concentration maps for soil (in mg/kg) and ground water (in µg/L); soil maps must also include sample interval depth, and date of sample collection;
- UST site maps indicating the source area(s) locations, point(s) of exposure and concentrations, and spatial distribution of COCs.

_____ Current & future ground water use determination:

- All water well logs within a 2,000 ft. radius of the UST site;
- References for all information source(s) used to determine the current and future ground water use classification;

_____ Saturated zone characterization tests:

- Documentation of any models and calculations used to evaluate data;
- Test data (include at end of the report).

_____ Geotechnical tests:

- Geotechnical test results for soil properties; present in tabular form referencing the ASTM method used for each test.

Site-Conceptual Exposure Model:
--

Summarize the exposure pathway analysis:

_____ The site conceptual exposure model including current and future land use scenarios;

_____ Land, ground water and surface water use determinations;

_____ Identification of complete exposure pathways to be evaluated in Tier 2 (if applicable);

_____ Results of exposure pathway evaluation:

- Exposure pathway evaluation, including identification of potential receptors, source areas, transport mechanisms, points of exposure, routes of exposure; potential receptors considering current and reasonably potential land use; fully document all information sources;
- Justification of exposure pathway elimination and site-specific exposure duration.

Tier Evaluation:

Summarize Tier 1 evaluation results, including identifying exposure pathways that require further tier evaluation (if applicable):

_____ Discussion of the tier evaluation results, including recommendations for NFA;

_____ Action level determination.

Tier 2 Evaluation Checklist (Page 4 of 4)

_____ Discuss the results of the tier evaluation performed, including recommendations for NFA;
 _____ SSTL determination:

- Present action level and SSTL in tabular form;
- Present and document all assumptions, equations, models, literature values, etc. used in determining action levels and SSTL.

_____ Attachments, including descriptions of any models used to evaluate data, providing all assumptions, input parameters, and output values;

_____ Details of any field vapor sampling or any collections of site-specific data;

_____ Discussion of land use/resource use restrictions with source documentation that details the restriction(s).

Interim Response Action:

_____ Summary of any interim response actions, including the volume of soil removed or ground water treated.

Tier 2 Evaluation-Conclusions/Recommendations:

_____ Remedial action(s), if appropriate (details to be included on the Remedial Action Plan);

_____ Discussion of further tier evaluation, if appropriate (details to be included in the Tier 3 Work Plan);

_____ Summary of appropriate monitoring;

_____ Justification for NFA recommendation (if appropriate).

Supporting Information:

Attach the appropriate supporting documentation, including:

_____ Printout of BUSTR’s Tier 2 spreadsheet;

_____ Printout of BUSTR’s Tier 2 spreadsheet;

_____ Equipment and standard procedures used;

_____ Chain-of-custody forms, analytical results, QA/QC procedures, and data quality objectives including all laboratory certificates of analysis (data sheets), completed Chain-of-Custody Forms indicating soil boring/monitoring well numbers and laboratory sample numbers;

_____ Bibliography of references.

Preparer Name _____

Preparer Signature _____ Date _____

O/O Name _____

O/O Signature _____ Date _____

Remedial Action Plan (RAP) Checklist (Page 1 of 2)

Contact Person: _____
 Phone Number: _____
 Facility Name: _____
 Facility Address: _____

 County: _____
 Facility Number: _____
 Site Longitude/Latitude: _____

Indicate page number for each item below.

RAP Report Must Include, At a Minimum:

- _____ Summary of the site assessment results and conclusions;
- _____ Table with a complete round of ground water sampling results obtained within 6 mo. prior to submitting the plan (if applicable);
- _____ Description of remedial alternatives considered;
- _____ Description of the remediation techniques to be implemented;
- _____ Description and results of any pilot studies conducted;
- _____ Schematic drawing of the remedial system;
- _____ Detailed diagram of the remedial system placement on-site, including proposed locations of equipment, pumps, recovery systems, etc.;
- _____ Description of permits or other approvals required for implementing the plan;
- _____ Proposed target levels to be achieved;
- _____ Description of a monitoring/sampling plan for use during the RAP implementation, including a site diagram that indicates the sampling locations for soil and/or ground water;
- _____ Implementation schedule and the projected completion date;
- _____ Description of the content and frequency of progress reports (i.e., monthly or quarterly).

Regular Progress Reports:

Upon RAP approval by BUSTR and implementation, RAP Progress Reports must include:

- _____ Status report of the system's performance;
- _____ Site diagram, if the placement of the remedial system is altered from that submitted in the RAP;
- _____ Air, soil and/or water monitoring analysis (i.e., submit in table format);
- _____ Monthly/quarterly quantity and disposition of soil treated and/or removed;
- _____ Monthly/quarterly quantity and disposition of water treated and/or discharged;
- _____ Depth to liquid and thickness of free product (if applicable);
- _____ Quantity and disposition of free product recovered (if applicable);
- _____ Sampling methodology as outlined in Appendix A;
- _____ Any other additional information necessary to evaluate the RAP's effectiveness.

Remedial Action Plan (RAP) Checklist (Page 2 of 2)

Having attained the action levels or SSTL and completing remediation, you must submit to BUSTR a completion report, which includes at a minimum:

- _____ Summary of all remedial activities;
- _____ Tabled or graphical results showing the effectiveness of the RAP over time;
- _____ Table with a complete round of recent ground water and soil sampling in the appropriate locations demonstrating that you have attained acceptable levels
- _____ Complete site map showing all sampling locations;
- _____ Discussion of wastes generated during all remedial activities including cumulative totals and final disposition;
- _____ Other information demonstrating that you have met the RAP's remedial objectives.

If you select monitoring only as a remedial option, you must submit the same sequence of reports as with remedial systems, describing the RAP or techniques replaced by monitoring plans or options, whichever is more appropriate.

Preparer Name _____

Preparer Signature _____ Date _____

O/O Name _____

O/O Signature _____ Date _____



Williams

Fulton

Lucas

Ottawa

Lake

Ashtabula

Defiance

Henry

Wood

Sandusky

Erie

Lorain

Cuyahoga

Geauga

Trumbull

Paulding

Putnam

Hancock

Seneca

Huron

Medina

Summit

Portage

Mahoning

Van Wert

Allen

Wyandot

Crawford

Richland

Ashland

Wayne

Stark

Columbiana

Mercer

Auglaize

Hardin

Marion

Morrow

Holmes

Tuscarawas

Carroll

Jefferson

Shelby

Logan

Union

Delaware

Knox

Coshocton

Harrison

Darke

Miami

Champaign

Franklin

Licking

Muskingum

Guernsey

Belmont

Preble

Montgomery

Clark

Madison

Franklin

Fairfield

Perry

Morgan

Noble

Monroe

Greene

Fayette

Pickaway

Fairfield

Perry

Morgan

Noble

Monroe

Butler

Warren

Clinton

Ross

Hocking

Athens

Washington

Hamilton

Clermont

Highland

Pike

Jackson

Meigs

Brown

Adams

Scioto

Gallia

Lawrence