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State of Washington

Guidance for Remediation of Petroleum Contaminated Sites

Toxics Cleanup Program

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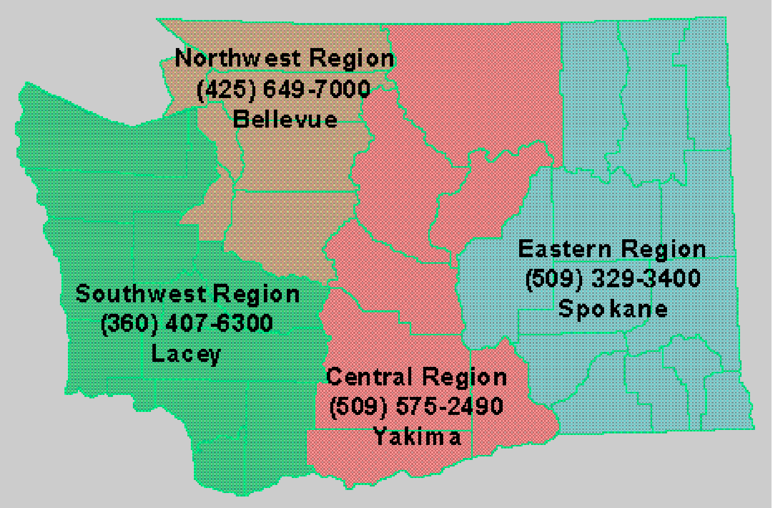

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Acronyms & Abbreviations

BTEX	Benzene, toluene, ethylbenzene, and xylenes
CUL	cleanup level
CLARC	Cleanup Level and Risk Calculations database
CSM	Conceptual Site Model
cPAH	Carcinogenic polycyclic aromatic hydrocarbons
CPOC	conditional point of compliance
CSWGP	Construction Stormwater General Permit (CSWGP)
EC	equivalent carbon
EDB	ethylene dibromide
EDC	1,2 dichloroethane
EPA	Environmental Protection Agency
EPH/VPH	extractable petroleum hydrocarbons / volatile petroleum hydrocarbons
HQ	Hazard Quotient
ISIS	Integrated Site Information System
L&I	Washington State Department of Labor & Industries
LUST	leaking underground storage tank
MTBE	methyl tert-butyl ether
MTCA	Model Toxics Control Act
NFA	no further action
NWTPH	Northwest Total Petroleum Hydrocarbon Method
PCBs	polychlorinated biphenyls
PLP	potentially liable person
PLIA	Pollution Liability Insurance Agency
POC	point of compliance
RCW	Revised Code of Washington
SEPA	State Environmental Policy Act

TEF	toxicity equivalency factor
TPH	total petroleum hydrocarbons
TPH-Dx	total petroleum hydrocarbons – diesel range organics
TPH-Gx	total petroleum hydrocarbons – gasoline range organics
TCLP	Toxicity Characteristic Leaching Procedure
TCP	Toxics Cleanup Program
UST	underground storage tank
VCP	Voluntary Cleanup Program
VI	vapor intrusion
WAC	Washington Administrative Code

Preface

This document is intended to update and replace previous guidance issued in November 1995 by the Department of Ecology's Toxics Cleanup Program titled *Guidance for Remediation of Petroleum Contaminated Soils* (Ecology Publication No. 91-30). It also updates and replaces the previous version of this publication dated September, 2011.

Ecology has received considerable, positive feedback regarding this guidance. In addition to several clarifying edits and updates, this revision includes the following changes:

- **Section 6.8.3:** Added new subsection addressing sampling soil exposed by excavation.
- **Section 6.9.1:** Revised the factors to consider when deciding whether to install monitoring wells.
- **Section 6.11:** Updated discussion and references related to vapor intrusion.
- **Section 8.10:** Updated the table summarizing applicable surface water standards and related discussion.
- **Section 10.3.1:** Changed the number of samples for the direct comparison test for groundwater compliance.
- **Section 11.2.5:** Added a discussion of the Toxics Substances Control Act.
- **Section 11.6:** Added a discussion of environmental covenants.
- **Section 11.9:** Added a discussion of model remedies.
- **Appendix A:** Added link to TCP webpage, "Checklists and Template for Plans and Reports" for Remedial Investigation Reports.
- **Appendix B:** Added link to TCP webpage, "Checklists and Template for Plans and Reports" for Feasibility Study Reports.
- **Appendix C:** Added instructions for using toxicity equivalency factors (TEFs) to determine compliance for carcinogenic polycyclic aromatic hydrocarbons (PAHs).

Acknowledgements

The following Ecology staff participated in the preparation of this guidance:

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Ecology also appreciates the many staff and consultants who took the time to comment on the previous versions of this guidance. While not every viewpoint could be incorporated, these comments were extremely helpful in making this document more useable and understandable.

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Disclaimers

This document provides guidance on the remediation of petroleum contaminated sites under the Model Toxics Control Act (MTCA) Chapter 70.105D, and its implementing regulations, Chapter 173-340 WAC. It is primarily intended to provide guidance to persons with technical backgrounds and experience in contaminated site cleanup, including Ecology Cleanup Project Managers (site managers), consultants and contractors. Others—such as owners and operators of facilities that have experienced petroleum releases, property owners impacted by petroleum releases from nearby properties, and the general public—may also find this guidance useful.

This guidance contains some recommendations and best management practices that are not mandated by law. Use best professional judgment when applying these recommendations to a specific site.

While the information provided in this guidance is extensive, it is neither exhaustive nor does it portend to be a complete review of the relevant rules or literature—users should become familiar with the rules governing cleanups and are encouraged to review the latest literature related to the issue of concern at a site.

Although this guidance has undergone review to ensure the quality of the information provided, there is no assurance that this guidance is free from errors. The information contained in this guidance should be independently verified.

This guidance does not establish or modify the rights or obligations of any person under the law. This guidance is not intended, and cannot be relied on, to create rights, substantive or procedural, enforceable by any party in litigation. Ecology may act at variance with this guidance and may modify or withdraw this guidance at any time. Further, in publishing this guidance, Ecology does not intend to impose upon itself any mandatory duties or obligations. Any regulatory decisions made by Ecology in any matter addressed by this guidance will be made by applying the governing statues and administrative rules to the relevant facts.

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1.0 Introduction

1.1 Background

In March of 1989, a citizen-mandated toxic waste cleanup law went into effect in Washington, changing the way petroleum contaminated sites in this state are cleaned up. Passed by voters as Initiative 97 in the 1988 general election, this law is known as the Model Toxics Control Act (MTCA), Chapter 70.105D RCW.

In 1990 and 1991, based on the authority provided in this statute, the Department of Ecology (Ecology) published rules describing the legal processes and technical requirements for cleanup of contaminated sites under MTCA. These rules are called the "Model Toxics Control Act Cleanup Regulation" and were adopted in Washington Administrative Code as WAC 173-340.

Since passage of the initiative, the statute has been amended numerous times by the legislature. The administrative rules have also been updated several times by Ecology.

In addition to requirements under MTCA, certain underground storage tank systems[1] containing petroleum (for example, underground storage tanks at gas stations) must also comply with the requirements specified in state Underground Storage Tank laws. These requirements can be found in Chapter 90.76 RCW and WAC 173-360.

This publication is intended to provide persons conducting studies and cleanups of petroleum contamination, and Ecology staff reviewing this work, with guidance on how to comply with these and other statutory and rule requirements.

1.2 Applicability of this Guidance

This guidance ***is generally applicable to*** all types of petroleum contaminated sites and media, including petroleum releases from regulated underground storage tank systems to soils.

This guidance ***may be applicable to*** sites with mixtures of petroleum and other hazardous substances (e.g., petroleum and chlorinated solvents or metals). The procedures described here do not take into account the added complexity of establishing cleanup standards and remediating these mixtures. For such sites, the user should contact Ecology staff to discuss the applicability of this guidance and what other additional factors may need to be considered as part of the remediation of these sites.

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[1] See Chapter 3 for a discussion of what constitutes a regulated underground storage tank system.

This guidance is ***not applicable to*** sites contaminated only with hazardous substances other than petroleum.

Some aspects of petroleum site cleanup such as natural attenuation and vapor intrusion are not discussed in detail in this guidance. Where appropriate, these issues are briefly discussed in this guidance and sources of additional information are provided.

1.3 Organization of this Guidance

This manual is comprised of 12 Sections. Each section provides a discussion of the appropriate subject and its related policies and procedures.

Section 1 provides an introduction to this guidance and general information about MTCA.

Section 2 provides an overview of key regulations.

Section 3 is a detailed discussion of regulatory requirements for releases from regulated underground storage tanks.

Section 4 discusses general considerations for site characterizations.

Section 5 reviews field screening methods.

Section 6 provides detailed guidance on conducting effective site characterizations.

Section 7 identifies testing recommendations and analytical methods.

Section 8 describes how to establish cleanup levels.

Section 9 describes points of compliance.

Section 10 describes how to determine compliance with cleanup levels.

Section 11 discusses cleanup technologies, remedy selection, and permit requirements.

Section 12 provides recommendations for the re-use of petroleum contaminated soils.

1.4 Gaining Approval from Ecology for Your Cleanup

Unlike some other laws, MTCA does not require that Ecology issue permits for cleanups. A person who finds contamination on their property must report the contamination to Ecology, but does not need a permit under MTCA to clean up the contamination. However, other permits such as a city- or county-issued shoreline or grading permit may be needed.

Many property owners choose to clean up their sites independent of Ecology oversight. This allows many smaller or less complex sites to be cleaned up quickly without having to go through a formal legal process. A disadvantage to property owners is that Ecology does not issue a written opinion on the adequacy of the cleanup. This can present a problem to property owners who need state approval of the cleanup to satisfy a buyer or lender.

While Ecology does not issue a “cleanup permit,” there are a variety of mechanisms available for Ecology to “approve” of a cleanup that complies with MTCA. One option for obtaining approval is through a formal agreement such as a consent decree or an agreed order. Alternatively, informal technical assistance can be obtained through Ecology’s Voluntary Cleanup Program. These mechanisms allow Ecology to take a more active role in overseeing or reviewing the cleanup, helping minimizing costs and the possibility that additional cleanup will be required in the future – providing significant assurances to investors and lenders.

Here is a summary of the most common mechanisms used by Ecology:

1.4.1 Voluntary Cleanup Program

Property owners who want to conduct an independent cleanup yet still receive some feedback from Ecology on the adequacy of the work can request technical assistance through Ecology’s Voluntary Cleanup Program. Under this voluntary program, the property owner submits a cleanup report and agrees to pay Ecology’s review costs. Based on the review, Ecology will either:

- Issue a letter stating that the site needs “No Further Action”;
- Find that a portion of the site is adequately cleaned up and issue a “Partial Sufficiency Letter,” or,
- Issue a letter identifying what additional work is needed.

Since Ecology is not directly involved in the site cleanup work, the level of certainty in Ecology’s response is less than in a consent decree or agreed order. However, many persons have found “No Further Action” and “Partial Sufficiency” letters to be adequate for property transactions and lenders, making the Voluntary Cleanup Program a popular option.

1.4.2 Consent Decree

A consent decree is a formal legal agreement or “settlement” of liability under MTCA that is filed in court. The work requirements in the decree and the terms under which it must be done are negotiated and agreed to by the potentially liable person (PLP), Ecology and the state Attorneys’ General office. Before a consent decree can become final, it must undergo a public review and comment period that typically includes a public hearing. Consent decrees protect the potentially liable person from being sued for "contribution" by other persons that incur cleanup expenses at the site. They can also facilitate contribution claims against other persons who are responsible for part of the cleanup costs. Sites cleaned up under a consent decree are also exempt from having to obtain certain state and local permits that could delay the cleanup. Ecology's administrative costs for processing a consent decree and overseeing work under that decree must be reimbursed by the person entering the settlement.

In addition to the standard form of a consent decree, there are two specialized forms of consent decrees that can be used in some selected situations. These are:

- ***De Minimus* Consent Decree:** Potentially liable persons whose contribution to site contamination is "insignificant in amount and toxicity" may be eligible for a *de minimus* consent decree. In these consent decrees, the person typically settles their liability by paying for some of the cleanup instead of actually conducting the cleanup work. Ecology usually accepts a *de minimus* settlement proposal only if the settlement is affiliated with a larger site cleanup that Ecology is currently working on.
- **Prospective Purchaser Consent Decree:** A consent decree may also be available for a "prospective purchaser" of contaminated property. In this situation, a person who is not already liable for cleanup and wishes to purchase a cleanup site for redevelopment or reuse may apply to negotiate a prospective purchaser consent decree. The applicant must show, among other things, that they will contribute substantial new resources towards the cleanup. Cleanups that also have a substantial public benefit will receive a higher priority for prospective purchaser agreements. If the application is accepted, the requirements for cleanup are negotiated and specified in a consent decree so that the purchaser can better estimate the cost of cleanup before buying the land. Ecology's administrative costs for processing a prospective purchaser decree and overseeing work under that decree are reimbursed by the person entering the settlement.

Christine Gregoire,
Governor of Washington (2005-2013) and
Ecology Director during initial MTCA
implementation (1988-1991).

1.4.3 Agreed Order

An agreed order is a legally binding, administrative order issued by Ecology but agreed to in advance by the potentially liable person. Agreed orders are available for remedial investigations, feasibility studies, and final cleanups. An agreed order describes the site activities that must occur for Ecology to agree not to take enforcement action for that phase of work. As with consent decrees, agreed orders are subject to public review and offer the advantage of facilitating contribution claims against other persons and exempting cleanup work from obtaining certain state and local permits. However, unlike a consent decree, an agreed order is not filed in court, is not a settlement, and does not provide contribution protection for the liable person. Ecology's administrative costs for processing an agreed order and overseeing work under that order must be reimbursed by the person agreeing to the order.

1.4.4 Enforcement Order

Under MTCA, Ecology has the authority to issue orders to require cleanup of contaminated sites. These orders are usually issued when Ecology believes a cleanup solution cannot be achieved expeditiously through negotiation or if an emergency exists. Violations of these orders are subject to stiff penalties of up to $25,000 per day of violation. Furthermore, if a potentially responsible party fails to comply with an order, Ecology can conduct the work required by the order (usually through a contractor) and ask a court to require the potentially liable person to pay Ecology for up to three times the costs the agency incurred in doing the work, in addition to assessing a fine for violation of the order.

1.5 Private Right of Action

In general, under MTCA, persons who own contaminated property or otherwise contributed to contamination of a property are required to pay for cleanup of the contamination. This liability is joint and several, meaning that any one of these persons could be required to pay for the entire cost of cleanup, even if others caused the problem. At sites where there are multiple companies involved, these parties often work together to share the cleanup costs. However, when this is not the case, one or more liable person may choose to move ahead with the cleanup and seek repayment from other liable persons by filing a "private right of action" in court.

If you intend to seek a "private right of action" against other potentially liable persons, there are specific steps that need to be taken to preserve your legal rights. These steps are described in RCW 70.105D.080 and The Model Toxics Control Act Cleanup Regulation, WAC 173-340-545. Ecology has also published a document titled *Private Right of Action* (Ecology Publication No. R-TC-95-137) that explains these requirements. That document can be found at http://www.ecy.wa.gov/biblio/rtc95137.html.

1.6 Financial Assistance

MTCA requires that persons who own contaminated property or otherwise contributed to contamination of a property pay for cleanup of the contamination. Depending on the extent of contamination, a cleanup can be very expensive, ranging from thousands to millions of dollars.

All regulated underground storage tank operators are required to carry at least one million dollars of liability insurance to cover the cost of cleanup from a leaking underground storage tank. The cost of cleanup of older releases may be covered by historic comprehensive general liability insurance policies (generally policies older than the late 1980's). All property owners and operators should always contact their insurance carriers as soon as they become aware that contamination exists on their property. Failing to notify your insurance carrier or doing cleanup work without notifying your carrier may negate any insurance coverage.

Financial assistance is available to local governments to help pay for the costs of cleanup. Each year, Ecology awards millions of dollars of grants and loans to cities, counties, port districts, schools and other public agencies. For additional information contact Ecology's Toxics Cleanup Program Section Manager for the Region in which the site is located in or go to http://www.ecy.wa.gov/programs/tcp/paying4cu/paying4cu.html.

Opportunities for grants are limited for private landowners. The following is a brief summary of currently available assistance.

If the property is slated for redevelopment, it may be possible to secure a federal "Brownfield" redevelopment grant or loan. The Department of Commerce administers a Brownfield loan program in Washington State on behalf of the U.S. Environmental Protection Agency. For more information on this program call (360) 725-4032 or go to http://www.commerce.wa.gov/ and search for "Brownfield."

If the owner has limited assets and can show the cleanup would cause financial hardship, it may also be possible to obtain a grant or loan through a "mixed funding agreement" from Ecology to help pay for the cleanup. Ecology can pay costs only if an agreement has been reached before the work starts. To request financial assistance for a Leaking Underground Storage Tank (LUST) cleanup, an owner or operator must submit an "Application for a consent decree and financial assistance for cleanup of releases from underground storage tanks." This application is available from LUST staff at Ecology regional offices. Ecology requires copies of Federal income tax statements from the previous three years to evaluate the owner's or operator's eligibility for financial assistance. A determination of eligibility is not a funding commitment. Actual funding will depend on the availability of funds. Current funding for the LUST Financial Assistance program is extremely limited.

The Pollution Liability Insurance Agency (PLIA) also may have funds available to aid in the cost of cleanup of underground storage tanks insured under their program. For additional information on PLIA's programs call 1-800-822-3905 or 360-586-5997, or go to http://www.plia.wa.gov/.

1.7 Other Publications and Resources

There are a variety of publications and online help tools published by Ecology. Below is a summary of information most relevant to petroleum contaminated site cleanup. Users of this guidance are also encouraged to sign up for Ecology's *Site Register*, a bi-weekly publication announcing the status of cleanup sites and publication of new policies and guidance related to site cleanup. You can find a link to join the Site Register list serve at http://www.ecy.wa.gov/programs/tcp/pub_inv/pub_inv2.html.

The following Ecology guidance documents, reports, focus sheets, and technical memoranda also provide valuable information on release reporting, site remediation, and preparing cleanup reports.

Policies

http://www.ecy.wa.gov/programs/tcp/policies/tcppoly.html

Policy 300: Site Discovery—Release Reporting: Provides guidance on the types of releases that should be reported to Ecology under MTCA and the procedures for reporting these releases.

Policy 840: Data Submittal Requirements: Describes requirements for submitting environmental data generated during the investigation and cleanup of contaminated sites under MTCA.

Focus Sheets

https://fortress.wa.gov/ecy/publications/UIPages/Home.aspx

For TCP Specific Publications:
https://fortress.wa.gov/ecy/publications/UIPages/PublicationList.aspx?IndexTypeName=Program&NameValue=Toxics+Cleanup&DocumentTypeName=Publication

Model Toxics Control Act Cleanup Regulation: Process for Cleanup of Hazardous Waste Sites (May 2001): Explains what constitutes a hazardous waste site, who is responsible for the cleanup, and how to work with Ecology to achieve a site cleanup.

Model Toxics Control Act Cleanup Regulation: Establishing Cleanup Standards and Selecting Cleanup Actions (January 2004): Provides an overview of how to establish cleanup standards and determine the extent and method of cleanup.

Developing Groundwater Cleanup Standards under the Model Toxics Control Act (August 2001): Describes the requirements and procedures for developing groundwater cleanup standards.

Developing Surface Water Cleanup Standards under the Model Toxics Control Act (August 2001): Describes the requirements and procedures for developing surface water cleanup standards.

Developing Soil Cleanup Standards under the Model Toxics Control Act (August 2001): Describes the requirements and procedures for developing soil cleanup standards.

Developing Air Cleanup Standards under the Model Toxics Control Act (August 2001): Describes the requirements and procedures for developing air cleanup standards.

Reports

https://fortress.wa.gov/ecy/publications/UIPages/Home.aspx

For TCP Specific Publications:
https://fortress.wa.gov/ecy/publications/UIPages/PublicationList.aspx?IndexTypeName=Program&NameValue=Toxics+Cleanup&DocumentTypeName=Publication

Hazardous Waste Considerations in Real Estate Transactions: Ecology Report R-TC-92-115 (September 1999): Discusses investigative techniques commonly used when considering purchasing a property to assess whether property has the potential to be contaminated. (see also the requirements for Real Property Transfers – Sellers Disclosures in Chapter 64.06 RCW.)

Hazardous Waste Cleanups: Selecting an Environmental Consulting Firm: Ecology Report R-TC-92-116 (December 2002): Provides an overview of what factors to consider when selecting an environmental consulting firm.

Private Right of Action Ecology Report R-TC-95-137 (December 2002): Explains the steps that need to be taken to preserve your right to recover cleanup costs from prior owners, operators and other contributors to contamination at a site.

Brownfields Resource Guide: Ecology Publication No. 97-608 (September 2009): Provides an overview of resources available for the redevelopment of Brownfield sites and key contacts in various federal and state agencies.

Implementation (Technical) Memoranda and Guidance

http://www.ecy.wa.gov/programs/tcp/policies/pol_main.html

Analytical Methods for Petroleum Hydrocarbons, Publication No. 97-602 (June, 1997).

Guidance on Remediation of Petroleum-Contaminated Groundwater by Natural Attenuation, Publication No. 05-09-091 (July 2005): Provides technical guidance on how to evaluate the feasibility and performance of alternatives that use natural attenuation to clean up petroleum-contaminated groundwater.

Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action, Publication No. 09-09-047 (October 2009 Review Draft).

Remedial Action Grants for Local Governments, Publication No. 14-09-058 (November 2014): Provides information on Ecology grants available for cleanup of contaminated sites, how to apply for these grants, qualifying criteria, eligible costs, and grant management.

Implementation Memo #2: Applicability of WAC 173-340-706 (August 1993): Describes when it is appropriate to use a Method C groundwater cleanup level at an industrial site.

Implementation Memo #4: Determining Compliance with Method A Cleanup Levels for Diesel and Heavy Oil (June 2004): Provides guidance on determining compliance with the Method A cleanup levels at sites with mixtures of diesel and heavy oil.

Implementation Memo #5: Collecting and Preparing Soil Samples for VOC Analysis (June 2004): Provides guidance for sampling soils suspected of being contaminated with volatile substances.

Implementation Memo #6: Soil Moisture Corrected Reporting by EPA Method 8000C (February, 2008): Provides guidance on adjusting volatile organics analysis for soil moisture.

Implementation Memo #9: Building Code Compliance for Factory Built Commercial Structures (May, 2011): Provides clarification on how the MTCA permit exemption applies to pre-fabricated structures containing groundwater or vapor treatment equipment.

Natural Background Soil Metals Concentrations in Washington State: Ecology Publication No. 94-115 (October, 1994): Provides data on the total metals concentrations in uncontaminated soils in Washington State.

Sediment Cleanup Users Manual (SCUM II); Ecology Publication No. 12-09-057 (December 2013 DRAFT). Provides guidance for implementation of the sediment cleanup standards in Washington State.

Statistical Guidance for Site Managers: Ecology Publication No. 92-54 (August 1992): Provides guidance on the use of statistics to determine compliance with cleanup levels.

Online Tools

http://www.ecy.wa.gov/programs/tcp/tools/toolmain.html

Cleanup Levels and Risk Calculation (CLARC): CLARC is an Excel spreadsheet of toxicological information, physical properties, and cleanup levels for various exposure pathways for a wide variety of chemicals.

MTCA STAT: Excel spreadsheets for calculating background concentrations and determining compliance with cleanup standards.

Natural Attenuation Analysis Tool Package: Provides instructions and Excel spreadsheets for calculating contaminant mass, plume status, mass flux and biodegradation rate constants related to the natural attenuation of petroleum constituents in groundwater.

Terrestrial Ecological Evaluation Process - An Interactive User's Guide: Provides instructions and a series of forms for evaluating the effect of contamination on upland plants and animals.

Workbook for Calculating Cleanup Levels for Individual Hazardous Substances (MTCASGL): Excel spreadsheet for calculating cleanup levels for single hazardous substances.

Workbook for Calculating Cleanup Levels for Petroleum Contaminated Sites (MTCATPH): Excel spreadsheet for calculating cleanup levels for TPH mixtures (MTCATPH).

UST Guidance

http://www.ecy.wa.gov/programs/tcp/ust-lust/tanks.html

http://www.ecy.wa.gov/programs/tcp/ust-lust/2011/06-other-info.html

Guidance for Site Checks and Site Assessments for Underground Storage Tanks: Ecology Publication No. 90-52 (May 2003): Provides information on the requirements for closing or removing underground storage tanks. The information contained in this document includes health and safety requirements, field sampling procedures, and quality assurance and quality control requirements. http://www.ecy.wa.gov/biblio/9052.html

Reporting Spills and Overfills of Petroleum: Ecology Publication No. 95-608 (November, 2004 revision).

Residential Heating Oil Tanks; Ecology Report R-TC-92-117 (December 2008 revision). Provides information on the closure and cleanup requirements for home heating oil tanks.

Small Spill Cleanup Guide: Ecology Focus No. 03-08-005 (June 2003)

2.0 Regulations

Petroleum contamination is the most common type of hazardous substance encountered at contaminated sites in Washington State. Even with Ecology's and underground storage tank operators' best efforts, there continue to be numerous releases of petroleum from regulated underground storage tank systems (Figure 2.1). There are three primary regulations governing the cleanup of petroleum-contaminated sites in Washington State:

- Underground Storage Tank Regulations, Chapter 173-360 WAC
- Model Toxics Control Act (MTCA) Cleanup Regulations, Chapter 173-340 WAC
- Sediment Management Standards, Chapter 173-204 WAC

Ecology's Toxics Cleanup Program is responsible for implementation of all of these regulations. Persons using this guidance should obtain an updated copy of these regulations and become thoroughly familiar with their content.

2.1 Underground Storage Tank Regulations, Chapter 173-360 WAC

Owners and operators of underground storage tank systems identified in Chapter 3 of this guidance must comply with the Washington State Underground Storage Tank (UST) Regulations, Chapter 173-360 WAC. These regulations govern the installation, operation and closure of underground storage tanks and are derived from the authority granted to Ecology under Chapter 90.76 RCW. The UST regulations can be obtained in three ways:

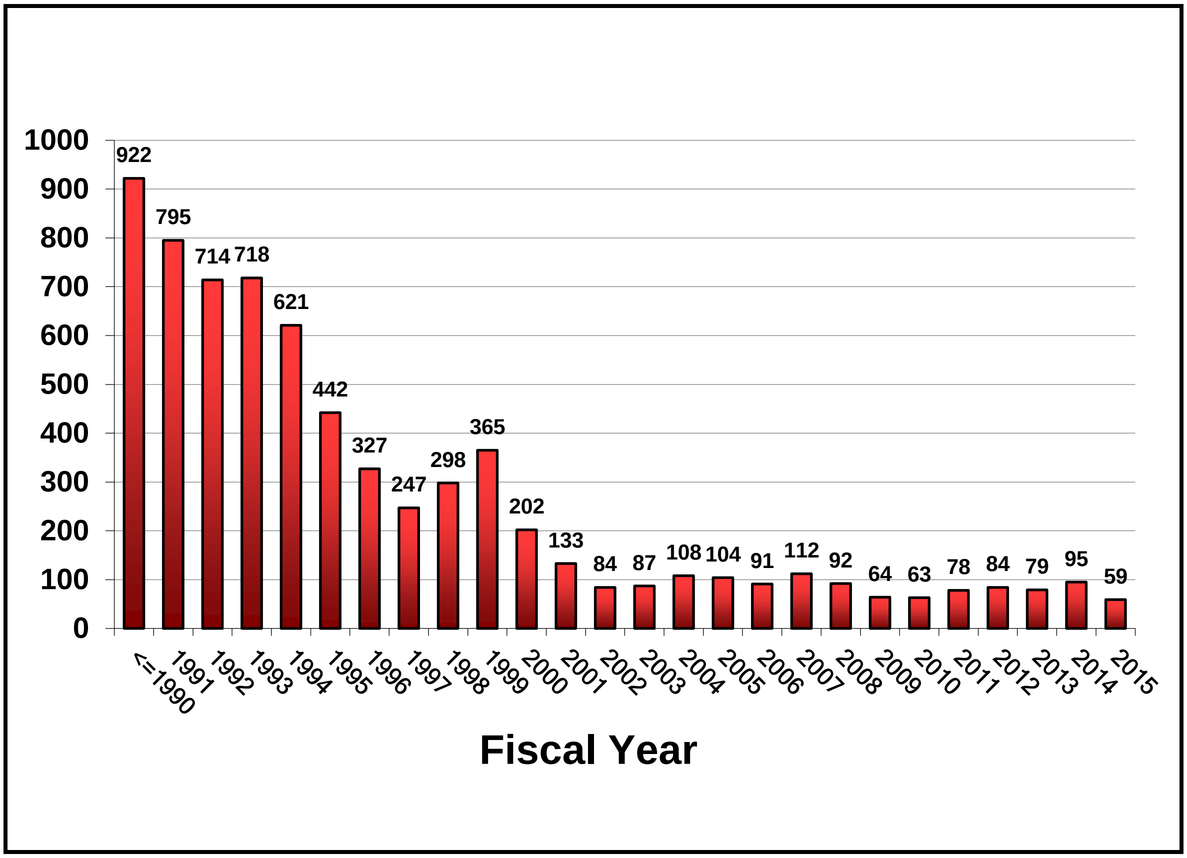
- A web version of Chapter 173-360 WAC may be accessed through the Washington State Legislature's web site at http://apps.leg.wa.gov/wac/.
- A PDF version of MTCA Chapter 173-360 WAC may be downloaded from Ecology's web site at https://fortress.wa.gov/ecy/publications/summarypages/9406.html.
- A printed copy of Chapter 173-360 WAC may also be obtained by calling Ecology's Toxics Cleanup Program at (360) 407-7170.

2.2 Site Cleanup Regulations, Chapter 173-340 WAC

At any site or facility where there is a release or threatened release of a hazardous substance, the owner/operator must comply with the Model Toxics Control Act Cleanup Regulations, Chapter 173-340 WAC. This rule is derived from the authority granted to Ecology through a citizens' initiative (I-97) passed in the November 1988 general election and embodied in Chapter 70.105D RCW. A full copy of the MTCA cleanup regulation can be obtained in three ways:

- A web version of MTCA Chapter 173-340 WAC may be accessed through the Washington State Code Reviser's web site http://www1.leg.wa.gov/CodeReviser/.
- A PDF version of MTCA Chapter 173-340 WAC may be downloaded from Ecology's web site at http://www.ecy.wa.gov/biblio/9406.html.
- A printed copy of MTCA Chapter 173-340 WAC may also be obtained by calling Ecology's Toxics Cleanup Program at (360) 407-7170.

Figure 2.1 Number of underground storage tank releases in Washington State.



2.3 Sediment Management Standards, Chapter 173-204 WAC

Petroleum-contaminated sites impacting marine or freshwater sediments also need to comply with the Sediment Management Regulations, Chapter 173-204 WAC. The freshwater Sediment Management Standards were recently updated to add table values for petroleum hydrocarbons. Otherwise, sediment cleanup standards must be developed on a site-specific basis. The Aquatic Lands Cleanup Unit at Ecology should be consulted for guidance on sediment contamination investigations and development of site specific cleanup levels. A copy of the Sediment Management Regulations can be obtained in three ways:

- A web version of MTCA Chapter 173-240 WAC may be accessed through the Washington State Code Reviser's web site http://apps.leg.wa.gov/WAC/default.aspx?cite=173-204.
- A PDF version of MTCA Chapter 173-240 WAC may be downloaded from Ecology's web site at https://fortress.wa.gov/ecy/publications/SummaryPages/1309055.html.
- A printed copy of MTCA Chapter 173-240 WAC may also be obtained by calling Ecology's Toxics Cleanup Program at (360) 407-7170.

2.4 Regulatory Requirements for Underground Storage Tanks on Tribal Lands

2.4.1 Land within Indian Reservations

There are two types of lands within Indian reservations—Trust Lands and Fee Lands. Tribal trust lands are lands owned by the United States and held in trust for a tribe or on behalf of tribal members. Fee lands are lands held in fee simple ownership just like most other private property. Lands within a reservation can be owned by individual tribal members, the tribe as a whole, or by individuals or companies who are not members of the tribe. On all lands within Indian reservations, trust lands and fee lands alike, underground storage tanks are subject to federal regulation (Chapter 40 Code of Federal Regulations Part 280). Within a reservation, the US EPA oversees compliance with underground storage tank regulations and remediation of releases from regulated systems.

One exception is the Puyallup Reservation. By special agreement, Ecology has regulatory authority on fee lands within this reservation (about 95% of the land). Thus, underground storage tanks on fee lands within the Puyallup Reservation are regulated under state law (UST regulations and MTCA).

2.4.2 Off-Reservation Tribal Trust Land

A tribe or its members may own land located outside of the reservation that is held in trust by the federal government. As described above for lands within reservations, the USEPA is generally responsible for implementation of underground storage tank regulations (Chapter 40 Code of Federal Regulations Part 280) and oversight of remediation of releases from underground storage tank systems located off-reservation on tribal trust land.

A tribe or its members often own land off-reservation that is not in trust status. Underground storage tanks on these lands are regulated under state law (UST regulations and MTCA), just like tanks on any other privately held land. If there is a question on the status of a particular parcel, check the county assessor records.

2.4.3 EPA Contact Information

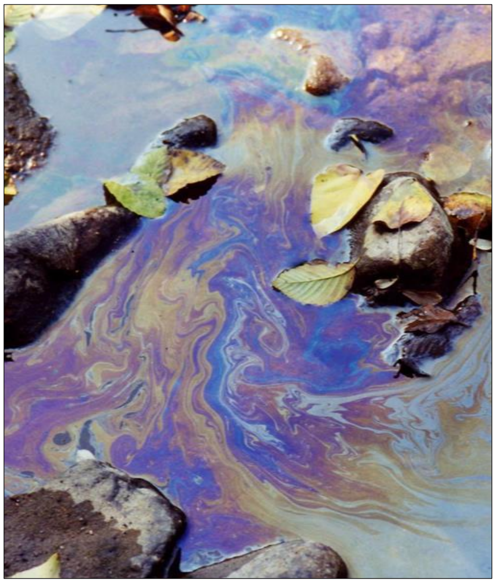
To report a leaking underground storage tank within an Indian reservation or on tribal trust lands located off-reservation, contact the Environmental Protection Agency's Washington State Operations Office at (206) 753-9540. Information on EPA's regulatory requirements for underground storage tanks can be found at http://www.epa.gov/ust.

3.0 Requirements for Releases from Regulated Underground Storage Tank Systems

This section provides an overview of the regulatory requirements for releases from regulated underground storage tank systems (UST systems) containing petroleum products, as well as reporting requirements in other regulations. In general, regulated UST systems include any tank or combination of tanks and connecting piping storing over 110 gallons of regulated hazardous substances (including gasoline and diesel fuel), of which 10% or more of the total volume is beneath the surface of the ground. There are specific exemptions for heating oil tanks and farm and residential UST tanks with a capacity of 1,100 gallons or less. Underground storage tank systems that were not operated after January 1, 1974 and were removed before May 8, 1986 do not need to comply with UST system requirements. However, the reporting and cleanup of releases from these and other exempt UST systems must still comply with MTCA. See WAC 173-360 for the definition of UST systems and a description of these and other exemptions.

3.1 UST Systems Release Reporting Requirements

Any release from an UST system that poses a threat to human health or the environment must be reported to Ecology by the owner or operator of that system, whether or not it is regulated under the UST rules. Consultants or contractors who discover a release should notify the owner or operator of the system and the owner/operator obligation to notify Ecology. “Release” means any intentional or unintentional entry of any petroleum into the environment including leaks, spills and overfilling. See WAC 173-340-300 for reporting guidance. The UST regulations (WAC 173-360-375) contain additional specific reporting requirements for regulated UST systems. In general, the following can be used as a guide to determine what releases should be reported to Ecology and satisfy the requirements of these two regulations:



- Any spill on pavement or concrete that cannot be immediately cleaned up or will not evaporate in a short period of time. All spills to soil, groundwater, surface water or catch basins.
- Any suspected underground leaks from underground storage tanks and piping systems that are confirmed by leak detection systems, unusual operating conditions, or other evidence.
- Any sheen or oil observed on surface water.
- Contamination found in a public or private well or monitoring well.
- Product found in nearby basements, utility lines, groundwater or soils.

Reports should be made by calling the Ecology regional office that is responsible for the area in which the release occurred (see inside front cover). Heating oil tank releases should also be reported to the Pollution Liability Insurance Agency at (360) 586-5997. Table 3.1 summarizes the time limits for reporting releases.

Table 3.1. Reporting Requirements for Releases from Underground Storage Tanks

Type of Release or Action	Reporting Requirement
Regulated Underground Storage Tanks (1)	
• Suspected releases (WAC 173-360-360) • Release observed in environment • Unusual operating conditions • Leak detection system signals release	• Must investigate immediately and confirm within 7 days using a system leak test and site check as needed (WAC 173-360-370)
• All confirmed spills, overfills, underground releases and any emergency actions taken	• Report within 24 hours (WAC 173-360-372)
• Interim Action Status Report	• Submit within 20 days after release (WAC 173-340-450)
• Site Characterization Report	• Submit within 90 days after release confirmation (WAC 173-340-450)
Releases from Non-Regulated Underground Storage Tanks, including heating oil tanks smaller than 1100 gallons	Report within 90 days (WAC 173-340-300)
Any Release to Surface Water (including wetlands)	Report immediately (RCW 90.56.280)
Independent Remedial Actions not otherwise required to report sooner (2)	Submit a report on actions taken within 90 days of completion of remedial action (WAC 173-340-515)

(1) Most UST systems over 110 gallons in capacity used for storing petroleum products like gasoline or diesel fuel are regulated under Chapter 173-360 WAC. Home heating oil tanks smaller than 1,100 gallons in capacity are not regulated under that Chapter.

(2) Independent remedial actions are studies, investigations and cleanup activities that are not being conducted as a result of an Ecology order, agreed order, or consent decree under MTCA.

Table 3.1 Reporting requirements for releases from underground storage tanks.

3.2 Home Heating Oil Tanks

Home heating oil storage tanks are exempt from regulation under Washington UST regulations. However, leaks from these tanks must be reported to Ecology and could subject the owner to liability for the cost of cleanup and other damages under MTCA and other state laws.

Heating oil tank cleanup costs are often not covered by homeowners insurance. In 1995, the State of Washington initiated expanded pollution liability coverage offered by the Pollution Liability Insurance Agency (PLIA) to cover heating oil tanks. This program was created in response to the rising number of heating oil tank releases and the significant impact contamination had on property values and the environment. To have an eligible claim for coverage under PLIA's insurance program, the heating oil tank owner must have registered the tank with PLIA prior to the release. Accidental releases occurring prior to registration are not eligible for coverage. A new property owner must submit a registration form to PLIA within 180 days of the property transfer to avoid a lapse in coverage from the previous registered owner. Abandoned or decommissioned heating oil tanks are generally not eligible for coverage except as provided in WAC 374-70-080(4) and 374-70-090(4). Registration can be accomplished by calling PLIA at (800) 822-3905 or through PLIA's web site at http://www.plia.wa.gov/.

KEY POINT: REGISTER HEATING OIL SYSTEMS WITH PLIA

To be eligible for insurance coverage under PLIA's heating oil tank insurance program, homeowners must have registered the tank with PLIA prior to the release.

Under an agreement between PLIA and Ecology, when a residential heating oil tank release is reported to Ecology, Ecology refers the report to PLIA to evaluate the site and, in most cases, oversee the cleanup.

Sometimes lenders will ask for a confirmation from a government agency of the adequacy of cleanup before they will approve a loan for the purchase or refinancing of a home with an actual or suspected release from a heating oil tank. Homeowners have the option of requesting opinion letters on the cleanup from either Ecology or PLIA. Both agencies charge a fee for these reviews and opinion letters. However, should you desire technical assistance with a home heating oil tank cleanup, Ecology recommends that you first consult with PLIA to figure out the best approach for your site.

PLIA maintains a list of service providers that perform work under the Heating Oil Pollution Liability Insurance Program which may be helpful in finding a contractor to remove or decommission a tank, or provide other remediation services. See http://www.plia.wa.gov/.

For releases from tanks not registered with PLIA, another option may be to explore whether any other insurance coverage exists. Owners experiencing difficulty with their insurance company may also want to contact the State Insurance Commissioner for help. The Insurance Commissioner's hotline is (800) 562-6900 or go to their web site for additional information at http://www.insurance.wa.gov/.

3.3 Regulated Underground Storage Tanks

The following summarizes the actions required to address releases from regulated UST systems.

3.3.1 Confirming and Reporting a Release (WACs 173-340-450(2) & 173-360-360)

When a release is suspected, the system operator should take immediate steps to determine whether a release has actually occurred. For example, product inventories or leak detection systems can sometimes falsely indicate a release has occurred when it hasn't. When a leak is detected by one of these methods, steps should be taken immediately to reconcile any discrepancies, test the detection system or take other measures to determine if the indicator is false.

If the discrepancy cannot be resolved, the system must be leak tested and, in some circumstances, a study (called a "site check") must be conducted to determine if a release has indeed occurred. Note that standard leak detection methods may be inadequate for detecting small leaks. See Ecology Publication No. 90-52 titled *Guidance for Site Checks and Site Assessments for Underground Storage Tanks* http://www.ecy.wa.gov/biblio/9052.html.

Within 24 hours of confirmation of a release from a regulated UST facility, the UST owner or operator must report the release to Ecology. It is important to note that under WAC 173-360-630, UST site assessors, in addition to owners and operators, must report confirmed releases. Some health departments/districts may also require they be notified of an UST release. For links to local health departments/districts, go to http://www.doh.wa.gov/AboutUs/PublicHealthSystem/LocalHealthJurisdictions.

3.3.2 Conducting Emergency Actions (WAC 173-340-450(2))

Within 24 hours of confirmation of an UST release, the UST owner or operator must take all of the following actions:

(a) Remove as much product from the UST as possible and necessary to prevent further release to the environment.

(b) Eliminate or reduce any fire, explosion or vapor hazards.

(c) Visually inspect any above ground releases or exposed below ground releases and prevent them from spreading into surrounding soils, groundwater and surface water.

3.3.3 Conducting Interim Actions (WAC 173-340-450(3))

As soon as possible, but no later than 20 days after confirmation of an UST release, the UST owner or operator must take all of the following actions:

(a) Continue to monitor and mitigate any additional fire and safety hazards posed by vapors or free product that may have migrated from the UST into structures in the vicinity of the site, such as sewers or basements.

(b) Reduce threats to human health and the environment posed by contaminated soils that are discovered during investigation or cleanup work.

(c) Test for hazardous substances in the environment where they are most likely to be present.

(d) Investigate for and remove free product to the maximum extent practicable, as soon as possible. [2]

3.3.4 Status Report (WAC 173-340-450(5)(a))

Within 20 days after an UST release, the UST owner or operator must submit a status report to Ecology. This report may be provided verbally. This status report must include the following information, if known:

(a) The types, amounts, and locations of hazardous substances released

(b) How the release occurred

(c) Evidence confirming the release

(d) Remedial actions taken and the results of these actions to date

(e) Planned remedial actions

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[2] Removal of free product remains one of the more vexing technical issues at petroleum contaminated sites. Discussion of this topic is beyond the scope of this document. Numerous guidance documents and technical publications addressing free product removal are available from the USEPA (1996, 2005) and various other organizations, and these documents should be consulted when compliance with this standard is an issue at a site.

3.3.5 Site Characterization Report (WAC 173-340-450(5)(b))

Within 90 days after release confirmation, unless directed to do otherwise by the department, the UST owner or operator must submit a report in writing to Ecology about the site and nature of the release. The site characterization report may be combined with the 20-day status report. Under WAC 173-340-450(5), the site characterization report must include, at least the following information (see also Section 6 in this document for guidance on site characterization):

(a) The information required for the status report.

(b) A site conditions map indicating approximate boundaries of the property, locations of hazardous substances, and sampling locations. The map may be a sketch at a scale sufficient to illustrate this information.

(c) Available data on surrounding populations, surface and groundwater quality, use and approximate location of wells potentially affected by the release, subsurface soil conditions, depth to groundwater, direction of groundwater flow, proximity to and potential for affecting surface water, locations of sewers and other potential conduits for vapor or free product migration, surrounding land use, and proximity to sensitive environments.

(d) Results of tests for hazardous substances.

(e) Results of free product investigations.

(f) Results of all completed site investigations, interim actions and cleanup actions and a description of any remaining investigations, cleanup actions and compliance monitoring that are planned or underway.

(g) Information on the free product removal efforts where investigations indicate free product is present. This shall include, at a minimum, the following:

  (i) Person responsible for implementing the free product removal measures.

  (ii) Estimated quantity, type, and thickness of free product observed or measured in wells, boreholes and excavations.

  (iii) Type of free product recovery system used.

  (iv) Location of on-site or off-site discharge during the recovery operation.

  (v) Type of treatment applied to, and the effluent quality expected from any discharge.

  (vi) Steps taken and planned to obtain necessary permits for any discharge.

  (vii) Disposition of recovered free product.

  (viii) Other information required by Ecology.

3.3.6 Remedial Investigation/Feasibility Study (RI/FS) (WAC 173-340-450(6))

A remedial investigation and feasibility study (RI/FS) consists of a more detailed characterization of the extent of contamination at the site and an engineering evaluation of alternatives for cleanup of the site. An RI/FS must be completed at regulated UST sites if any of the following conditions exist (WAC 173-340-450(6)):

(a) There is evidence that the release has caused hazardous substances to be present in the groundwater in excess of either the groundwater standards in WAC 173-200-040 or the cleanup levels in Table 720-1 in WAC 173-340-900. These standards are compiled in Table 3.2. (See Subsection 6.9 of this guidance for groundwater testing recommendations).

(b) Free product is found.

(c) When otherwise required by Ecology (such as part of a submittal under Ecology's Voluntary Cleanup Program).

At other petroleum-contaminated sites, an RI/FS must be completed if the MTCA cleanup standards are found or suspected of being exceeded.

The scope of the study will depend on the complexity of the site, but sufficient information must be collected and evaluated to allow selection of a cleanup remedy. For specifics on what elements an RI/FS should include, see WAC 173-340-350 and Section 6 in this guidance.

If an RI/FS is necessary at a regulated UST site, the RI/FS must be submitted to Ecology as soon as feasible and may be included with other required reports.

KEY POINT: QUICKER CLEANUPS REDUCE LIABILITY COSTS

The MTCA rule does not specify a particular timeframe for completion of an RI/FS or for the cleanup to be completed at petroleum contaminated sites. However, the sooner the extent of the contamination is defined and addressed, the less opportunity there is for contamination to spread and exposure to the contamination to occur, ultimately reducing cleanup costs and potential liability for third party damages. Completing this work in a timely manner also helps avoid potential enforcement action by Ecology.

3.3.7 Cleanup Action Requirements

At sites where the remedial investigation finds contamination above cleanup standards, it will be necessary to clean up ("remediate") the contamination. Information compiled in the RI/FS is used to select an appropriate remedy under WAC 173-340-360.

Once a remedy has been selected, plans and specifications for the cleanup are prepared. For specifics on what to include in these documents, see WAC 173-340-400. The level of detail in these documents will vary depending on the remedy selected and complexity of the site. For independent cleanups, the MTCA rule does not specify a particular legal deadline for completion of site cleanup. Sites being cleaned up under a MTCA order or decree will have cleanup deadlines specified in that legal document.

Table 3.2 Groundwater Petroleum Concentrations Triggering a Remedial Investigation at Regulated UST Facilities

Contaminant	**Groundwater Concentration (1) (µg/l or ppb)**
Benzene	1
Ethylbenzene	700
Toluene	1,000
Xylene (total)	1,000
Benzo (a) pyrene	0.008
EDB (ethylene dibromide)	0.001
EDC (1,2 dichloroethane)	0.5
Lead	15
MTBE	20
Naphthalenes (2)	160
PAHs (carcinogenic) (3)	0.01
PCBs	0.01
TPH (NWTPH-Gx)	800
TPH (NWTPH-Dx)	500

(1) Most stringent of WAC 173-200-040 and the cleanup levels in Table 720-1 in WAC 173-340-900 as per WAC 173-340-450(6).

(2) Naphthalenes = total of naphthalene, 1-methyl naphthalene and 2-methyl naphthalene

(3) Total toxic equivalent concentration of benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene and indeno(1,2,3-cd)pyrene. See Appendix C for how to calculate a toxic equivalent concentration.

NOTE: Not all of the above contaminants must be tested for at every site. See Section 7 of this guidance for testing recommendations.

Table 3.2 Groundwater petroleum concentrations triggering a Remedial Investigation at regulated UST facilities.

4.0 Site Characterization: General Considerations

After dealing with the immediate problems caused by a petroleum release, the next step is to assess or characterize the site. For regulated UST facilities, this site characterization study must be completed within 90 days after confirmation of a release. For other petroleum-contaminated sites, there is no specific deadline in the MTCA regulation, unless Ecology sets one under an order or decree. In this later case, site characterization work would be part of the remedial investigation. This section discusses general issues that should be considered in any site characterization study.

4.1 Location of Underground Utilities

Increasingly, many of the utility services provided to homeowners and businesses are buried underground. Damaging these utilities can result in fines and large damage claims. Under Washington State law (Chapter 19.122 RCW), anyone who digs more than 12 inches below the ground surface is required to call to locate utilities two business days before digging.

In general, you only have to make one call. Most owners of underground utilities, such as telephone, cable, water, sewer, electricity, and natural gas, have cooperated in providing a one-call utility locate service. Simply call 811 or 1- 800- 424 -5555 two business days before you plan on digging.

How does the utility locate system work?

When you call the toll-free number, your call is routed to a utility location request center. The center is responsible for making sure participating utilities in your area are alerted to your digging plans and have the information necessary to determine whether a utility locate must be performed. In turn, the utility companies are obligated to make those markings within the next two business days after the call has been made. Some utilities like private water systems are not members of the one-call service. If you are aware the site is located within the service boundary of such a utility, contact the utility directly for locating service. To learn more about the utility locating process in Washington State, visit the Washington Utilities Coordinating Council website http://www.washington-ucc.org/.

NOTE: Underground storage tanks and connecting piping systems are not part of the utility locate system. Release of product due to damage to these systems during site investigations could result in liability for resulting contamination. Also, not all utilities on private property will be marked under the utility locate system, such as laterals and underground power connections between the service meter, pump islands and lights. A private utility locating service should be contacted to help identify these line locations. In addition, for safety reasons, the use of air knife, vacuum excavation and/or hand tools to clear utility zones are recommended when working in the vicinity of marked underground utilities and where unmarked underground utilities could be located.

KEY POINT: CALL 811 OR (800) 424-5555 BEFORE YOU DIG!

Dig without calling two (2) business days in advance:
Pay $1000 fine.

Dig without calling two (2) business days in advance and damage a utility:
Pay $10,000 fine and triple the repair costs.

Dig without calling within 35 feet of a large pipeline:
Pay $1,000 fine and spend 30 days in jail.

Dig without calling and damage a large pipeline:
Pay $10,000 fine, triple the repair costs and spend 30 days in jail.

Source: Utilities and Transportation Commission

4.2 Health and Safety

Most petroleum products are highly toxic and flammable. Investigation of a site contaminated with these products requires thoughtful planning to anticipate the myriad of health and safety issues that could arise during petroleum-contaminated site investigations and remediation.

For most locations in Washington State, employers are required to comply with workplace safety and health regulations administered by the Washington State Department of Labor and Industries. For contaminated site cleanup, in addition to core workplace safety requirements, there are additional specific requirements for site safety plans, characterization, monitoring and employee training. The most relevant regulations include:

- Chapter 296-24 WAC (General Safety and Health Standards)
- Chapter 296-62 WAC (General Occupational Health Standards)
- Chapter 296-155 WAC (Safety Standards for Construction Work)
- Chapter 296-843 (Hazardous Waste Operations)

On certain federal properties, and on navigable waters, the corresponding federal regulations apply (29 CFR 1910 and 29 CFR 1926) with enforcement through the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA).

KEY POINT: PETROLEUM PRODUCTS ARE TOXIC AND THEIR VAPORS CAN BE EXPLOSIVE

Company cited for blast that killed man in Lacey

(Source: The Olympian, March 18, 2004)

A Vancouver-based company has been cited for numerous employee-safety violations in connection to an underground gas tank explosion that killed a worker in September.

The owners will face $15,300 in fines.

Company had been hired to repair a gas tank at a gas station on Ruddell Road. Robert Blackman, 43, of Portland died September 2nd while completing repairs inside a 12,000 gallon underground storage tank at the station. The explosion shot a fiery plume into the sky and launched Blackman about 40 feet from the tank.

The tank had been emptied and cleared of flammable vapors but the company mistakenly assumed the tank's ventilation system was isolated from other tank on the property, according to citations. The other tanks were connected to the same ventilation system, which allowed fumes to seep in while Blackman was working.

Assistance and copies of WISHA regulations may be obtained from the Labor and Industries' regional field service by calling 1-800-423-7233 or by going to the following web sites: http://lni.wa.gov/safety/rules/ and http://lni.wa.gov/Safety/Consultation/Consultants.asp.

For information on OSHA requirements, call the OSHA regional office at 206-757-6700 or visit their website at https://www.osha.gov/oshdir/r10.html.

4.3 Professional License Requirements

Under Washington State law, specifically Chapters 18.43 and 18.220 RCW, hydrogeologic investigations and engineering work must be conducted by, or under the direct supervision of, a licensed geologist or professional engineer qualified to conduct the work. Any site investigation/cleanup document containing geologic or engineering work (generally, interpretation of geologic or groundwater data, design calculations/plans, or as-built plans) must be submitted under the seal of an appropriately licensed professional. However, not all remedial action work requires a license. If you are unsure whether your work requires one of these licenses, please contact the applicable licensing board, identified below.

For additional information, refer to the following:

1. Geologists:
    - Statute: Chapter 18.220
    - Rules: Chapter 308-15 WAC
    - Licensing Board: http://www.dol.wa.gov/business/geologist/

2. Engineers:
    - Statute: Chapter 18.43
    - Rules: Title 196 WAC
    - Licensing Board: www.dol.wa.gov/business/engineerslandsurveyors/

In addition, under WAC 173-360-630, certain investigations and remedial actions for regulated underground storage tanks must be conducted under the supervision of a certified UST supervisor. Licensed engineers are exempt from this requirement.

4.4 Drilling Method and Boring/Well Installation Requirements

Well construction and soil borings are regulated by Ecology's Water Resources Program under WAC 173-160. The installation/construction of soil borings, vapor probes and extraction wells, groundwater monitoring wells and extraction systems (including direct push wells), and associated soil, water or gas sampling are considered well construction. A "Notice of Intent" for these installations must be filed with Ecology and 72 hours must pass after fees are paid before downhole sampling, or well construction of any kind, can begin. [3]

Furthermore, there are specific well labeling, reporting, construction and decommissioning requirements in WAC 173-160 that must be followed. See Ecology's rule governing well drilling at http://www.ecy.wa.gov/programs/wr/wells/wellhome.html.

Ecology recommends that direct push, hollow stem auger, sonic, or cable tool methods be used for soil and groundwater investigations. Test pits are also useful for shallow soil investigations, enabling direct observation of soil layers and contaminated zones but could end up generating significant quantities of contaminated soil that may need to be disposed of. Air rotary drilling is not recommended where soil sampling is being conducted unless geologic conditions don't allow the use of other methods, as this method can strip volatile components from the soil during the drilling process. Drilling fluids should not be used unless no other reasonable alternative exists

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[3] NOTE: HB 1467, passed in the 2011 legislative session added the following exemption to definition of a well (RCW 18.104.020(23)): "Inserting any device or instrument less than ten feet in depth into the soil for the sole purpose of performing soil or water testing or analysis or establishing soil moisture content as long as there is no withdrawal of water in any quantity other than as necessary to perform the intended testing or analysis." The application of this exemption to contaminated sites is still evolving but Ecology recommends that a licensed well driller be used whenever mechanical drilling equipment is used to install shallow soil borings or monitoring wells or to obtain samples at a site. Licensed drillers know how to log soil and groundwater conditions encountered during drilling, procedures to minimize cross-contamination, how to properly disposal of investigative derived wastes, and procedures for properly decommissioning a drill hole when it is no longer needed.

as these fluids can influence chemical and physical test results. At sites with extensive contamination, a combination of drilling methods will likely be necessary.

Direct push drilling technology is fast becoming the drilling method of choice at many sites where site conditions allow its use. [4] However direct push wells have significant limitations. Wells installed with direct push are often difficult to develop properly. Accordingly, direct push drilling is typically used to collect one-time groundwater samples to obtain a "snapshot" of site conditions. If recurrent well sampling is anticipated, another drilling method that enables installation of larger diameter, permanent monitoring wells should be considered. The well code contains a special section devoted to direct push well construction that should be consulted if that method is used (WAC 173-160-351). For a good description of direct push and other technologies for site characterization, see the following sources of information:

USEPA Cleanup Information webpage on Characterization and Monitoring.

http://clu-in.org/char1_tech.cfm

Chapter 15 in Ohio EPA's "Technical Guidance Manual for Hydrogeologic Investigations and Ground Water Monitoring" contains an excellent discussion of direct push technology. http://www.epa.ohio.gov/ddagw/tgmweb.aspx

For a study comparing the results of direct push wells versus traditional drilled wells, see Kram, et. al, (2001). http://www.clu-in.org/download/char/nfesc_dp_well_eval.pdf.

4.5 Expedited Site Assessment

Historically, site characterization has been done in stages or multiple phases, often by different consultants, which can result in added expense and reduced efficiency. "Expedited site assessment" is an alternative that can produce quality data in a single study conducted in a short period of time. Other terms for this concept include "*rapid site characterization*" or "*rapid site investigation.*" EPA's TRIAD approach (http://clu-in.org/triad/) is based on this same concept of using systematic planning, real-time measurement technologies (field screening) and dynamic work plans to characterize sites. This technique can often save time and money.

Expedited site assessments rely on or use:

- Information from previous site investigations, other nearby sites, and regional soil, geologic and groundwater studies
- Field screening instruments
- Where geologic conditions permit, direct push technology to sample both soil and groundwater

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[4] Direct push does not work well in dense glacial tills or soils with cobbles or buried debris.

- On-site, mobile laboratories or off-site fast turn-around analysis
- Experienced personnel to interpret data and make decisions in real time
- Higher up front budgets to cover the full cost of investigations

Expedited site assessments are now a mainstream practice for petroleum site characterization. Ecology generally supports the use of expedited site assessment techniques, when done appropriately, in characterizing petroleum-contaminated sites. At sites with work being conducted under an order or decree, check with your Ecology Cleanup Project Manager (site manager) about the appropriateness of using these techniques under the circumstances present at your site.

KEY POINT: EXPEDITED SITE ASSESSMENTS CAN SAVE TIME AND MONEY

The traditional multi-phased approach to petroleum site characterization is often less efficient and more costly. Instead, consider using expedited site assessment techniques to characterize source areas and down gradient plume boundaries.

4.6 Data Management

Environmental sampling data for all cleanup sites must be submitted both in printed form AND entered into Ecology's data management system (Electronic Information Management system or EIM system), consistent with procedures specified by Ecology and as required by WAC 173-340-840(5). Ecology staff will typically not issue a no further action opinion until it is confirmed the data has been entered into EIM.

The EIM system is Ecology’s main repository for electronic environmental monitoring data. It provides an accessible system for compiling and evaluating environmental monitoring data. The EIM system now includes a robust set of tools to allow Ecology staff, engineering consultants, and citizens to search for data for a specific site, a group of sites or within a geographic area. It includes statistical tools and mapping capabilities.

For further information on the EIM data management system, please see http://www.ecy.wa.gov/eim/index.htm.

4.7 Management of Investigative Wastes

The drilling of test borings and wells, digging test pits and sampling soil and groundwater will bring potentially contaminated soil, groundwater and waste materials to the ground surface where exposure can occur. These materials are often called “investigative wastes” or “investigation derived wastes.” Proper disposal of these waste materials is important as improper disposal can result in additional cleanup costs. Spreading contaminated drill cuttings or dumping purge water near monitoring wells could also increase sampling technicians’ exposure to contaminants and the potential for cross-contamination of equipment during future sampling events.

Arrangements for the proper containment and disposal of investigative wastes should be made well in advance of site investigations. Most waste handling facilities have specific requirements for testing materials prior to accepting them for disposal, so check with the receiving facility for its testing requirements.

All investigative wastes (drill cuttings and purge water) should be contained in drums or tanks until sample test results are received. If site investigation tests are insufficient to characterize the contents of the drum, the drum contents should be tested for the parameters specified in Section 7 of this guidance.

Storage of investigative wastes should be limited to a maximum of 90 days in a secure location unless the facility is specifically permitted to store such materials. If longer term storage of these wastes is anticipated, or large volumes are anticipated, see Subsection 11.3 of this guidance for additional information.

Make sure storage drums are labeled with the type and source of the materials in the drum. Labeling should be weather and vandal resistant. Storage locations should be checked weekly for security breaches, vandalism, and continued readability of labels.

KEY POINT: PROPERLY LABEL AND STORE ALL DRUMS OF INVESTIGATIVE WASTE!

Drums holding investigative waste should be stored in a secure area. All drums should be labeled with the following information:

- Description of contents (soil, water, waste)
- Boring/well source of material in drum
- Date material placed in drum
- Drilling company that did the work
- Company for which the investigation was conducted
- Contact information

Clean drill cuttings can be spread on the ground surface at the site. Contaminated drill cuttings should be disposed of at an appropriately licensed solid waste or hazardous waste facility.

Purge water from potentially contaminated monitoring wells should never be dumped on the ground near the wells or down storm drains. Instead, it should be drummed up until the sample test results have been received. Clean water with no detectable levels of contaminants can then be dumped on the ground in a location away from monitoring wells where it can soak in and not affect water level readings. There are several options for disposal of contaminated purge water, including:

- Discharge to a sanitary sewer or an existing on-site permitted industrial wastewater treatment facility with a discharge to surface water (not a septic system). Always obtain permission from the sewer utility or industrial treatment plant operator before considering this option. Pretreatment may be required.

- Trucked to a permitted municipal or industrial wastewater treatment facility.
- Treated on-site and discharged to the ground surface. A state waste discharge permit is required for discharges of contaminated water, even if treated to non-detectable levels prior to discharge.

See Subsection 11.2.5 for a more detailed discussion of water quality permit requirements.

Soils from backhoe test pits can typically be placed back into the test pit or trench from which they were generated. An exception would be if the digging reveals a layer of waste materials or obviously contaminated soil within a particular zone. These materials should either be placed in a container and removed from the site or (less preferred) placed back in the test pit or trench at approximately the same depth as they were found.

KEY POINT: FAILURE TO PROPERLY LABEL DRUMS HAS CONSEQUENCES

Hazmat crew in training gives real assignment 'both barrels'

The Reporter, (Vacaville, CA) - Wednesday, March 7, 2007
By: Melissa Murphy/Staff Writer

Suspicious-looking barrels found Tuesday behind the Mission Shopping Plaza in Fairfield provided real duty for a hazardous-material crew that was training at a nearby fire station.

A call was received a little after 10 a.m. from officials at a neighboring church who noticed that four barrels had been sitting outside for several months.

"We were ready to roll when we got the call," said Fairfield Assistant Fire Marshall Jerry Clark.

Ironically, the hazmat team, made up of Fairfield firefighters and police officers and Vallejo, Vacaville and Benicia firefighters, was already participating in its monthly training at Fairfield Fire Station 38.

Donning protective gear, the team carefully checked the content of each barrel. It turned out to be only water.

"We're not sure what exactly they're there for, but the guys had a really good exercise this morning," Clark said. "We try to err on the side of safety and expect the worst until it can be determined otherwise."

The barrels were to be hauled off later Tuesday.

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Melissa Murphy can be reached at mmurphy@thereporter.com.

4.8 Horizontal and Vertical Datum and Survey Precision and Accuracy

For property boundary surveys, the North American Datum of 1983, updated in 1991 (NAD83(1991)) is the horizontal datum standard that must be used (WAC 332-130 and RCW 58.20). As a best management practice, Ecology recommends this datum also be used for mapping all other site work.

Ecology also recommends that all upland site and sampling elevations be expressed in the North American Vertical Datum of 1988 (NAVD88). If a vertical control monument to NAVD88 is not reasonably available, use the National Geodetic Vertical Datum of 1929 (NGVD29) or a locally available datum. Sediment elevations and bathymetry in tidally influenced waters should be expressed relative to the mean lower low-water elevation.

These standards are intended to allow site measurements to be tied to regional topographic and water level information and to other nearby studies.

To facilitate site work, a site coordinate system should be established to tie the locations of points within the site relative to one or more on-site or near-site reference monument(s). The reference monument(s) should be established at a location that is unlikely to be disturbed by future remediation or site redevelopment activities and identified on the site map.

If it is cost prohibitive to establish coordinates and the vertical elevation of the reference monument(s) using conventional surveying methods or a survey-grade global positioning system, coordinates and elevations can be estimated using other methods. For example, using a non-survey grade GPS device to establish a benchmark location and elevation that is then used as a reference point for other measurements. Whatever method is used to establish the coordinates and elevation of the reference monument(s) and other site measurements, the method and its accuracy (survey closure or GPS equivalent) should be described.

Where feasible, measurements should be recorded with at least the following precision relative to an on-site reference monument:

- The horizontal location of objects and sampling locations should be measured to within 1.0 foot; For sediment sample locations not accessible by foot which require the use of a boat or other vessel, location data should follow guidance provided in Subsection 4.5.1, Station Positioning, in Ecology's Sediment Cleanup Users Manual II, Publication No. 12-09-057, available at https://fortress.wa.gov/ecy/publications/SummaryPages/1209057.html.
- The ground surface elevation at boreholes, monitoring wells and soil sampling locations should be measured to within 0.1 foot.
- For boring logs and backhoe test pits, sample depths should be measured to within 1.0 foot. For surface soil samples (generally the upper 2 feet), the sample depth should be measured to within 0.1 foot.
- For all monitoring wells, the vertical elevation of the reference point on the top of casing for water levels should be measured to within 0.01 foot. Subsequent water levels should be measured to within 0.01 foot from this reference point on the casing.

- For surface waters, the reference point on any staff gauge should be measured to within 0.01 foot. Subsequent water levels should be measured to within 0.01 feet where feasible (allowed by current or wave action).
- For sediment samples, the precision of vertical elevation measurements will depend on the softness of the sediments, depth below the water surface, and clarity of the water. For competent sediments accessible by foot, a precision of 0.1 foot should be achievable. For soft sediments and/or sample locations requiring the use of a boat or other vessel, a precision of 0.5 foot may be the best that is achievable.

For more information on horizontal and vertical datum and survey precision and accuracy see:

Washington State Department of Transportation Survey Manual
http://www.wsdot.wa.gov/Publications/Manuals/M22-97.htm

NOAA Technical Memorandum NOS NGS-58: Guidelines for GPS-Derived Ellipsoid Heights:
http://www.ngs.noaa.gov/PUBS_LIB/NGS-58.html

Standards and Guidelines for Land Surveying using Global Positioning System Methods, WA State Dept. of Natural Resources, 2004
http://www.dnr.wa.gov/Publications/eng_plso_gps_guidebook.pdf

Geometric Geodetic Accuracy Standards and Specifications for using GPS Relative Positioning Techniques, Federal Geodetic Control Committee, 1989
http://www.ngs.noaa.gov/PUBS_LIB/GeomGeod.pdf

5.0 Field Screening

The objective of this chapter is to provide background information and best management practices for field screening methods. Ecology recommends that field screening methods supplement and guide traditional site characterization work. This is because these methods can provide real-time information to target problem areas and make real time decisions, saving time and money in the site investigation. With field screening there is no need to wait until sample analyses come back from the lab before deciding what to do next.

Before conducting any field work, including field screening, it is important to conduct a thorough review of the site history and available information (see Table 6.2 for more detail):

- Interview people associated with the site.
- Locate all process and UST system components.
- Conduct a preliminary site visit.
- Identify areas where releases have occurred or have likely occurred.
- Evaluate site logistics (underground and overhead utilities, power availability, water availability, necessary safety precautions, vehicle access points, etc.).

5.1 Quality Assurance for Field Screening Methods

Ecology recognizes that most field screening methods will yield qualitative information. Even so, some level of quality assurance needs to be identified for field screening methods. The level of quality assurance will depend upon the objectives of the sampling. Table 5.1 provides examples of data quality objectives (DQOs) for field screening methods and a corresponding level of quality assurance.

Table 5.1 Example Data Quality Objectives (DQOs) and Quality Assurance (QA) for Field Sampling Methods

DATA QUALITY OBJECTIVE (DQO)	LEVEL OF QUALITY ASSURANCE
Qualitative: is contamination present?	Low (for example, the sheen and jar test)
Semi-qualitative: what are approximate concentrations?	Low to Medium (for example, headspace analysis, colormetric methods)
Is the field screening data reproducible?	Medium to high (use split samples, sequential samples, sample blanks)
Is the field screening data quantitative?	High (use mobile laboratory with full QA protocols)

Table 5.1 Example data quality objectives (DQOs) and quality assurance (QA) for field sampling methods.

If the objective of the sampling is qualitative (for example, a sheen test with a yes / no decision on whether petroleum is present), then extensive quality assurance is unnecessary. Conversely, if the objective of the sampling is to provide quantitative test results, then a high level of quality assurance will be needed in the field screening effort.

EPA has published guidance on demonstrating the applicability of field screening methods under the Triad Program. This guidance can be found at http://brownfieldstsc.org/pdfs/Demonstrations_of_Methods_Applicability.pdf.

KEY POINT: USE FIELD SCREENING METHODS TO GUIDE LABORATORY ANALYSES

By law, you are required to use EPA or state-approved analytical methods and accredited laboratories for analysis of representative samples from a site. [5] However, not every sample needs to be analyzed in a laboratory to adequately characterize a site. Ecology recognizes that field screening methods do serve a useful and important function in screening which samples should be analyzed in a laboratory.

Sampling plans should address use of field methods to determine which samples must be analyzed in a lab. At sites with investigations being conducted under an Order or Decree, work with the Ecology Cleanup Project Manager (site manager) to develop decision making criteria before the investigation begins. At sites conducting independent remedial actions, the site investigator should document the field screening methods and decision criteria used in the report submitted to Ecology.

5.2 Soil Gas Surveys

Before starting the site characterization, consider doing a soil gas survey to identify source areas. There are two types of soil gas surveys: active and passive. In an active survey, vapor concentrations are measured by pumping air from a pipe or tube inserted into the ground thorough a vapor detector. In a passive survey, a device is left in the ground that absorbs vapors over time. See Chapter IV, Soil Gas Surveys in: “Expedited Site Assessment Tools for Underground Storage Tank Sites”, available at http://www.epa.gov/ust/expedited-site-assessment-tools-underground-storage-tank-sites-guide-regulators.

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[5] WAC 173-340-830(3)

5.3 Field Screening Methods[6]

A wide variety of field screening methods and equipment are available. The following are brief descriptions of the more common methods. Use the internet and vendor information to obtain the latest information on specific equipment. The methods are grouped from the easiest to hardest to use. These methods can be used on soil and water samples obtained by surface sampling, backhoe test pits, push technology or through more traditional drilling methods.[7]

5.3.1 Visual Screening

Visual screening consists of inspecting the soil for stains indicative of petroleum-related contamination. Visual screening is generally more effective when contamination is related to heavy petroleum hydrocarbons such as used motor oil, hydraulic fluids, or bunker fuels, or when hydrocarbon concentrations are high.

5.3.2 Sheen Test

Water sheen screening involves placing about one tablespoon of soil in a pan of water (such as a gold pan) and observing the water surface for signs of a petroleum sheen. To enhance visual observations, a small amount of hydrophobic dye can be dropped on the water. The dye, which is soluble in oil but insoluble in water, will cause the oil to change color, making visual detection easier. Sheens observed are classified in Table 5.2. Sheen screening is most effective at detecting middle distillate (diesel) and heavy end fuels and oils with low solubility. It will not detect low levels of volatile contaminants and thus should not be used by itself to screen for these contaminants.

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[6] Mention of specific products or methods does not constitute an endorsement by Ecology.
[7] See http://www.clu-in.org/characterization/ for more information.

Table 5.2 Sheen Test Descriptors
NS (no sheen) No visible sheen on the water surface.
SS (slight sheen) Light, colorless, dull sheen; spread is irregular, not rapid. Natural organic oils or iron bacteria in the soil may produce a slight sheen.
MS (moderate sheen) Pronounced sheen over limited area; probably has some color/iridescence; spread is irregular, may be rapid; sheen does not spread over entire water surface.
HS (heavy sheen) Heavy sheen with pronounced color/iridescence; spread is rapid; the entire water surface is covered with sheen.
NOTE: False positive results may be generated by the presence of decaying organic matter and iron bacteria, which can produce a rainbow-like sheen similar to an oil sheen. These sheens, unlike oil sheens, can typically be broken up when agitated or disturbed. Source: Presented with the permission of Steve Perigo, Pyramid Consulting

Table 5.2 Sheen test descriptors.

5.3.3 Non Aqueous Phase Liquid (NAPL) Jar Tests

A simple jar test can sometimes be helpful in identifying soil samples containing petroleum NAPL. This is done by mixing soil and water in a jar and then visually checking for free product or NAPL. Cohen et al. (1992) found that adding a hydrophobic dye to the jar, followed by UV fluorescence, is the most simple and effective means for visual detection of NAPL in a soil sample.

5.3.4 Headspace Vapor Analysis

Headspace vapor screening involves placing a soil or water sample in an enclosed container and measuring the vapors with an organic vapor detector, usually a flame ionization detector (FID) or photo ionization detector (PID). Table 5.3 lists several advantages and disadvantages of FID and PID detectors.

Headspace vapor screening generally is only effective in detecting volatile hydrocarbons. These measurements provide a qualitative indication of soil contamination.

Table 5.3 Advantages and Disadvantages of FID and PID Detectors
Flame Ionization Detectors (FID)
• Useful for gasoline and most middle distillates (Table 7.1). • Wide detection range. • Must have an abundant oxygen supply to avoid flame-out. • Concentration readings depend on instrument flow rate. • Must fully purge the instrument between sample analyses. • Methane gas may bias results.
Photo Ionization Detectors (PID)
• Useful for gasoline spills, but less so for diesel spills. • Water vapor and high humidity can suppress response to organic vapors. • The proper UV lamp must be selected to detect hydrocarbons. • Responses are suppressed when exposed to high level gasoline or carbon dioxide vapors. • Lower response for weathered fuels. • Response can be affected by electrical interferences, e.g., power lines. • Cannot detect methane gas and thus should be used in conjunction with an FID.
Source: Robbins et al. (1996) and manufacturer's information. This is not intended to be a complete list.

Table 5.3 Advantages and disadvantages of FID and PID detectors.

In one technique, about one to two cups of soil are placed in a plastic bag. Air is captured in the bag, and it is sealed. The bag is shaken to volatilize contaminants in the soil. The probe of an instrument designed to measure vapors is then inserted into the bag and the vapor concentration is measured.

In another technique, a jar is partially filled with soil or water, and then covered with aluminum foil. Vapors are then measured by poking the probe of a FID or PID detector through the aluminum foil.

When using these techniques, it is important to use a consistent technique for all samples at a site as there are a number of factors that can cause the results to vary. Factors that can influence jar headspace test results are summarized in Table 5.4. For these reasons, these tests should not be considered as providing quantitative results.

An example jar headspace protocol is provided in the State of Massachusetts UST Manual, available at http://www.mass.gov/eea/docs/dep/water/drinking/alpha/i-thru-z/uicjar.doc.

Table 5.4 Factors Influencing Jar Headspace Test Results

- ***Soil to headspace ratio:*** Readings increase with increasing amounts of soil in the jar. Also, larger jars (e.g., mason jars) resulted in higher vapor readings.
- ***Agitation (jar shaking):*** Vigorously agitating (shaking) the jar resulted in higher vapor readings.
- ***Temperature:*** Lower temperatures increase the time for the vapors in the jar to equilibrate with the soil. In cold weather (below 50 degrees F), it is helpful to warm the samples by placing them on the hood of a heated vehicle or on another heated surface (but not within the vehicle cab to avoid potential exposure) before taking a FID/PID reading.
- ***Equilibration time:*** Increasing equilibration time can result in higher vapor readings.
- ***Sampling:*** High flow rates can dilute sample results. Once the aluminum foil is pierced with the organic vapor detector tip, outside air is immediately drawn into the jar, diluting vapor concentrations. The amount of dilution depends upon the flow rate of the detector and the size of the aluminum foil hole.

Source: Robbins, et al. (1996); Fitzgerald (1993) and North Dakota Dept. of Health (2002)

Table 5.4 Factors influencing jar headspace test results.

5.3.5 Colormetric Test Kits / Immunoassays

There are a variety of test kits for qualitative contamination assessment. These methods are relatively easy to use and have a low cost per sample. In general, these methods extract a soil sample using methanol or some other organic solvent. Both methods then involve mixing the extract with a catalyst/enzyme that reacts with the solution to create a color. The intensity of the color is then measured to estimate the sample concentration. Some methods use paper strips immersed in the sample to estimate sample concentration. There are a wide variety of proprietary products available that purport to measure petroleum product concentrations. While some have impressive claims for detection limits, Ecology recommends that these methods be used only for order of magnitude estimates of concentration, with confirmation through laboratory analyses.

http://www.clu-in.org/characterization/technologies/color.cfm

http://www.clu-in.org/characterization/technologies/immunoassay.cfm

5.3.6 Fiber Optic Chemical Sensors (measures TPH)

Fiber optic chemical sensors are emerging as a tool to screen soil, vapors or water for hydrocarbon contamination. This method measures the intensity of light from a light emitting diode passing through a fiber optic cable to a probe. Hydrocarbons adsorbed onto the probe affect the intensity of the light, which is converted to a measurable electrical current and concentration.

Laser Induced Fluorescence devices are fiber optic sensors attached to the tip of a cone penetrometer. Light at a specific wavelength is generated from a laser and then passed down a fiber optic cable to a window in the tip of the cone penetrometer string. The cone penetrometer is then advanced through the subsurface. The laser light excites two- or three-ring aromatic compounds or polycyclic aromatic hydrocarbons (PAH), in the soil adjacent to the window, causing them to fluoresce. The relative response of the sensor depends on the specific analyte being measured because of the varying ratios of PAHs in each hydrocarbon mixture. The induced fluorescence from the PAHs is returned over a second fiber to the surface where it is quantified using a detector system.

Fiber optic chemical sensors have been found to be most useful for detecting very high concentrations of hydrocarbons in fine-grained soils where NAPL is more challenging to identify using other more conventional methods. They are also particularly useful in identifying thin layers of contamination migrating through permeable lenses in heterogeneous environments where discrete sampling may miss these zones.[8]

http://www.sandia.gov/sensor/MainPage.htm

http://www.clu-in.org/char/technologies/focs.cfm

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[8] Personal communication, John H. McCorkle, Cardno, ERI.

5.4 Field or Mobile Laboratories

Field or mobile laboratories can range from small trailers with simple analytical equipment to fully-equipped, accredited environmental laboratories that are comparable to a fixed laboratory. Mobile laboratories allow the site investigator to make real-time decisions as the investigation proceeds. Mobile laboratories can even provide higher quality data than a fixed lab due to a shorter sample holding time, less opportunity for problems during sample collection and transport, and the ability to adjust analytical methods to site-specific conditions as information is learned during the investigative process (e.g. changing the suite of chemicals being tested for, sampling protocols, sample preparation methods, or laboratory instrumentation).

The use of EPA sample preparation and analytical methods with adequate quality assurance is the key to the acceptance of quantitative data from a mobile laboratory.

6.0 Conducting an Effective Site Characterization

The objective of a site characterization is to define the horizontal and vertical zone impacted by the petroleum release. That is, characterizing the site means defining the nature and extent of the contamination in three dimensions.

Over the last decade, a number of studies have been conducted on the inadequacy of petroleum site characterization. For example, in their study of Arizona LUST sites, Dahlen et. al. (2003) found that:

- A predominant groundwater flow direction was not accurately determined at some 70% of the sites investigated.
- At sites where the groundwater direction was known, only 16% of all monitoring wells (1 in 6) were classified as being down gradient of the source zone (30% of the sites had no down gradient wells and 60% had only 1-2 wells).
- Due to the inability to accurately identify groundwater flow direction and the lack of down gradient wells, it was not possible to accurately identify the extent of down gradient contamination.

Ecology’s experience has been similar in Washington State, where petroleum-contaminated sites are often found to be inadequately characterized. In addition to the above inadequacies, we’ve observed investigations with:

- Drilling to pre-selected depths and locations with no consideration of conditions encountered during site investigations or groundwater flow direction.
- Installation of long-screened monitoring wells that provide inaccurate water level readings when strong vertical gradients exist, resulting in an inaccurate water table and no ability to assess vertical gradients or vertical transport of contaminants.
- Incomplete assessment of entrapped product or concentration variability with depth.
- Stopping the investigation at the property boundary in spite of clear indications the contamination extends beyond the property boundary.
- Sample handling and storage techniques inadequate for assessment of volatile compounds.
- Failure to analyze samples for all required contaminants.
- Use of analytical methods with reporting limits higher than cleanup levels.

Poor information can result in delays in decision-making, costly additional investigations, and inaccurate cleanup cost estimates.

This section is intended to help investigators avoid problems by providing guidance for better characterization of petroleum-contaminated sites.

6.1 Immediate Risk Evaluation

The first step in the site investigation process is an immediate risk evaluation. Some issues to consider when conducting an immediate risk evaluation of petroleum releases include:

- Are there any fire or explosion hazards?
- Do subsurface vapors present immediate human health risks (inhalation)?
- Has free product infiltrated into storm drains or along the backfill around these or other subsurface utilities?
- Are there any residential or municipal drinking water wells immediately down gradient of the site? Are there any plastic water lines that contaminants could permeate into?
- Has free product been observed in any monitoring wells or test pits?
- Is there an oily sheen on surface water bodies or wetlands near the site?
- Can all or a majority of the contamination be removed as part of the initial response?

If the answer to any one of these questions is yes, then an interim action should be conducted to mitigate the immediate threat to human health and the environment. In addition, for regulated UST facilities, WAC 173-340-450(2) and (3) and Subsections 3.3.2 and 3.3.3 of this Guidance describe the actions that <u>must</u> be taken within the first 24 hours and subsequent 20 days of confirmation of an UST release.

6.2 Regulatory Requirements for Remedial Investigations

Section 3 of this guidance describes the requirements for investigating releases from regulated underground storage tanks. Should these investigations confirm the need for a more detailed remedial investigation, or should preliminary investigations at other nearby petroleum-contaminated sites find a release, additional work will need to be conducted to characterize the site as described in this section. The specific requirements for remedial investigations are described in WAC 173-340-350(7). In general, a remedial investigation must include the information in Table 6.1. The actual scope will vary depending on site-specific conditions.

Table 6.1 General Categories of Information Required for Remedial Investigations (WAC 173-340-350(7))

- General facility information (Appendix A)
- A site conditions map (Appendix A)
- Field investigations sufficient to characterize: (Section 6 of this guidance)
    - Surface water and sediments
    - Soils
    - Geology and groundwater system characteristics
    - Air Quality and Vapor Characterization
    - Land use
    - Natural resources and ecological receptors
    - Hazardous substances sources
    - Regulatory classifications of affected media
- Safety & health plan (Subsection 4.2);
- Sampling and analysis plan (Subsection 6.4)
- Sufficient information for the lead agency to conduct an analysis under the State Environmental Policy Act (SEPA) (Subsection 11.2.1)
- Other information as necessary to adequately characterize the site
- Must conform to the general submittal requirements in WAC 173-340-840 (Appendix A)

Table 6. 1 General categories of information required for Remedial Investigations (WAC 173-340-350(7)).

6.3 Use of a Conceptual Site Model

The first step in conducting an effective site characterization is to develop an initial conceptual site model. A conceptual site model is a visual or narrative tool that is used to describe or map:

- Known and suspected sources of contamination
- Types and concentrations of contaminants
- Potentially contaminated media
- Known and potential routes of exposure or “exposure pathways”
- Current and potential future impacted land and resource uses
- Persons and environmental receptors that could be exposed to the contaminants (human and environmental receptors)

A conceptual site model is used to guide the site characterization process by identifying what to test for, where to test, and other information needed to understand the site impacts and design a remedy to address these impacts. Development of a conceptual site model for a site is an iterative process. Information acquired during the site investigation can be used later in the investigative process to refine the model.

KEY POINT: A CONCEPTUAL SITE MODEL IS NOT STATIC

The formulation of a good conceptual site model is a dynamic process – it will evolve as new information about the site is learned during the remedial investigation. If the investigation is done in phases, the model may change as contaminant concentrations change over time due to contaminant migration and degradation.

Examples of conceptual site models for a commercial gas station are provided in Figures 6.1 and 6.2. Figure 6.1 is presented in the form of a schematic; Figure 6.2 is presented in the form of a visual depiction of the site.

Ecology recommends the following process for developing a conceptual site model:

- Review existing site information
- Visit the site
- Conceptualize (visualize) the site
- Identify potential exposure pathways and develop preliminary cleanup levels
- Identify potential remedial options

Details on each of these components are discussed in the following subsections.

6.3.1 Conceptual Site Model – Review Existing Information

Prior to conducting any field work, it is important to conduct a thorough review of all relevant background information related to the site. This is extremely important as information from past investigations doesn't always make its way into later investigations, resulting in duplication of earlier testing and added expense. If a site check or site assessment has already been completed for the site, review this and available historical information and then conduct a reconnaissance site visit to determine the scope of additional investigation needed to adequately characterize the site. ***See table 6.2 for potential sources of site information.***

KEY POINT: CHECK HISTORICAL DATA!

Always check historical data before doing any field work.
Don't assume that it is no longer valid or of little use!

Figure 6.1 Commercial gas station schematic conceptual site model.

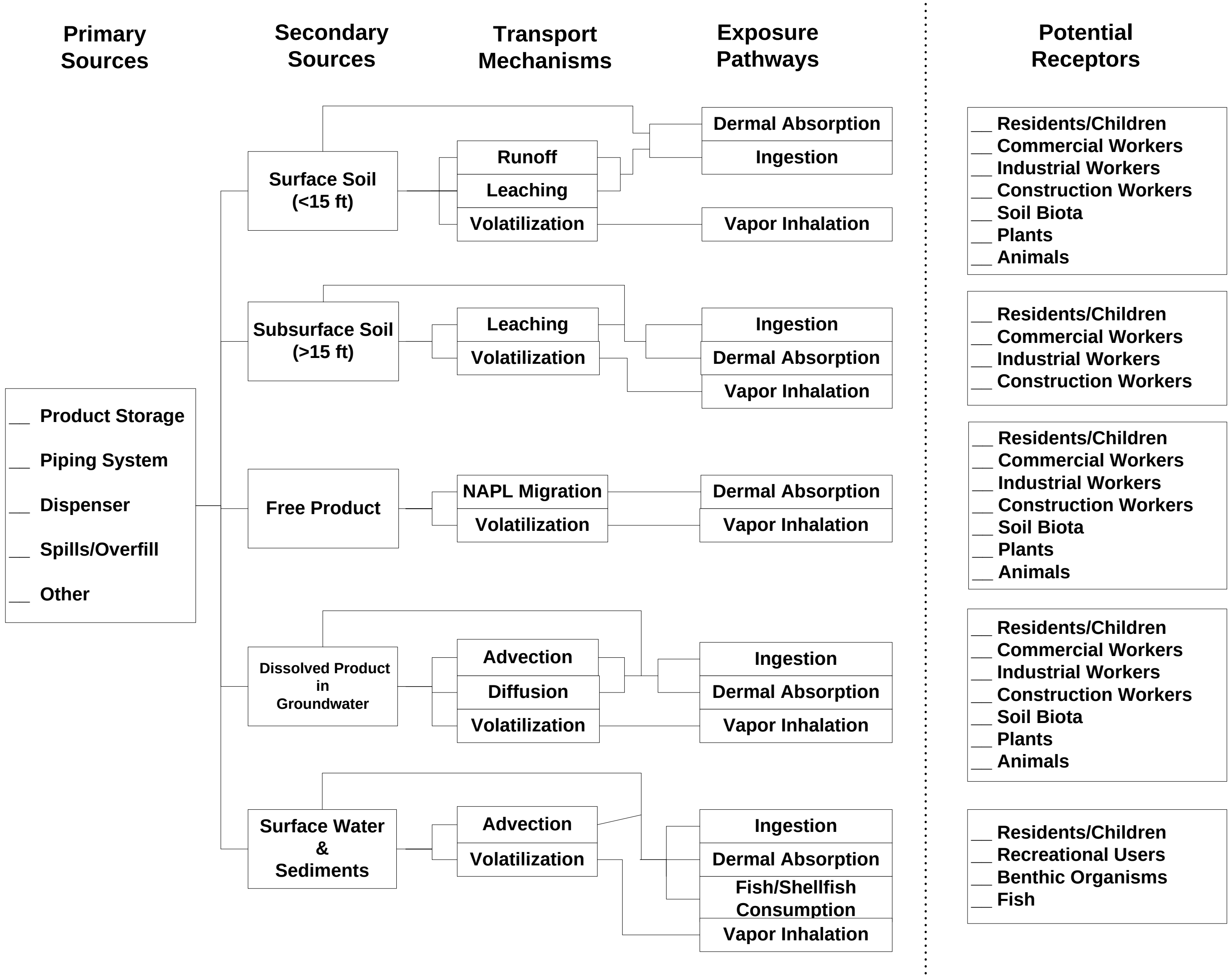

Figure 6.2 Commercial gas station visual depiction of conceptual site model (courtesy of Hun Seak Park).

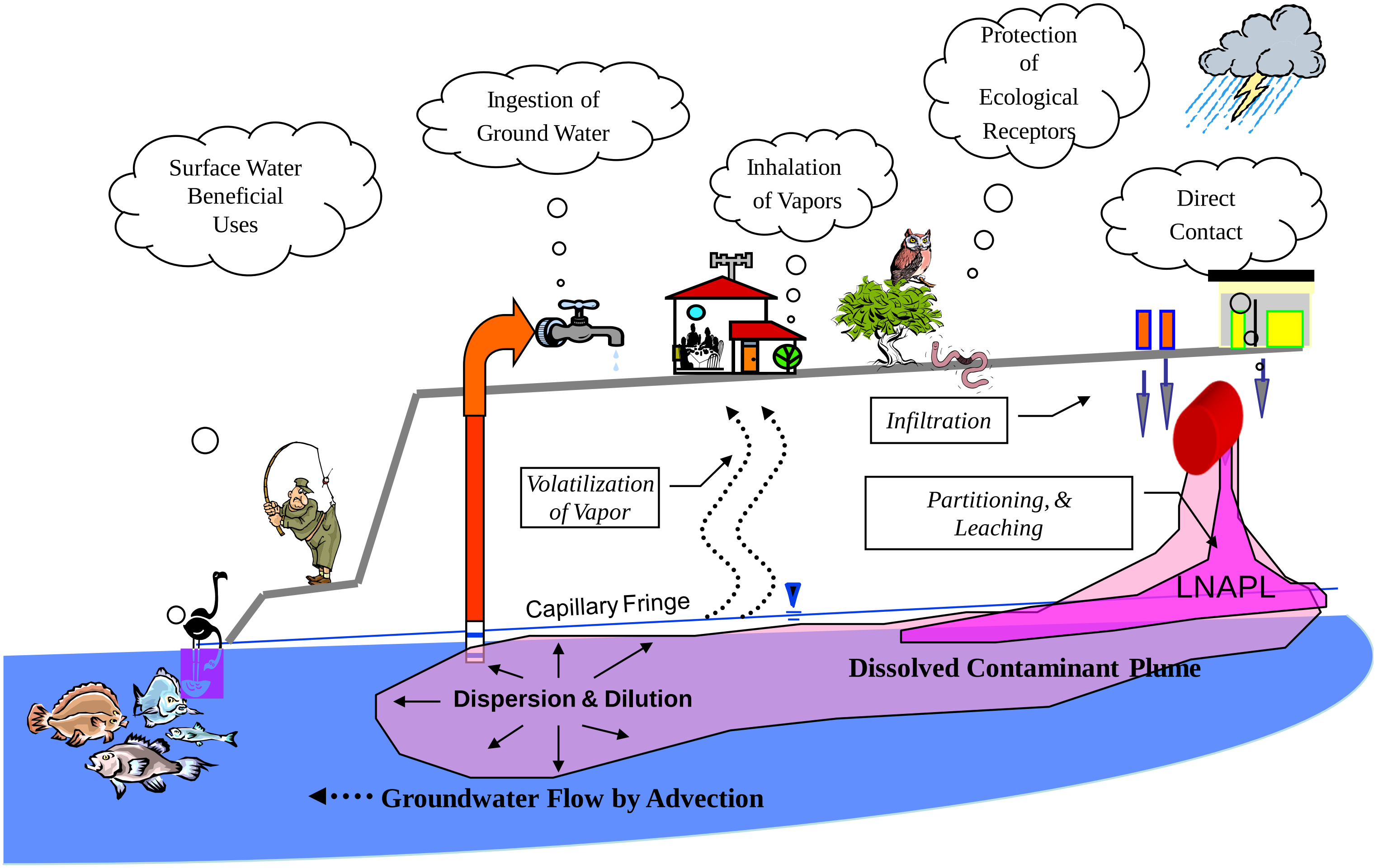

Table 6.2 Potential Sources of Site Information

Regulatory Reports, Files and Information:

- Review Ecology, EPA, County Health Department/District, local land use permitting agency and fire department files related to the facility. Look for information about the site and for nearby contaminated sites and facilities. There are a variety of private companies that search available databases for a fee. Ecology's database can be found at https://fortress.wa.gov/ecy/gsp/SiteSearchPage.aspx.
- Review construction plans for the facility to locate underground tanks and connecting piping, filling and off-loading locations. Historic fire insurance maps may also be of use. These maps are available for purchase through http://www.sanborn.com/. They may also be accessed at many public libraries and universities as part of their collections or through "ProQuest".
- Review County assessor records for lot lines and property ownership history.
- Contact the local land use agency for a copy of that portion of the comprehensive plan and zoning documents governing use of the property and nearby areas.
- Call 811 or (800) 424-5555 to locate all underground utilities.

Historical Documents:

- Review historical photographs and directories. There are many public and private sources of historical aerial photos. State and local museums and libraries may have records or ground level photos of the facility. The Washington State Library is a good place to start http://www.sos.wa.gov/library/

Topographic and Geologic Information:

- Review available surface topographic maps for the facility and surrounding area. The USGS is a good source of low resolution maps. Other potential sources include local government records, previous reports for the site and on other nearby contaminated sites and facilities. Using these images and a site visit, identify the likely direction of groundwater flow and nearby surface water bodies, wetlands, drainage ditches and other areas where runoff from spills could accumulate.
- There are a variety of regional geologic and groundwater reports and site-specific studies available on-line. Local health departments and water purveyors may also be aware of other available studies. Some useful links:
  - √ National Resource Conservation Service soils maps near surface soils (upper 6 feet)
http://websoilsurvey.nrcs.usda.gov/app/
  - √ United States Geological Survey (USGS)
http://www.usgs.gov/state/state.asp?State=WA
  - √ Ecology's Watershed Inventory Resource Areas
http://www.ecy.wa.gov/water/wria/
  - √ Local Health Departments (See Dept. of Health web page providing links)
http://www.doh.wa.gov/AboutUs/PublicHealthSystem/LocalHealthJurisdictions
  - √ Local water purveyors (see Dept. of Health web page on Group A and B systems)
http://www.doh.wa.gov/DataandStatisticalReports/EnvironmentalHealth/DrinkingWaterSystemData
http://mrsc.org/getdoc/fdbaee22-e491-4b33-b5cf-5fe65f66410c/Washington-Water-and-Sewer-Districts-Listed-by-Cou.aspx
  - √ Ecology's water supply bulletins
http://www.ecy.wa.gov/programs/eap/wsb/index.html

Interviews

- Interview personnel associated with the site, former employees, neighbors, adjacent business owners and persons involved with previous site investigations.

Table 6.2 Potential sources of site information.

6.3.2 Conceptual Site Model – Visit the Site

Once historical information has been compiled, visit the site. Examples of what to look for while on site include:

- Previous sampling locations, including identifying of any pre-existing monitoring wells
- Signs of potential sources of contamination such as filler pipes for USTs, above ground storage tanks, underground piping, staining of soil, dead vegetation, odors
- Underground utilities that may be conduits for contaminant migration
- Current land use of the site and surrounding area
- Ecological resources that may be impacted by the site, including nearby surface water and wetlands and undeveloped/vegetated areas.

As part of a site visit, evaluate logistics that could impact the investigation, such as property boundaries, right of ways, underground utilities, overhead power lines, building locations, access points, pedestrian and traffic patterns, etc.

6.3.3 Conceptual Site Model – Conceptualize (visualize) the Site

Using the background information and observations from the site visit, sketch out a plan view of the site. Illustrate potential source areas and the major physical features of the site including: buildings; streets and paved areas; surface waters and wetlands; and vegetated areas. Indicate the anticipated direction of groundwater flow and areas of groundwater recharge and discharge. Next, sketch conceptual east-west and north-south cross-sections illustrating the sources of contamination, subsurface utilities, soil types likely to be encountered, anticipated depth of water bearing layers, nearby surface waters and wetlands, building basements, and water supply wells.

This initial conceptualization of the site will be refined with the information acquired from field investigations.

6.3.4 Conceptual Site Model – Determine Potential Exposure Pathways and Preliminary Cleanup Levels

To determine the appropriate analytical methods for analyzing samples obtained from the site, target concentrations for each contaminant of concern need to be identified. These target concentrations should be based on the anticipated cleanup levels expected to apply to potentially impacted media at the site.

Under MTCA, cleanup levels are based on reasonable maximum exposure scenarios or potential routes of exposure that are spelled out in the MTCA rule. The reasonable maximum exposure is defined as “the highest exposure that can reasonably be expected to occur for a human or other living organisms at a site under current and potential future site use”. [9] It includes both current and potential future exposure routes.

The most common exposure scenarios for petroleum-contaminated sites are identified in Table 6.3. Cleanup levels are based on the most stringent concentration for the various exposure pathways. Additional information on calculation of cleanup levels is provided in Section 8.

Table 6.3	**Common Exposure Pathways at Petroleum-Contaminated Sites**
Soil	Direct contact by construction workers and residents; leaching to underlying groundwater or nearby surface water; runoff/erosion into nearby surface water; direct contact by plants & animals; migration of vapors into overlying structures
Groundwater	Drinking water use; migration of vapors into overlying structures; discharge to surface waters
Surface Water	Contact by persons and aquatic organisms with contaminated sediments and surface water; consumption of fish, shellfish and other aquatic organisms
Air/Vapors	Breathing vapors by workers/residents; exposure to utility workers

Table 6.3 Common exposure pathways at petroleum-contaminated sites.

6.3.5 Conceptual Site Model--Identify Potential Remedial Options

Once potential exposure pathways have been identified for the site, potential remedial options should be identified. This is important because some remedial options may require specific data or measurements in order to evaluate their feasibility. With modest adjustments to the investigation, it may be possible to address many of these data needs, limiting the need for subsequent sampling events or at least limiting the scope of these subsequent events.

Additional information on potential remedial options for petroleum-contaminated sites and the data needed to support design of these options is provided in Chapter 11.

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[9] WAC 173-340-200.

6.4 Sampling and Analysis Plan

After developing a conceptual site model, the next step is to construct a sampling and analysis plan that fills in the data gaps identified in the initial conceptual site model. A Sampling and Analysis Plan specifies the process for obtaining environmental data of sufficient quantity and quality to characterize the site. This plan explains "what to do" and "how to do it." Specifically, the sampling and analysis plan provides details on:

- How samples will be collected
- Number and location of samples
- Analytical procedures, including target detection limits and practical quantitation limits.

A Sampling and Analysis Plan must be prepared prior to initiating field sampling activities. This plan does not need to be a separate document. At many petroleum-contaminated sites it can be incorporated into other work plans. MTCA has specific requirements for sampling and analysis plans. See Table 6.4 for a summary of those requirements.

Sites with sediment contamination have another level of complexity that will need to be addressed in the sampling and analysis plan. See Subsection 6.7 of this guidance for a brief discussion of this topic and references.

KEY POINT: GOOD SAMPLING AND ANALYSIS PLANS SAVE MONEY

Poorly crafted Sampling and Analysis Plans are the root cause of many poor or unusable site characterization data. Not carefully planning sampling activities may result in wasted time and money! Ecology highly recommends that adequate time and budget be invested up front to prepare a good Sampling and Analysis Plan to minimize the need for subsequent site investigations to fill in data gaps.

Table 6.4 MTCA Sampling and Analysis Plan Rule Requirements under WAC 173-340-820

(1) Purpose. A sampling and analysis plan is a document that describes the sample collection, handling, and analysis procedures to be used at a site.

(2) General requirements. A sampling and analysis plan shall be prepared for all sampling activities that are part of an investigation or a remedial action unless otherwise directed by the department and except for emergencies. The level of detail required in the sampling and analysis plan may vary with the scope and purpose of the sampling activity. Sampling and analysis plans prepared under an order or decree shall be submitted to the department for review and approval.

(3) Contents. The sampling and analysis plan shall specify procedures that ensure sample collection, handling, and analysis will result in data of sufficient quality to plan and evaluate remedial actions at the site. Additionally, information necessary to ensure proper planning and implementation of sampling activities shall be included. References to standard protocols or procedures manuals may be used provided the information referenced is readily available to the department. The sampling and analysis plan shall contain:

(a) A statement on the purpose and objectives of the data collection, including quality assurance and quality control requirements;

(b) Organization and responsibilities for the sampling and analysis activities;

(c) Requirements for sampling activities including:

- **(i)** Project schedule;
- **(ii)** Identification and justification of location and frequency of sampling;
- **(iii)** Identification and justification of parameters to be sampled and analyzed;
- **(iv)** Procedures for installation of sampling devices;
- **(v)** Procedures for sample collection and handling, including procedures for personnel and equipment decontamination;
- **(vi)** Procedures for the management of waste materials generated by sampling activities, including installation of monitoring devices, in a manner that is protective of human health and the environment;
- **(vii)** Description and number of quality assurance and quality control samples, including blanks and spikes;
- **(viii)** Protocols for sample labeling and chain of custody; and
- **(ix)** Provisions for splitting samples, where appropriate.

(d) Procedures for analysis of samples and reporting of results, including:

- **(i)** Detection or quantitation limits;
- **(ii)** Analytical techniques and procedures;
- **(iii)** Quality assurance and quality control procedures; and
- **(iv)** Data reporting procedures, and where appropriate, validation procedures.

The department shall make available guidance for preparation of sampling and analysis plans.

See the following publications for additional guidance:

Quality Assurance Project Plans: http://www.ecy.wa.gov/biblio/0403030.html

Sediment Cleanup Users Manual: https://fortress.wa.gov/ecy/publications/summarypages/1209057.html

Table 6.4 MTCA Sampling and Analysis Plan rule requirements.

6.5 Data Quality Objectives

While not required under MTCA, Ecology recommends that EPA's data quality objectives (DQOs) process be considered during the development of the Sampling and Analysis Plan.

EPA defines Data Quality Objectives as a process that: [10]

> *"…is used to develop performance and acceptance criteria (or data quality objectives) that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions."*

EPA has identified a seven step process for identifying DQOs. It is intended to provide a systematic approach for designing a sampling and analysis plan. The level of detail and effort needed to identify DQOs will vary depending on the complexity of the site. For simple sites,[11] use the steps in Table 6.5 as a checklist to think through prior to developing the sampling and analysis plan. For more complex sites, document the steps in the DQO process in the sampling and analysis plan.

Additional information on DQOs can be obtained from the following sources:

Pacific Northwest National Laboratory, Visual Sample Plan
http://vsp.pnnl.gov/dqo/

How EPA Manages the Quality of its Environmental Data
http://www.epa.gov/quality

Guidance on Systematic Planning using the Data Quality Objective Process, EPA QA/G-4. EPA/240/B-06/001. USEPA, February, 2006.
http://www.epa.gov/fedfac/guidance-systematic-planning-using-data-quality-objectives-process

KEY POINT: SAFETY FIRST!

Prior to conducting field work, a Safety and Health Plan and Sampling and Analysis Plan must be prepared. See Subsections 4.2 and 6.4 of this guidance for additional information on these plans.

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[10] Guidance on Systematic Planning using the Data Quality Objective Process, EPA QA/G-4. EPA/240/B-06/001. USEPA, February, 2006.

[11] Like those with soil and minor groundwater contamination where Method A cleanup levels will be used.

Table 6.5 EPA's Seven Step Data Quality Objectives (DQO) Process (1)
Step 1: State the Problem Using a conceptual site model, describe the sources and types of contamination and expected concentrations to be encountered, likely transport mechanisms, receptors and exposure routes.
Step 2: Identify the Goals of the Study Identify questions/data gaps to be addressed by the study ("study questions").
Step 3: Identify Information Inputs Identify data and information needed to answer study questions. (For example, media needing to be sampled, likely cleanup levels, analytical methods, detection limits and practical quantitation limits.)
Step 4: Specify Study Boundaries Define the geographic boundaries of the study area, population of interest (for ecological and human health studies), timeframe for completing the study and other constraints.
Step 5: Define Decision Criteria Develop if / then statements by which the final decision will be made. (For example, if groundwater contamination is found in wells along the property boundary, then the investigation will need to be expanded to include off property areas.)
Step 6: Specify Error Limits Specify what level of certainty is needed to make a cleanup decision. (For example, laboratory recovery rates, whether a 1-time sample is sufficient or multiple samples are needed to address variability over time.)
Step 7: Develop the Sampling and Analysis Plan Incorporate the above information into the sampling and analysis plan.
(1) Based on "Guidance on Systematic Planning using the Data Quality Objective Process, EPA QA/G-4". EPA/240/B-06/001. USEPA, February, 2006. http://www.epa.gov/fedfac/guidance-systematic-planning-using-data-quality-objectives-process.

Table 6.5 EPA's seven step data quality objectives (DQO) process (1).

6.6 General Facility Information and Map

Compile information describing the facility and current site conditions. See Appendix A for a list of recommended information.

6.7 Surface Water and Sediment Characterization

Sufficient surface water and sediment sampling should be conducted to adequately characterize the distribution and concentration of contaminants in these media. This should include sampling of runoff, any surface waters, wetlands, and associated sediments within the site, in addition to any nearby surface waters and wetlands that are likely impacted by the facility. Surface waters that could influence the migration of contaminants from the source areas by influencing the flow of groundwater will also need to be at least hydraulically characterized. In eastern Washington, focus particular attention on irrigation systems as these can significantly influence groundwater flow.

Include one or more maps showing surface drainage patterns, seeps, surface waters, wetlands, floodplain limits, storm drains and connecting ditches and piping systems, stormwater treatment facilities including sedimentation/detention ponds and infiltration galleries. Estimate surface water and seep flow rates and variability and identify areas of likely sediment erosion and deposition.

Install a staff gauge in nearby surface waters to enable recording of the surface water elevation at the same time groundwater levels are measured. This will help determine the interaction between the surface water and groundwater at the site.

Conduct sediment sampling if the site is next to surface water, especially if contaminants have been found in the groundwater or seeps have been observed discharging to surface water. This should include not just permanent surface waters but also sampling and analysis of potentially impacted sediments in ditches and storm drainage structures.

Sediment analyses in potentially impacted surface waters should include measurement of total organic carbon content as some sediment standards for organic contaminants are normalized to organic carbon content. The organic content of the sediment will also be helpful when evaluating if groundwater cleanup levels will be protective of sediment.

The standards for sediment sampling and analysis plans are in WAC 173-204-600. For additional guidance on how to perform sediment sampling see:

Sediment Cleanup Users Manual II (SCUM II)
https://fortress.wa.gov/ecy/publications/summarypages/1209057.html

Sediment testing can include chemical analyses, laboratory bioassays, and benthic community analysis. The study design can be very different for different objectives. It is strongly recommended to contact Ecology's Aquatic Lands Cleanup Unit very early in the study to learn what data and sampling protocols are required and how that data will be analyzed and interpreted. The Sediment Sampling and Analysis Plan should be submitted for review by Ecology staff well in advance of planned sampling. Having review prior to any sampling will help ensure that the data collected is appropriate and sufficient to meet the study objectives, saving time and money by avoiding re-sampling.

For additional information on Ecology's sediment management standards and requirements, see http://www.ecy.wa.gov/programs/tcp/smu/sediment.html.

6.8 Soil and Bedrock Characterization

A key component of any site investigation is to characterize the area and vertical extent of soils impacted by the petroleum release. This is because petroleum trapped in or adsorbed onto the soil is a continuing source of groundwater contamination.

The soil and bedrock physical and chemical characteristics should be carefully documented during site investigations, with appropriate laboratory analysis to confirm field observations and field screening test results. Construction of soil borings is regulated by Ecology's Water Resource Program under WAC 173-160-420. Among other things, these rules require a report be submitted for all borings and monitoring wells (see Subsection 4.4 and Table 6.6). It is recommended a similar report also be prepared for test pits. The form for recording this information, the Resource Protection Well Report, is available at http://www.ecy.wa.gov/biblio/ecy05012.html.

In addition to the information required by WAC 173-160-420, it is recommended that each log include:

- Vertical position of all samples field tested or retained for physical or chemical testing;
- Results of soil tests (physical & chemical) conducted in the field;
- Water level observations and measurements during drilling (if encountered);
- The well/boring location using the North American Datum of 1983, updated in 1991. See also Subsection 4.8 of this guidance; and
- Wellhead altitude (vertical elevation) using North American Vertical Datum of 1988 (NAVD88). See also Subsection 4.8 of this guidance.

Table 6.6 Resource Protection Wells and Geotechnical Soil Borings Reporting Requirements Under WAC 173-160-420

A form for reporting this information can be found at http://www.ecy.wa.gov/biblio/ecy05012.html.
For questions regarding these requirements, contact Ecology’s Water Resources Program.

WAC 173-340-420(10) Resource Protection well reports.

a) Anyone who constructs or decommissions a well is required to submit a complete well report on the construction or decommissioning of all resource protection wells and geotechnical soil borings. Reports must be submitted to the water resources program within thirty days after completion of construction or decommissioning. Submission of a well report to consulting firms does not meet the requirement of this section. The report must be an accurate summation of data collected in the field taken from field notes written as the well was constructed or decommissioned. Field notes must be available at all times during construction or decommissioning for review by state and local inspectors and kept until the well report is submitted.
b) The resource protection well report must be made on a form provided by the department, or a reasonable facsimile of the form, as approved by the department.
c) Where applicable, the report shall include the following information:
   i) Owner’s name; operator/trainee name; operator/trainee license number; contractor registration number; drilling company name,
   ii) Tax parcel number,
   iii) Well location address,
   iv) Location of the well to at least ¼, ¼ section or smallest legal subdivision,
   v) Unique well identification tag number,
   vi) Construction date,
   vii) Start notification number,
   viii) Intended use of well,
   ix) The well depth, diameter, and general specifications of each well,
   x) Total depth of casing,
   xi) Well head elevation,
   xii) Drilling method,
   xiii) Seal material, seal location, and type of placement used,
   xiv) Filter pack location; filter pack material used,
   xv) The thickness and character of each bed, stratum or formation penetrated by each well including identification of each water bearing zone,
   xvi) Casing gauge, diameter, stickup, type of material, and length, also of each screened interval or perforated zone in the casing,
   xvii) The depth to the static water level, as measured below the land surface; and
   xviii) Such additional factual information as may be required by the department.
d) The well report must include one of the following:
   i) The license number and signature of the person who constructed or decommissioned the well,
   ii) The license number and signature of the trainee and the licensed operator under Chapter 18.104 RCW; or
   iii) The license number and signature of an exempted individual as defined under RCW 18.104.180(3).
e) This rule shall allow an individual to submit electronic reports in accordance with department procedures.

The use of a digital signature in the electronic reports will be authorized as a substitute for an original signature under (d) of this subsection.

Table 6.6 Resource protection wells and geotechnical soil borings reporting requirements under WAC 173-160-420.

If site investigations encounter contamination in bedrock, or such contamination is suspected, continuous core samples of the bedrock should be obtained. Bedrock properties that should be recorded include fracture frequency, rock quality designation and percent recovery.

Use field screening methods described in Section 5 to determine which soil samples should be chemically analyzed. Where soil conditions permit, soil samples should be collected utilizing techniques for obtaining undisturbed samples like a split spoon, Shelby tubes, or direct push sleeves. Samples should not be composited for testing purposes. Soil samples not used for field screening should be immediately contained and preserved to minimize volatile loss of contaminants.

See Ecology Implementation Memo No. 5, available at https://fortress.wa.gov/ecy/publications/summarypages/0409087.html, for guidance on proper field preservation techniques for soil samples containing volatile substances.

Where compatible with the drilling method, geotechnical tests should be conducted while drilling. For example, a standard penetration test (blow counts) or cone penetrometer resistance can be used to estimate formation density. For fine grained soils, a pocket penetrometer or vane shear can be used to estimate shear strength. Sharp contrasts in these soil properties can be used to help delineate soil layers, areas of loose man-made fill from natural deposits, preferential contaminant migration pathways, as well as provide useful information for foundation design for site redevelopment.

All soil layers encountered during borings/test pit investigations should be field classified according to the Unified Soil Classification System (see Table 6.7). For each major soil layer encountered, at least three (3) soil samples should be analyzed for grain size distribution and Atterberg limits (plastic limit, liquid limit, and plasticity index) as necessary to confirm field textural classifications. More frequent testing may be necessary if the soil layer is highly variable. At least one soil sample should be collected and analyzed from the anticipated screened interval of any subsequently installed monitoring well.

KEY POINT: CAREFULLY CHARACTERIZE THE WATER TABLE ZONE

When petroleum is released, it will typically drain down through the unsaturated zone until it reaches the water table. The rate of this drainage and spreading of the petroleum once it reaches the water table is impacted by a variety of factors including soil texture, soil heterogeneities and groundwater table fluctuations but usually occurs fairly rapidly.

Since most petroleum products are less dense than water, they will typically be concentrated near the top of the water table, creating a zone enriched in nonaqueous phase liquid (NAPL). As the water table fluctuates, this NAPL will rise and fall with the water table, creating a "smear zone" of higher petroleum concentrations just above and below the water table. In this zone, samples should be taken at a higher density (recommended at one (1) foot intervals). This will help in estimating the contaminant mass present at the site, information necessary to design a treatment or natural attenuation remedy. It will also provide an indication of historic water table fluctuations. See Section 6.10 for a further discussion of NAPL movement and characterization.

Soil borings should be of sufficient aerial extent and extend to sufficient depth to define the site geology and hydrogeology within the zone of contamination. It may be necessary to conduct borings laterally beyond the zone of contamination where the geology or aquifer characteristics of a broader area is needed to refine the conceptual site model or evaluate potential future contaminant migration pathways. Except in the case of minor releases to fine grained soils, soil borings should extend at least ten (10) feet below the lowest elevation where contamination is encountered. This may require obtaining soil samples below the water table.

Make sure samples are analyzed for all relevant chemical parameters. If fractionated petroleum testing is anticipated, make sure a sufficient number of samples are collected for analysis to adequately characterize the source. If there are multiple types of contamination on the site, then sufficient analyses should be conducted to characterize each source area. See Section 7 for analytical recommendations.

Soil & bedrock samples not destroyed for testing should be retained until the remedial investigation has been reviewed by Ecology. While probably not usable for additional chemical analyses, these samples may be useful if questions about the physical characteristics of soils at the site arise.

If it is anticipated a site-specific partitioning coefficient (Kd) will be developed using site-specific fraction of organic carbon (*foc*) data, consider archiving several clean soil samples from each major soil layer encountered for future *foc* analysis.

Table 6.7 Unified Soil Classification System (from ASTM D 2487)

Major Divisions			Group Symbol	Typical Names
Course-Grained Soils More than 50% retained on the 0.075 mm (No. 200) sieve	**Gravels** More than 50% of course fraction retained on the 4.75 mm (No. 4) sieve	Clean Gravels (less than 5% fines)	GW	Well-graded gravels and gravel-sand mixtures, little or no fines
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines
		Gravels with Fines (more than 12% fines)	GM	Silty gravels, gravel-sand-silt mixtures
			GC	Clayey gravels, gravel-sand-clay mixtures
	Sands 50% or more of course fraction passes the 4.75 (No. 4) sieve	Clean Sands (less than 5% fines)	SW	Well-graded sands and gravelly sands, little or no fines
			SP	Poorly graded sands and gravelly sands, little or no fines
		Sands with Fines (more than 12% fines)	SM	Silty sands, sand-silt mixtures
			SC	Clayey sands, sand-clay mixtures
Fine-Grained Soils *50% or more passes the 0.075 mm (No. 200) sieve*	***Silts and Clays*** *Liquid Limit less than 50*		*ML*	*Inorganic silts, very fine sands, rock four, silty or clayey fine sands*
			CL	Inorganic clays of low to medium plasticity, lean clays
			OL	Organic silts and organic silty clays of low plasticity
	Silts and Clays Liquid Limit 50 or more		MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts
			CH	Inorganic clays of high plasticity, fat clays
			OH	Organic clays of medium to high plasticity
Highly Organic Soils			PT	Peat, muck, and other highly organic soils

Prefix: G = Gravel, S = Sand, M = Silt, C = Clay, O = Organic, PT = Peat
Suffix: W = Well Graded, P = Poorly Graded, M = Silty, L = Clay with LL < 50%, H = Clay with LL > 50%

NOTE: This is only a partial chart. See ASTM D 2487 for the full classification system.

Table 6.7 Unified soil classification system (from ASTM D 2487).

6.8.1 Soil Characterization – Number of Soil Samples

Enough borings need to be installed and soil samples taken to fully characterize the extent of contamination and the range of concentrations present at the site. Borings should extend both horizontally and vertically until clean soils are encountered.

Petroleum contaminated site investigations have been conducted for over 20 years in Washington State and Ecology has numerous reports on file documenting these investigations. In many cases these investigations were phased over several years and conducted by different consultants, an inefficient approach that often resulted in duplication of earlier work and increased expense.

In preparation of this guidance, Ecology staff reviewed selected reports to determine the number of soil borings and soil samples needed to characterize a "typical" petroleum-contaminated site. We reviewed reports from 29 well-characterized petroleum-contaminated sites in western Washington (mostly UST facilities with leaking tanks). Table 6.8 provides a summary of that review and can be used as a general guide for site investigations. The intent of this table is to help environmental professionals better estimate up-front what it takes to adequately characterize soils at a petroleum-contaminated site and is not intended to be prescriptive. The actual number of borings and soil samples at a given site will vary depending on site-specific conditions and the type of remedy anticipated. [12] Very small sites and sites with complex geology will likely require a higher intensity of investigation than would be indicated in Table 6.8.

6.8.2 Soil Characterization – Sampling Soil Stockpiles

Where contaminated soils have been previously excavated and stockpiled on site, Table 6.9 provides general guidelines for the typical number of samples to take from the stockpiled soils for chemical analysis based on Ecology's experience. Discrete grab samples should be collected with hand tools 6 to 12 inches beneath the surface of the pile and immediately preserved per Ecology's Technical Memorandum #5. Locate of each of these samples where field instrument readings indicate contamination is most likely to be present. If field instruments do not indicate contamination, divide the pile into sections and sample each section.

Other factors that could influence the number of samples necessary to characterize a soil pile include:

- Historic knowledge of the source of the stockpiled soils. For example, if the stockpile is known to be clean overburden, fewer samples will be necessary to verify the soil is clean.
- Variability of the field screening tests. Highly variable test results may require more intense sampling,
- Ultimate disposition of the soil. If all of the soil is planned to be hauled off to a landfill or treatment facility, check the disposal site waste testing requirements.

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[12] For example, if a dig and haul remedy is anticipated; fewer samples may be needed to estimate soil volumes than if soil treatment is to be used where volume, concentration distribution and subtle differences in soil properties will be important, depending on the treatment technology selected.

Table 6.8 Number of Soil Borings and Soil Samples Reported at Well-Characterized Petroleum-Contaminated Sites (1)

Category of Site	Number of Soil Borings		Number of Soil Samples for Chemical Analysis (2)	
	Within the Source Property Boundary (3)	Off-Property Areas	Within the Source Property Boundary (3)	Off-Property Areas
Service Stations	20 to 30 soil borings per acre	Insufficient data	35 to 45 soil samples per acre	Insufficient data
Other Petroleum Contaminated Facilities	20 to 35 soil borings per acre	10 to 30 additional soil borings (4)	30 to 50 soil samples per acre	Insufficient data

(1) Based on 29 facilities located in Western Washington.

(2) This is the number of samples analyzed in a laboratory and doesn't not include field screening to determine which samples to send to a laboratory for analysis.

(3) Most UST facilities are on properties substantially smaller than 1 acre, so the actual number of on-site soil borings will be less than the number shown. For example: A 100 X 150 foot parcel = 15,000 s.f. or 0.344 acres. At the above ranges, this would require 7 to 12 borings and 10 to 17 soil samples.

(4) Based on sites with large off-property groundwater plumes. The number of borings is in addition to on-property soil borings.

Table 6.8 Number of soil borings and soil samples reported at well-characterized petroleum-contaminated sites (1).

Table 6.9 Typical Number of Samples Needed to Adequately Characterize Stockpiled Soil (1)

Cubic Yards of Soil	Number of Samples for Chemical Analysis
0-100	3
101-500	5
501-1000	7
1001-2000	10
>2000	10 + 1 for each additional 500 cubic yards

(1) Source: 1995 Guidance for Remediation of Petroleum Contaminated Soil.

Table 6.9 Typical number of samples needed to adequately characterize stockpiled soil (1.)

6.8.3 Soil Characterization – Sampling Excavation Margins

At some sites, underground and above ground storage tanks, other structures, and obviously contaminated soil may be in the process of being removed before the site has been fully characterized. An open excavation presents a unique opportunity to visually observe and characterize the soil at the margins of the excavation. Ecology recommends that site investigators take advantage of these situations to document either a) that the excavation has completely removed the soil contamination, or, b) if contamination remains, the extent and location of residual contamination.

Ecology's *Guidance for Site Checks and Site Assessments for Underground Storage Tanks* has specific recommendations for investigating if a release has occurred at the time a tank is permanently closed or when a release is suspected. That guidance should be consulted when demonstrating compliance with UST regulatory requirements for site checks and site assessments. This section is intended to supplement that guidance when the sampling data will be used to help characterize the soil at the margins of an excavation, as part of a remedial investigation for any petroleum release (e.g. USTs, above ground storage tanks, oily dump sites, hydraulic systems leaks, electrical equipment leaks, spills).

Before conducting sampling, prepare a health and safety plan as discussed in Subsection 4.2 of this guidance. In particular, use extreme caution when entering an open excavation to sample, in order to avoid being overcome by vapors, lack of oxygen, or unstable side slopes. Among other requirements, review and comply with confined space entry procedures, as well as slope stability and shoring requirements. Be aware that locating soil stockpiles or driving heavy equipment next to an open excavation can increase slope instability. For regulations and guidance related to safe trenching and excavation practices see:
http://www.lni.wa.gov/Safety/Topics/AtoZ/TrenchingExcavation/
https://www.osha.gov/dts/osta/otm/otm_v/otm_v_2.html

During excavation, the soil types on the sidewalls and bottom of the excavation should be photographed and mapped. Samples should be retained for potential physical analysis. If collecting samples with a backhoe or hand tools, use the backhoe or a shovel to expose new sidewall and bottom soils just prior to sampling to ensure that "fresh" samples are obtained for chemical testing. As an alternative, use a hand auger or drill rig to sample unexposed soils immediately next to the excavation sidewall or in the bottom of the excavation.

Collect and analyze discrete grab samples so contaminant variability is characterized. As with other soil samples, use appropriate sampling and preservation methods to minimize loss of volatile contaminants.

If using a backhoe to collect samples, make sure the bucket is clean of other soil before sampling. When practical, take soil samples directly from the middle of the backhoe bucket, from soils that have not contacted the sides of the bucket. When sampling the sides of an excavation, make sure soils from higher up in the excavation do not fall into the bucket or other sampling device.

Conducting sampling in any areas where visual observations or field screening of excavated soils during excavation indicate that contamination may be present can minimize the possibility of having to collect more samples. Carefully examine locations where there is a change in soil texture due to backfill or natural conditions, seepage from saturated lenses, pockets of debris, or other anomalous conditions, as these locations are where product will often accumulate. Where contamination isn't apparent, it is a good idea to focus sampling on areas where leaks are more likely to have occurred, such as beneath tank fill locations, tank gauging access ports, dispenser islands, pipe joints, and sump locations where contaminated runoff may have accumulated.

The actual number of samples sent to a laboratory for analysis will vary depending on the size of the excavation and results of visual observations and field screening tests. To help ensure adequate characterization of soils, it is recommended that at least one soil sample be taken from each side of the excavation, and one soil sample from the bottom of the excavation (i.e. a minimum of five samples).[13]

For larger excavations, try to take additional samples so there is at least one sample every 20 feet horizontally along the sidewalls, and one sample for every 400 square feet of exposed bottom (i.e. each 20 ft X 20 ft bottom area should have at least one soil sample). Multiple samples may need to be taken vertically along the sidewalls in deeper excavations.

For long piping runs outside the main excavation where there are no joints, take samples from the bottom of any exposed trench on no less than 50 foot intervals if conditions allow.

See Figure 6.3 for illustrations of complex and small site excavation sampling schemes.

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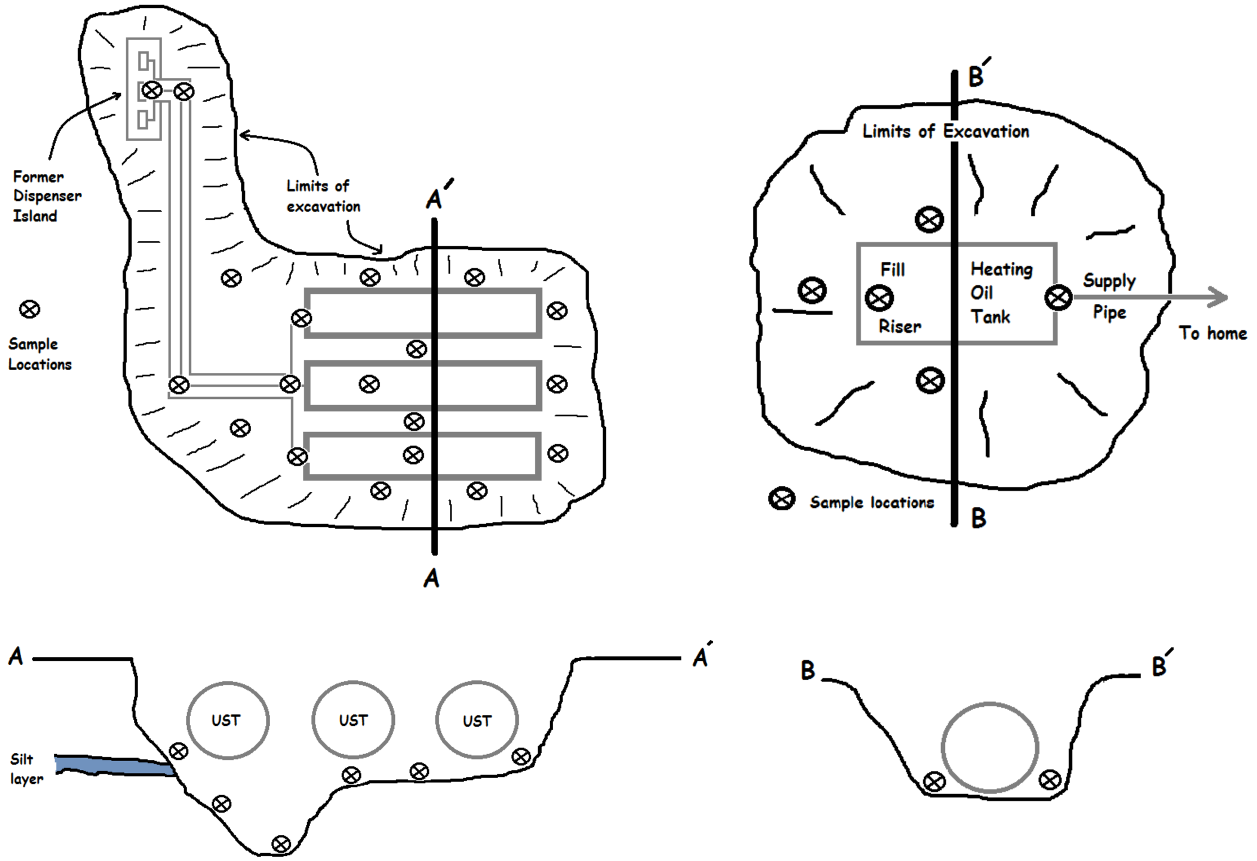
[13] "Side" and "Sidewall" as used here means the sloping wall of the excavation. For long, narrow excavations, such as those created by the removal of an UST, this means both the sides and ends of the excavation. For round excavations with no obvious side and end, space the samples equally around the perimeter of the excavation.

Figure 6. 3 Conceptual illustrations of complex and simple site excavation sampling.



6.8.4 Soil Characterization – Focused vs. Grid Soil Sampling

There are two approaches that can be used to characterize soils at a site—focused and grid (systematic grid or random grid) sampling.

Focused sampling is sampling soils where contamination is known to be present. Focused sampling relies on historical knowledge of release locations, visual observations, and field screening to take samples from locations with a high probability of contamination (e.g., stained soils).

While focused sampling is done to some degree at nearly every site, it is typically supplemented by grid sampling to confirm the full extent of the contamination. Grid sampling should also be used at sites where knowledge of releases is incomplete or where releases of product have occurred over a wide area (e.g., random spills throughout an industrial operation). At such sites use either a random or systematic grid sampling method for determining where to take soil samples.

The first step in grid sampling is to identify on a map the area believed to be contaminated. In the second step, a grid is superimposed over the contaminated area. For the third step, use one of the two following methods to determine sample locations:

- Systematic grid sampling: A sample is taken from each section of the grid for analysis.
- Random grid sampling: Numbers are assigned to each grid location. Samples are then collected from grid locations selected at random.

For additional information on focused and grid methods of sampling, see "Guidance on Sampling and Analysis Methods," Ecology Publication No. 94-49, June 1995. A copy of this publication is available online at http://www.ecy.wa.gov/biblio/9449.html.

KEY POINT: SITE CHARACTERIZATION DATA CAN BE USED TO DEMONSTRATE COMPLIANCE

While site investigations are focused on characterizing the site, it is important to recognize that some of the data gathered may also be useful for determining compliance with cleanup standards at the completion of site cleanup. For this reason, it is important the site investigator be familiar with the regulatory requirements for determining compliance with soil cleanup standards described in WAC 173-340-740(7). See also Section 9 of this guidance for determining compliance with soil cleanup standards.

6.9 Geology and Groundwater Characterization

Characterization of the groundwater typically occurs concurrent with soil and bedrock investigations. Table 6.10 and this Section provide several recommendations to improve the usability of groundwater investigations.

6.9.1 Is installation of groundwater monitoring wells necessary?

Groundwater monitoring wells serve three primary purposes:

- Installing wells enables collection of soil samples to understand soil and bedrock stratigraphy and potential influence of this stratigraphy on contaminant migration.
- Wells enable collection of groundwater samples to define extent of groundwater contamination. Sampling wells over an extended period of time can document improvements in groundwater quality over time and ultimately lead to removal of the site from Ecology's contaminated sites list.
- The wells can be used to define aquifer properties and groundwater flow conditions, enabling projection of plume migration, potential future groundwater and surface water impacts, and appropriate cleanup standards (such as, whether the aquifer qualifies as non-potable).

If a release has not occurred, then groundwater sampling is not generally necessary. All of the following observations are typically needed to confirm that a release has not occurred:

- No indication of a release from the leak detection system.
- All soil samples from the site assessment are clean (based on visual observations, field instrument readings and laboratory confirmation below the PQLs in Table 7.3).
- No holes are observed during examination of the removed tank and piping system.
- No sheen or free product is observed on the groundwater or on any nearby surface waters.
- No vapors have entered buildings, utility manholes, or other structures.

While qualitative observations like those above are allowed for a routine site check, once a release has been confirmed, Ecology interprets MTCA to require ground water testing unless there is clear evidence, as described below, that contamination has not reached groundwater.

Table 6.10 Recommended Practices to Improve Groundwater Investigations

- To construct a water table surface map, wells cannot be installed in a straight line but must be spread throughout the site. If the ground surface elevation varies over the area impacted by the site, wells should also be installed in or near each major geomorphic feature (e.g., ridges, lowlands, next to surface waters).
- Wells should be installed beyond the current limits of contamination to facilitate tracking of contaminate migration over time without having to remobilize and drill additional wells.
- A staff gauge should be installed in nearby surface waters and wetlands and the water level in these waters recorded when groundwater level measurements are made to help determine the interaction between these surface waters and groundwater. Pay particular attention to irrigation facilities as they can greatly influence shallow groundwater levels and direction of flow.
- Soils encountered during drilling should be logged and classified. Where soil conditions permit, consider collecting continuous soil cores, especially near the water table. This will facilitate detection and characterization of product that is entrapped near the water table.
- To avoid misidentifying wells, all wells should be numbered and clearly labeled with that number. If a site-specific well numbering system is used, the well should also be tagged with the number complying with WAC 173-340-420(5). The top of the casing should be surveyed to establish its elevation within 0.01 feet, the ground surface elevation next to the well to within 0.1 feet and the horizontal location within 1.0 foot. A permanent mark should be made at the top of the casing at this reference elevation and all future water level depth measurements should be made relative to this reference elevation.
- Make sure all wells are properly developed prior to conducting slug or pumping tests or water quality sampling. Henebry and Robbins (2000) found that there was up to a factor of 10 difference in pre- and post-development slug tests results. BP Corporation (2002) found improper development of direct push wells lead to erroneously high contaminant levels compared to properly developed conventional monitoring wells. Aggressive well development using a surge block followed by pumping to flush sediment from the well is strongly recommended. Development of small diameter direct push wells can be particularly challenging as the slightest imperfection in well construction can prevent the use of a surge block and pumping technologies. If this is a problem at the site, consider using direct push wells for qualitative measurements and installing conventional monitoring wells for long term monitoring.
- After development, allow a well several days to chemically stabilize before sampling.
- Water level measurements should be taken from all wells and nearby surface waters within as short a time frame as is practical (within a few hours to a day) to avoid a rising or falling water table influencing the readings. If the site is near fluctuating surface water (tides, dams or irrigation conveyances) or influenced by pumping wells, it is recommended that a continuous water level recorder be installed at selected wells to establish the influence of these fluctuations on groundwater elevation and flow direction.
- Water level measurements should initially be taken once a week for 3-4 weeks. Measurements should continue monthly or quarterly after the initial measurements to determine if the groundwater elevation and flow direction are influenced by the seasons.

Table 6.10 Recommended practices to improve groundwater investigations.

Factors Ecology considers in determining if there is clear evidence that groundwater contamination is unlikely include:

- Verifiable records that only a small quantity of petroleum product has been released
- Thorough soil testing showing the soil contamination has not significantly migrated
- Predominance of fine textured soils without interconnected coarse deposits (i.e. silts and clays, GM, GC, SM, SC [see Table 6.7 for soil classifications]) in the area of soil contamination, reducing the likelihood of contaminant migration
- Considerable depth to groundwater (more than 50 feet from the ground surface)
- Products less prone to migration (e.g. heavy fuels/oils, mineral oils and waste oils as defined in Table 7.1)

Even with the above evidence, if the site is within the 10 year wellhead protection area of a public water supply well or within 1,000 feet of a public or private water supply well, then the groundwater should be tested to confirm contamination has not reached the groundwater. Testing of the groundwater should be done using properly constructed and developed wells, not sampling of water in the UST tank excavation, to ensure representative samples are obtained.

6.9.2 Groundwater Characterization – Number of Monitoring Wells

In general, enough monitoring wells need to be installed and ground water samples taken to fully characterize the extent of contamination and the range of concentrations present at the site. Investigations should extend both horizontally and vertically until clean groundwater (concentrations below the PQLs in Table 7.3) is encountered. Where more than one water-bearing unit (aquifer) is present beneath a site, it is important to determine if there is interconnectivity between the aquifers, and whether an aquitard separating the units is present and forms a competent barrier throughout the extent of the contaminant plume.

In preparation of this guidance, Ecology staff reviewed selected reports from previous investigations to determine the number of wells needed to characterize a "typical" petroleum-contaminated site. We reviewed reports from 29 petroleum-contaminated sites with thorough groundwater investigations in western Washington (mostly UST facilities with leaking tanks). Table 6.11 provides a summary of Ecology's work and can be used as a general guide for site investigations. The intent of this table is to help environmental professionals better estimate up-front what it takes to adequately characterize a petroleum-contaminated site and is not intended to be prescriptive. It is anticipated that this table will be refined over time as additional investigations are conducted. The actual number of wells will vary depending on site-specific conditions.

Table 6.11 Number of Wells Reported at Petroleum-Contaminated Sites with Thorough Groundwater Investigations (1)

Category of Site	Number of Wells (2)		Number of Well Clusters (3)	
	Within the Property Boundary	**Off-Property Areas**	**Within the Property Boundary**	**Off-Property Areas**
Service Stations	14 to 16 wells per acre	Insufficient data	1 to 3 total	Insufficient data
Other Petroleum Contaminated Facilities	10 to 14 wells per acre	Insufficient data	Insufficient data	Insufficient data

(1) Based on 29 facilities located in Western Washington.
(2) Water table wells. Most UST facilities are on properties substantially smaller than 1 acre, so the actual number of on-site wells will be less than the number shown. For example: A 100 X 150 foot parcel = 15,000 s.f. or 0.344 Acres. At the above ranges, this would require 5 to 6 wells.
(3) Multiple wells with short screens installed in different boreholes close to each other but screened at different depths to determine vertical gradients and concentration of contaminants with depth.

Table 6.11 Number of wells reported at petroleum-contaminated sites with thorough groundwater investigations.

6.9.3 Groundwater Characterization – Determining the Direction of Groundwater Flow

Accurately defining the predominant groundwater flow direction is a dynamic process. Both the horizontal and vertical flow directions should be characterized. Before conducting a site-specific investigation, it is important to review available reports on groundwater conditions in the site area. Regional studies are often available that provide an indication of the depth to groundwater, likely direction of groundwater flow, and areas of recharge and discharge. It is important to note, however, that such studies often focus on aquifers of economic significance (used for private or public water supply wells). In contaminant investigations, it is also important to investigate water bearing units that may not be used for water supply as these water bearing units can act as conduits for contaminant transport, affecting deeper water bearing units or impacting surface waters.

If there is significant topographic relief in the site vicinity, it should be possible to estimate the direction of groundwater flow, as often the slope of the groundwater table mirrors the slope of the ground surface. This information, along with information from regional studies noted above, can then be used to select initial well locations.

To define the horizontal direction of groundwater flow at most sites, it will be necessary to install multiple wells spread throughout the site with water level measurements taken several times over a period of weeks or months to capture seasonal variability in groundwater levels and flow direction. Vertical groundwater gradients can be determined by installing two or more wells in different boreholes close to each other but screened at different depths. Characterizing vertical gradients is particularly important at sites with finer grained deposits, heterogeneous deposits, or the presence of a geomorphic feature that can cause significant vertical gradients (e.g. high topographic relief, groundwater divide or nearby surface water).

For sites with significant groundwater contamination, groundwater flow direction investigations should be for a sufficient period of time to characterize the site for both wet and dry seasons. Other site characteristics that could lead to an extended study include: pre-existing regional studies or studies at other nearby contaminated sites indicating fluctuating groundwater flow characteristics; the presence of large capacity municipal or irrigation wells-especially those with seasonal use; and, contaminant distribution patterns that don't coincide with the apparent groundwater flow direction.

KEY POINT: DOUBLE CHECK ALL ELEVATIONS!

One of the most common and significant site characterization errors is inaccurate groundwater elevations. All top of casing and depth to groundwater readings should be taken to an accuracy of 0.01 feet. Water depth measurements should be made relative to an established reference mark on the well casing. For nested wells, make sure to confirm the depth of the well being measured.

Where multiple water elevation measurements have been taken over time, it can be useful to construct water level graphs for each individual monitoring well to look for seasonal variations and anomalous readings.

The subsurface at most developed sites has been disturbed by construction and placement of fill material, underground storage tanks, piping and utilities. This can impact groundwater flow and create preferential pathways for contaminant migration. For example, underground storage tanks are often bedded with sand or pea gravel, which can result in an accumulation of water in the base of the tank pit. Recharge of this water may create an unnatural mound. This mounding can bias water level measurements from wells installed near underground tanks and should be considered in data interpretation. Other site features that can bias water level measurements include:

- Stormwater detention ponds
- Underground infiltration galleries (commonly used to manage stormwater on-site)
- Leaking water pipes
- Irrigation systems
- Septic drain fields
- The presence of NAPL (see key point on next page)

In addition, the backfill around buried pipes and utilities can act as preferential pathways for contaminant migration.

Thus, if unusually high groundwater levels or large fluctuations in water levels are present in some wells and not others, or the contaminant data is inconsistent with the conceptual site model, then the data from these wells should be carefully evaluated for appropriateness in constructing water level maps and mapping contaminant plumes.

KEY POINT: CORRECT GROUNDWATER ELEVATIONS FOR NAPL THICKNESS!

If significant NAPL is present at the site, it may be necessary to correct water level readings for NAPL thickness. Equation 6.1 can be used to make this correction:

Equation 6.1:

$$h_c = h_m + \left[H_o \frac{\rho_o}{\rho_w} \right]$$

h_c = Corrected hydraulic head (ft.)

h_m = Measured petroleum-water interface elevation (ft.)

H_o = LNAPL thickness (ft.)

ρ_o = LNAPL density (g/ml)

ρ_w = Water density (g/ml) (assume 1 g/ml)

NOTE: If the water table elevations are adjusted or corrected by this or other methods, then pieziometric maps should be presented for both corrected and non-corrected water elevations.

Source: EPA (1997)

6.9.4 Groundwater Characterization – Determining Hydraulic Conductivity of Water Bearing Units

It is important to determine the permeability or hydraulic conductivity of water-bearing layers as this information is necessary to project the rate of contaminant migration and evaluate remedial options. There are a wide variety of equations that purport to correlate soil texture and hydraulic conductivity. However, use of such equations is not recommended, as several studies (Dahlen et. al., 2003, Salarashayeri and M. Siosemarde, 2012, and Rosa et. al. 2014) have found that there is generally a poor correlation between soil texture and quantitative hydraulic conductivity values. For site assessment, Ecology recommends the use of slug tests or short-term pumping tests to measure hydraulic conductivity for representative wells in each geologic unit. Longer-term pumping tests will likely be needed later in the process for the design of a pump and treat system, if such a system is deemed necessary at a site. If pumping is expected to exceed 5,000 gallon from all wells on the site on any single day, a preliminary permit under RCW 90.03.250 may be necessary from Ecology's Water Resources Program.[14]

KEY POINT: BE CAREFUL INTERPRETING SLUG TESTS FROM WELLS WITH SCREENS SPANNING THE WATER TABLE!

Binkhorst and Robbins (1998) found that conducting and interpreting slug tests in wells with screen sections and sand packs that span the water table are complicated by sand pack drainage and re-saturation. Sand pack drainage reduces the actual head difference between the well and the formation. Re-saturation of the drained sand pack must be properly accounted for, or the formation hydraulic conductivity will be in error.

6.9.5 Groundwater Characterization – Groundwater Contaminant Sampling

It is recommended that groundwater encountered in all monitoring wells, even temporary well points, be sampled for the full suite of contaminants as discussed in Section 7.

MTCA requires all analyses be conducted on unfiltered samples, unless it can be demonstrated that a filtered sample provides a more representative measure of groundwater quality. Prior to collecting samples, every effort should be made to develop the well to the extent possible to minimize suspended soil particles in the sample. If the well is developed in fractured bedrock or a clean sand or gravel, proper development of the well should eliminate the need for field filtering. Well development is particularly important for direct push wells in formations with fine grained soil layers, as the direct push installation process smears the soil, introducing suspended soil particles into water samples that can result in false high readings (BP, 2002). After development, wells should not be sampled for 48 hours, to allow an opportunity for the groundwater geochemistry to stabilize.

Prior to sampling, it is best to purge each well until indicator parameters (such as specific conductance, pH, dissolved oxygen and redox potential) or field VOC screening methods indicate well concentrations have stabilized or, failing that, a minimum of 3 to 5 well volumes. If the formation does not yield enough water to enable this level of well purging, purge as much as the well yield allows. Use of no flow/no purge sampling methods is <u>not</u> recommended without comparative data from several wells at the site demonstrating the method will provide representative samples under the conditions present at the site.

Sampling should be conducted using low-flow submersible or bladder pumps. Peristaltic pumps can be used for sampling very shallow groundwater (generally 15 feet or less), unless the groundwater is saturated with gas (numerous gas bubbles form on the container sides). Where

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[14] For more information, please see the Water Resources program's page at http://www.ecy.wa.gov/programs/wr/wrhome.html.

trace levels of volatile organics are a concern, avoid using bailers for sampling as the transfer process can result in loss of volatile compounds.

KEY POINT: DO NOT EXPOSE GROUNDWATER SAMPLES TO AIR!

Groundwater is often in a reduced (oxygen poor) state. Eliminating exposure of well samples to the air is important. Exposure to the atmosphere can cause de-gassing of carbon dioxide dissolved in the groundwater, raising the sample pH and causing metal precipitation. Oxygen in the air can also result in the oxidation of dissolved metals such as iron, changing the valence state (from Fe^{+2} to Fe^{+3}), and precipitating it out as an iron hydroxide. Iron hydroxide is a strong metal absorber so this could not only result in low dissolved iron results but also low values for other dissolved trace metals. This process can happen very quickly (less than a minute).

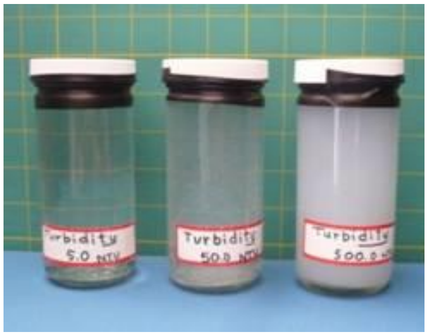
A common technique to avoid exposure of a sample to the air is to extract the sample from the well using a small pump with the discharge tube directed to the sample container. If filtering is necessary for metals, the pump discharge tube is connected directly to the filtering apparatus so the water can pass through the filter and then directly into the sample container. Once filtered, the samples should be preserved as per laboratory instructions and sent to the laboratory with a request for a total metals analysis. (If you request a filtered metals analysis, the laboratory will filter the sample again when it processes the sample!)

Do not filter groundwater samples obtained from active public or private water supply wells, as well water typically is not filtered for drinking water purposes.

There is no need to filter samples to be analyzed for major inorganic ions and indicator parameters (e.g., specific conductance, pH, oxygen content, redox potential). The presence of suspended matter does not significantly impact these tests and the act of filtering could alter test results by exposing the sample to air.

Never filter samples to be analyzed for organic contaminants as the organic contaminants can be absorbed by the filtering apparatus. Samples for volatile organics analysis should be placed in completely filled containers with no head space present.

Samples to be analyzed for iron, manganese, lead and other naturally occurring trace metals may be filtered where it is not possible to develop the well to obtain a relatively clear sample (less than 50.0 Nephelometric Turbidity Units or NTU). If filtering is conducted, it should be done in the field as the sample comes out of the well, without any exposure to the air and prior to adding any preservative. If the well is developed in fractured bedrock or coarse gravel formation and it is not possible to develop the well to remove suspended matter, there is a possibility that colloidal transport of contaminants is occurring. In these situations, both filtered and unfiltered samples should be collected to examine this possibility.



Turbidity at 5, 50, and 500 NTU

6.9.6 Groundwater Characterization – What to do When Contamination Extends Beyond the Facility Property

Ecology understands that in many cases, groundwater contamination will extend beyond the facility property boundary since facilities that store petroleum are often located in dense urban or industrial areas where land use is at a premium.

Nevertheless, MTCA requires investigation of all areas where contamination has come to be located, which can extend beyond the facility's property boundary. If it is impractical to install borings or dig test pits on other properties, then other methods will need to be used to check for contamination. For example, while it may not be possible to obtain permission for installation of a permanent well, neighboring property owners will often allow access for one-time measurements, such as with direct push technology. It may also be possible to gain permission to drill borings or wells within a public right of way or easement.

Nearby underground utility vaults for water, sewer, storm drains, telephone and cable should be checked for the presence of product. Check sewers and storm drains for petroleum products as these pipes are often not water tight, allowing contamination to enter these lines.

The characterization of areas down gradient of the source should focus on answering the following types of questions:

- What are concentrations at various distances from the source?
- What are concentrations at various depths relative to the source?
- Where should permanent groundwater monitoring points be located and to what depth should the screened interval be installed?
- Is the dissolved phase plume impacting any nearby water supply wells or discharging to nearby surface water?

6.10 Characterizing Petroleum Source Areas

Prior to the passage of hazardous waste laws in the early 1980s it was common practice for service stations to dump used oil and other fluids behind the station or in a low spot on the property. In addition, until the mid-1990's older tanks were not always removed when underground storage tanks were upgraded. Historic photos and interviews of former employees can be a good source of information regarding historic practices. Consider conducting a geophysical survey of the property using a magnetometer and/or ground penetrating radar to identify unrecorded buried tanks and piping. A soil gas survey can also help identify areas impacted by product releases and to pinpoint initial boring locations.

When characterizing the soils and groundwater in a source area, remember that the source area dimensions for lower permeability formations (silts, clays and tills, etc.) is generally much smaller than formations dominated by sands and gravels with little fines. Thus, when working in tills or clays, it will likely be necessary to space boreholes and test pits more closely to determine source dimensions (e.g., 10 feet apart). Conversely, when working in sands and gravels, a larger interval may be sufficient (e.g., 25–50 feet or more).

Characterizing the thickness and extent of the non-aqueous phase liquids (NAPL) is one of the most important aspects of petroleum site characterization. The relatively low solubility of petroleum products means that NAPL can be a continuing source that impacts groundwater quality for many years.

The true extent of NAPL is sometimes undetected or missed altogether. When petroleum product is released to soil, it will flow downward under the influence of gravity. As it flows downward, it will leave behind globs of NAPL trapped in the pores of the soil. If there are lenses of more permeable material within the soil column, the NAPL will follow these lenses before continuing its downward migration. If layers of fine grained soil are encountered, the NAPL will build up and spread out laterally until it finds a pathway to continue downward.

Upon reaching the water table the NAPL will spread out like a pancake and flow laterally outward until it flattens out sufficiently that there is no longer a gradient to push the NAPL out further, the degree of NAPL saturation is insufficient to displace the groundwater, or both. The spread will tend to be elongated in the direction of groundwater flow. If sufficient NAPL is present, it can displace the groundwater and push below the water table, even though petroleum is less dense than water. Later, as the water table fluctuates, the elongated pancake of NAPL will smear vertically within the zone of groundwater fluctuation, contaminating soil that was not within the initial flow path of the release.

Some suggestions to improve NAPL characterization are (Robbins, et. al. (1997) and others):

- If at all possible, identify the petroleum release point. Sample vertically downward at this location using continuous sampling, carefully noting textural changes in the soil that can influence the direction of NAPL flow. If significant lenses of permeable material or fine grained soils are encountered, conduct additional sampling laterally along these zones to determine the extent of NAPL spreading within these zones.
- When the water table is encountered, collect continuous soil samples through the smear zone, both above and below the water table. Use visual observations and field screening methods to identify the smear zone. If NAPL is encountered, conduct additional sampling laterally along this interface to determine the extent of NAPL spreading.
- Collect groundwater samples while drilling within the smear zone. Consider using temporary well points with 6 to12 inch screens. Make sure the groundwater sample depth corresponds to the soil sampling depth. These are “hot zone” groundwater samples. All samples should be field screened with several analyzed for the full suite of applicable analytical parameters.
- Install a permanent monitoring well, screened across the water table, at locations where NAPL is encountered. Screen length should be the minimum necessary to accommodate groundwater fluctuations.
- The NAPL thickness in a monitoring well can vary considerably as the water table fluctuates. Typically, the NAPL thickness increases when the water table drops as trapped

> NAPL drains into the well screen, and decreases when the water table rises and the NAPL is smeared out. A well that appears free of NAPL during one sampling event may show significant NAPL during a later event and vice versa. This is why it is important to monitor NAPL thickness over time as the water table fluctuates.

For additional information on the behavior and recovery of non-aqueous phase liquids consult the following resources:

American Petroleum Institute’s Light Non-Aqueous Phase Liquid (LNAPL) Resource Center: http://www.api.org/LNAPL .

EPA’s Leaking Underground Storage Tanks Corrective Action Resources: http://www.epa.gov/ust/leaking-underground-storage-tanks-corrective-action-resources#3corr

Interstate Technology and Regulatory Council: http://www.itrcweb.org/Guidance

ASTM E 2531-06: “Standard Guide for Development of Conceptual Site Models and Remediation Strategies for Light Nonaqueous-Phase Liquids Released to the Subsurface” http://www.astm.org/cgi-bin/resolver.cgi?E2531.

Non-Aqueous Phase Cleanup Alliance: http://www.rtdf.org/public/napl/publications/.[15]

6.11 Vapor Characterization

Petroleum is a flammable liquid and vapors from petroleum can not only make people sick, but under the right conditions, these vapors can also pose a fire and explosion hazard. The migration of petroleum vapors into nearby buildings and utility vaults is a potential issue primarily at sites where a release of gasoline has occurred. Vapors can also be an issue at sites that are contaminated with diesel fuel and heavier petroleum products and where site conditions are conducive to vapor migration. Pay particular attention to the potential for vapors to enter nearby structures or utility vaults by traveling along the granular bedding materials that are often used in the installation of underground utilities.

Fortunately, most petroleum products have a distinct odor that can be detected by most people well before

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[15] This website is no longer being supported and may be phased out in 2016. Many of the documents available on this site may be found by entering “LNAPL” into the search bar of https://clu-in.org/.

explosive concentrations can accumulate. However, lack of odor doesn't mean there isn't a vapor intrusion problem. People have widely varying sensitivity to odors and, concentrations of health concern for some petroleum contaminants, like benzene, are below the odor threshold. Furthermore, methane, an odorless gas, can sometimes be produced by the decomposition of petroleum, especially gasoline with ethanol. For these reasons it is important to evaluate sites for potential vapor hazards, and should a potential problem be identified, conduct appropriate testing.

Detailed guidance for vapor intrusion investigations is beyond the scope of this document. To help guide vapor intrusion evaluations, Ecology issued draft guidance in 2009. [16] This guidance and related information can be found at http://www.ecy.wa.gov/programs/tcp/policies/VaporIntrusion/vig.html.

Ecology has also updated the soil vapor and groundwater vapor screening levels in CLARC. These new values should be used in place of those in the 2009 guidance. These values can be found at https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx.

Since Ecology issued its guidance, EPA has issued two important vapor intrusion guidance documents. Both of these documents, and other technical information, can be found at http://www.epa.gov/vaporintrusion.

- Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air, OSWER Publication 9200.2-154, June 2015
- Technical Guide For Addressing Petroleum Vapor Intrusion At Leaking Underground Storage Tank Sites, EPA 510-R-15-001, June 2015

In addition, the Interstate Technology and Regulatory Council has published guidance that provides a good discussion of field investigation methods. This guidance can be found at http://www.itrcweb.org/Guidance

The science and policy related to vapor intrusion is quickly evolving. Readers are encouraged to follow the literature and consult other vapor intrusion guidance and technical support documents as they become available.

6.12 Land Use

From the local land use planning agency, compile information on the present comprehensive plan requirements and zoning for the facility and surrounding area. Talk to planning staff in the local land use agency about currently allowed uses and any pending changes. Ask about the status of land uses that are different from the underlying zoning (nonconforming uses).

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[16] *Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action*, Publication No. 09-09-047 (October 2009 Review Draft).

As part of a site visit, identify other nearby current land uses for other potential sources of contamination and for potential impacts. Pay particular attention to building construction (e.g. slab on grade, crawl space or basement) as this can give an indication of the likelihood of potential vapor hazards (buildings with basements tend to be most vulnerable to accumulation of vapors).

Be sure to look for the presence of a public water system (water meters and fire hydrants are an indication that the area is likely served by a public water system). Similarly, look for sewer manholes, as these are an indication the area is served by a public sewer system. Talk to the local utility providers to confirm whether the area is served by public water and sewer and, if it is not, what the water and sewerage system plans are for providing these services. Current or former septic drain fields in unserved areas may be a source of contaminants. The presence of public water and sewer systems or plans to develop such systems can significantly increase the intensity of commercial and residential land use, increasing the potential for future exposures. Backfill around these pipes can be conduits for vapors or contaminated groundwater. If these pipes are located within contaminated groundwater, product may seep into sewer or stormwater pipe joints and can even diffuse into pressurized plastic water pipe, tainting the water quality.

Note that just because an area is served by public water or sewer does not mean all residents and businesses in the area will be connected to these systems. Even billing records may not be completely accurate in identifying which properties are served as sometimes property owners are billed in a service area whether or not they are connected to the service.

6.13 Natural Resources and Ecological Receptors

Gather information on the natural resources and ecological receptors at the site so that potential ecological impacts can be evaluated. Aerial photos and a site reconnaissance visit can help to identify potential ecological habitat that could be impacted by the facility. This includes surface waters, wetlands, wooded areas, undeveloped open space, parks and large managed landscaped areas.

A terrestrial ecological evaluation (TEE) for evaluating potential impacts on upland plants and animals must be conducted at all sites. Many sites in urban areas will meet one of the exclusions provided for in the MTCA rule, quickly ending the TEE process. The next subsections provide some basic information on how to conduct a TEE. For additional information on the terrestrial ecological evaluation process, users are encouraged to access Ecology's Interactive User's Guide at http://www.ecy.wa.gov/programs/tcp/policies/terrestrial/TEEHome.htm.

Evaluation of impacts to surface water or sediment ecological receptors is beyond the scope of this document. If these are issues at the site, consult with Ecology on the scope of information that needs to be included in the remedial investigation.

6.13.1 Why Terrestrial Ecological Evaluations Are Needed

There are three reasons Terrestrial Ecological Evaluations are necessary:

- To determine if a release of hazardous substances is toxic to or can otherwise harm soil biota, plants and animals on the property.
- To identify and understand - to characterize - the existing ecological system; the soil biota, plants and animals that may be exposed to hazardous substances in the soil.
- To establish cleanup standards to protect not only human health, but the plants and animals, and ecologically important functions of the soil biota as well.

Note that a terrestrial ecological evaluation only addresses upland organisms. Aquatic organisms are addressed through the evaluation of the surface water exposure pathway.

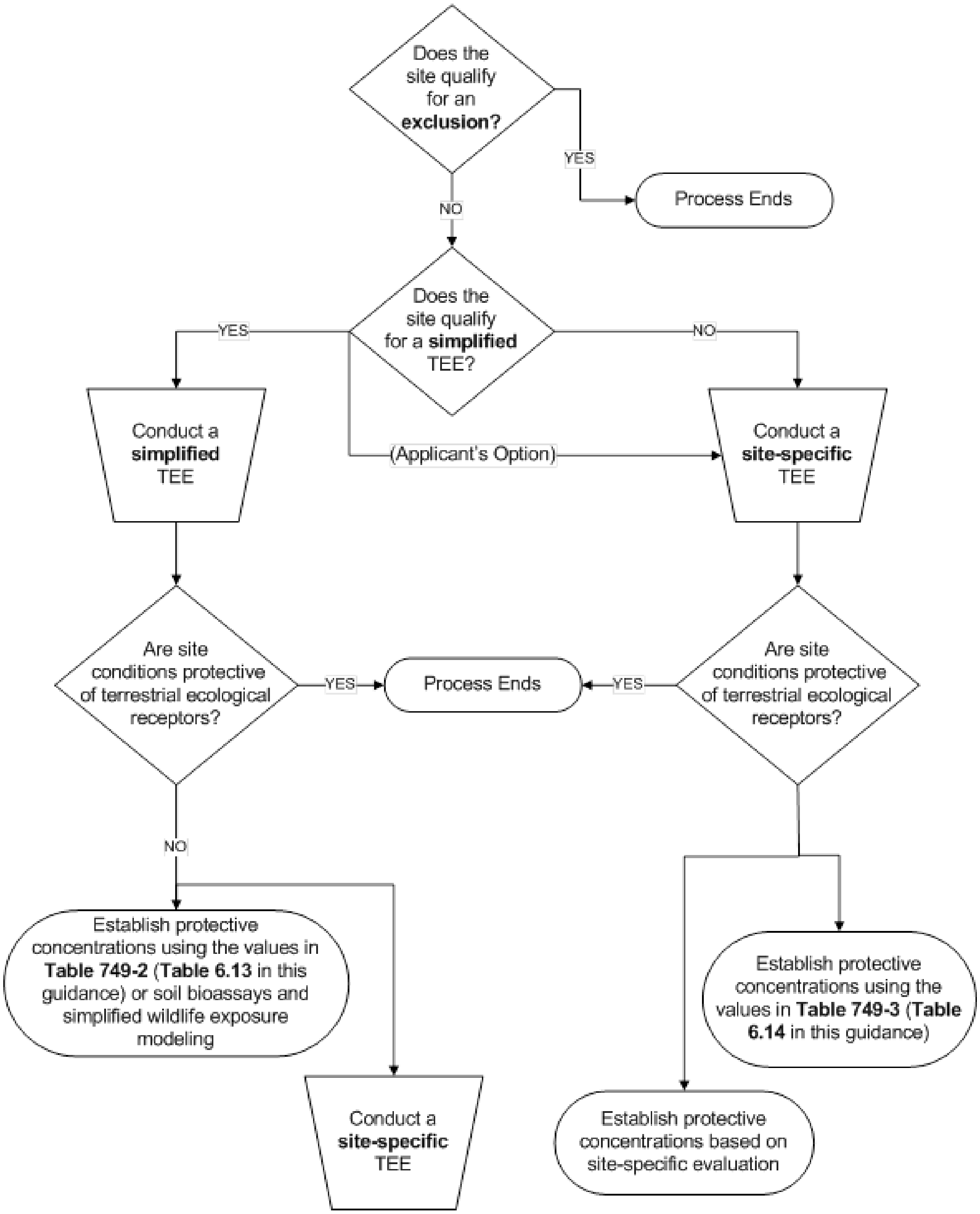
6.13.2 Terrestrial Ecological Evaluation Requirements

A schematic diagram of the Terrestrial Ecological Evaluation process is provided in Figure 6.4. When hazardous substances are released to the soil at a site, one of the following three actions must be taken:

1. Document that the site qualifies for an exclusion. Gas stations and similar small commercial sites in urban areas often qualify for an exclusion; however the process described below must be followed and documented to reach this conclusion. (See 6.13.4)
2. Conduct a Simplified Terrestrial Ecological Evaluation. This is only available for sites that qualify for the simplified evaluation process. (See 6.13.5)
3. Conduct a Site-Specific Terrestrial Ecological Evaluation. This requires assistance from an experienced ecological risk assessor. (See 6.13.7)

Suggested information to compile to support a TEE evaluation is summarized in Table 6.12

Figure 6.4 Schematic diagram of the Terrestrial Ecological Evaluation (TEE) process. [17]



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[17] Tables 749-2 and 749-3, taken from the MTCA statute, are reproduced in part in this document as Tables 6.13 and 6.14.

Table 6.12 Suggested Information to be Compiled in Support of a Terrestrial Ecological Evaluation (TEE)

- Hazardous substances present at the site and the size of area affected.
- Depth of contamination currently and at completion of remedial action.
- Current and anticipated future land use and zoning for the property and areas within 500 feet of the area of contamination.
- Location and size of undeveloped land within 500 feet of the area of contamination.
- Existing and anticipated future buildings and roads, parking and other physical barriers that will prevent plants and wildlife from being exposed to contamination (i.e., prevent wildlife from feeding on plants, earthworms, insects or other food in or on the soil).
- Observations of the site to determine if it attracts wildlife or is likely to do so. Examples: Birds frequently visit the area to feed; evidence of high use by mammals (tracks, scat, etc.); habitat "island" in an industrial area; unusual features of an area that make it important for feeding animals; heavy use during seasonal migrations.
- Use of the site by threatened or endangered species; a wildlife species classified by the Washington State Department of Fish and Wildlife as a "priority species" or a "species of concern" under Title 77 RCW; or a plant species classified by the Washington State Department of Natural Resources Natural Heritage Program as "endangered," "threatened," or "sensitive" under Title 79 RCW. For plants, "use" means that a plant species grows at the site or has been found in the past growing at the site. For animals, "use" means that individuals of a species have been observed to live, feed or breed at the site. Contact WA State DNR and Fish and Wildlife for site-specific information.
- Rating of the quality of habitat within the site and within 500 feet of the area of contamination:

  Low: Early-successional vegetative stands; vegetation predominantly noxious, nonnative, exotic plant species or weeds. Areas severely disturbed by human activity, including intensively cultivated croplands, athletic fields and intensively managed landscaped areas. Areas isolated from other habitat used by wildlife.

  High: Area is ecologically significant for one or more of the following reasons: Late-successional native plant communities present; relatively high species diversity; used by an uncommon or rare species; priority habitat (as defined by the Washington State Department of Fish and Wildlife); part of a larger area of habitat where size or fragmentation may be important for the retention of some species.

  Intermediate: Area does not rate as either high or low.

Table 6.12 Suggested information to be compiled in support of a Terrestrial Ecological Evaluation (TEE).

6.13.3 Terrestrial Ecological Evaluations at Commercial and Industrial Sites

For industrial or commercial land uses, the terrestrial ecological evaluation process focuses on evaluation of impacts to wildlife. The effect of soil contamination on plants and soil biota need not be considered unless one of the following conditions exist:

- A plant species is present on the facility that is protected under the Endangered Species Act.
- The soil contamination is located on an area of an industrial or commercial property where vegetation must be maintained to comply with local government land use regulations.

The MTCA rule defines what constitutes "industrial property" and "commercial property."

KEY POINT: WHAT'S "INDUSTRIAL" AND "COMMERCIAL" PROPERTY UNDER LOCAL ZONING MAY NOT BE THE SAME AS UNDER MTCA

Some local zoning classifications may allow a wide variety of uses, including residential uses under industrial and commercial zoning. This is not the case under MTCA.

Under MTCA "Industrial properties" means properties that are or have been characterized by, or are to be committed to, traditional industrial uses such as processing or manufacturing of materials, marine terminal and transportation areas and facilities, fabrication, assembly, treatment, or distribution of manufactured products, or storage of bulk materials, that are either:

- Zoned for industrial use by a city or county conducting land use planning under Chapter 36.70A RCW (Growth Management Act); or
- For counties not planning under Chapter 36.70A RCW (Growth Management Act) and the cities within them, zoned for industrial use and adjacent to properties currently used or designated for industrial purposes.

See WAC 173-340-745 for additional criteria to determine if a land use not specifically listed in this definition would meet the requirement of "traditional industrial use" and for evaluating if a land use zoning category meets the requirement of being "zoned for industrial use."

The term "commercial property" is defined in WAC 173-340-7490:

"Commercial Property" means properties that are currently zoned for commercial or industrial property use and that are characterized by or are committed to traditional commercial uses such as offices, retail and wholesale sales, professional services, consumer services and warehousing.

6.13.4 Criteria for Exclusion from Terrestrial Ecological Evaluations

Not all sites require a detailed terrestrial ecological evaluation. The MTCA rule identifies the criteria for determining if a site can be excluded from further evaluation. Each site must be evaluated on a site-specific basis.

No further evaluation is required if Ecology determines that a site meets any one of the four criteria in WAC 173-340-7491(1)(a–d). These "exclusions" are intended to remove from further evaluation those sites that do not pose an existing or potential threat to terrestrial ecological receptors. The exclusions are primarily based on the potential for plants and animals being exposed to the soil contamination. Only one substantiated exclusion is necessary to exclude a site from further terrestrial ecological evaluation. Exclusion from a terrestrial ecological evaluation does not exclude the site from consideration of potential ecological effects to sediments, wetlands and surface water.

KEY POINT: FUTURE LAND USES MUST HAVE A COMPLETION DATE!

Any terrestrial remedy, including exclusions, based on habitat present after future development must include a completion date for this development that is acceptable to the department. As part of Ecology's periodic (5 year) review of such cleanups, if the development assumed in the terrestrial ecological evaluation has not been completed, the site cleanup may need to be re-opened to account for existing land-use conditions.

Exclusion Criterion (a)

If the contamination is located below the point of compliance of 15 feet, then no further evaluation is required. A conditional point of compliance of 6 feet is allowed with the use of institutional controls limiting future excavation unless an alternative depth is justified on a site-specific basis. (WAC 173-340-7491(1)(a))

Exclusion Criterion (b)

If soil contamination is contained by a physical barrier "that will prevent plants or wildlife from being exposed to the soil contamination", no further evaluation is required, provided an institutional control is placed on the property to ensure that the barrier is maintained. The criterion provides three examples of physical barriers that are likely to meet the functional standard: buildings, paved roads and pavement (e.g., a concrete sidewalk). These examples are not intended to preclude other possibilities that may meet the standard on a case by case basis. For example, a compacted gravel surface is a candidate, although its effectiveness would depend on thickness, size distribution, degree of compaction and maintenance. (WAC 173-340-7491(1)(b))

Exclusion Criteria c (1) & c (2)

Sites without significant "continuous undeveloped land" on or near the site qualify for an exclusion if both of the following conditions are met (WAC 173-340-7491(1)(c)):

(1) For sites contaminated with hazardous substances other than those specified in (2) below, there is less than 1.5 acres of contiguous undeveloped land on the site or within 500 feet of any area of the site.

(2) For sites contaminated with any of the following hazardous substances: Chlorinated dioxins or furans, PCB mixtures, DDT, DDE, DDD, aldrin, chlordane, dieldrin, endosulfan, endrin, heptachlor or heptachlor epoxide, benzene hexachloride, toxaphene, hexachlorobenzene, pentachlorophenol, or pentachlorobenzene, there is less than 1/4 acre of contiguous undeveloped land on or within 500 feet of any area of the site affected by these hazardous substances.

"Undeveloped land" means the land is not covered by buildings, roads, paved areas or other barriers that would prevent wildlife from feeding on plants, earthworms, insects or other food in or on the soil. (WAC 173-340-7491(1)(c)(iii))

"Contiguous" undeveloped land means the habitat is not divided in smaller areas by highways, extensive paving, structures or similar features that are likely to reduce the potential use of the overall area by wildlife. Roads, sidewalks, and other structures that are unlikely to reduce potential use of the area by wildlife are not considered to divide a contiguous area into smaller areas (WAC 173-340-7491(1)(c)(iii)). For example, habitat divided by two-lane local access streets, undivided collectors and minor arterials (per WSDOT classification system),[18] sidewalks and similar features are typically considered contiguous.

Exclusion Criterion (d)

Sites with all soil contaminants at or below natural background concentrations qualify for an exclusion. (WAC 173-340-7491(1)(d))

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[18] See http://www.wsdot.wa.gov/mapsdata/travel/hpms/functionalclass.htm

6.13.5 Simplified Terrestrial Ecological Evaluations Criteria

Sites that do not qualify for one of the above exclusions must conduct either a simplified or a site-specific terrestrial ecological evaluation. The following criteria, specified in WAC 173-340-7491(2)(a)(i-iv), identify ecologically sensitive sites. If <u>any</u> of the four criteria below apply to the site, then a site-specific TEE must be conducted. If <u>none</u> of the criteria apply to the site, then a simplified TEE can be conducted. The user may also choose to conduct a site-specific terrestrial ecological evaluation.

<u>Criterion 1 (WAC 173-340-7491(2)(a)(i))</u>

A site-specific terrestrial ecological evaluation must be conducted if the site is located on, or directly adjacent to, an area where management or land use plans will maintain or restore "native" or "semi-native" vegetation. For example, green-belts, protected wetlands, forestlands, locally designated environmentally sensitive areas, open space areas managed for wildlife, and some parks or outdoor recreation areas. This does not include park areas used for intensive sport activities such as baseball or football. (WAC 173-340-7491(2)(a)(i))

"Native vegetation" means "any plant community native to the state of Washington..."
"Semi-native vegetation" means "a plant community that includes at least some vascular plant species native to the state of Washington..." [see MTCA rule for complete definitions]

<u>Criterion 2 (WAC 173-340-7491(2)(a)(ii))</u>

A site-specific terrestrial ecological evaluation must be conducted if the site is used by: a threatened or endangered species; a wildlife species classified by the Washington State Department of Fish and Wildlife as a "priority species" or a "species of concern" under Title 77 RCW; or, a plant species classified by the Washington State Department of Natural Resources Natural Heritage Program as "endangered," "threatened," or "sensitive" under Title 79 RCW. (WAC 173-340-7491(2)(a)(ii))

For plants, "used" means that a plant species grows at the site or has been found growing at the site. For animals, "used" means that individuals of a species have been observed to live, feed or breed at the site.

<u>Criterion 3 (WAC 173-340-7491(2)(a)(iii))</u>

A site-specific terrestrial ecological evaluation must be conducted at a site if the site is located on a property that contains at least ten (10) acres of native vegetation within 500 feet of the site. (WAC 173-340-7491(2)(a)(iii))

<u>Criterion 4 (WAC 173-340-7491(2)(a)(iv))</u>

A site-specific terrestrial ecological evaluation must be conducted at a site if the department determines the site "may present a risk to significant wildlife populations" (WAC 173-340-7491(2)(a)(iv)). This determination would typically be made by Ecology during review of the remedial investigation for sites under an order or decree or review of a comparable document for sites requesting a review under Ecology's Voluntary Cleanup Program.

6.13.6 Conducting a Simplified Terrestrial Ecological Assessment

The process for conducting a simplified terrestrial ecological assessment is provided in WAC 173-340-7492(2). A simplified TEE may be conducted if all four criteria listed in 6.13.5 do not apply to the site.

Step 1. Area of Contamination (WAC 173-340-7492(2)(a)(i))

Measure the total area of soil contamination. If this area is less than 350 square feet, no further assessment is needed.

Step 2. Table 749-1 (WAC 173-340-7492(2)(a)(ii))

Use Table 749-1 in MTCA to determine if the land use at the site and surrounding area makes substantial wildlife exposure unlikely. If so, then no further evaluation is required.

Step 3. Pathways Analysis (WAC 173-340-7492(2)(b))

Conduct an analysis of potential exposure pathways for soil biota, plants and wildlife (only wildlife [e.g. small mammals & birds] need be considered for commercial and industrial property). Pathways would be considered incomplete if exposure is blocked by natural or man-made physical barriers (such as pavement & buildings). If there are no exposure pathways, no further evaluation is required. If manmade barriers (either existing or to be placed within a timeframe acceptable to the department) are relied on, an environmental covenant is required to ensure continued maintenance of these barriers.

Step 4. Table 749-2 (WAC 173-340-7492(2)(c)(i))

Use the values in Table 749-2 in MTCA as screening levels. If none of the hazardous substances at the site are listed in Table 749-2 or exist at the site at the applicable points of compliance in concentrations that exceed these values, then no further evaluation is required. The petroleum related contaminants in Table 749-2 are reproduced in Table 6.13.

If site concentrations exceed these values, the values in Table 749-2 may also be used as cleanup levels for concentrations protective of plants and animals at these sites.

Step 5. Bioassays (WAC 173-340-7492(2)(c)(ii))

The values in Table 6.13 are based on studies of fresh gasoline and diesel products. As an alternative to using these values, bioassays can be conducted to evaluate the toxicity of petroleum-contaminated soil and establish a site-specific bioaccumulation factor for specific contaminants (for use in wildlife exposure modeling). Bioassay methods are described in WAC 173-340-7493 (3)(b) and Table 7.5 of this guidance. Consult with the Ecology Cleanup Project Manager (site manager) if you plan to use bioassays to establish site-specific cleanup levels.

Key Point: Use Bioassays to Save on Cleanup Costs

The toxicity of petroleum to soil biota varies with the type of petroleum product and aging of the soil contamination. Use bioassays to evaluate the toxicity of weathered products and save on cleanup costs.

Table 6.13 Simplified TEE Soil Screening Levels for Petroleum Products and Constituents (1)

Petroleum Products	**Unrestricted Land Use**	**Industrial/Commercial site (3)**
Gasoline Range Organics	200 mg/kg	1,000 to 12,000 mg/kg (4)
Diesel Range Organics (2)	460 mg/kg	2,000 to 15,000 mg/kg (4)
PCB Mixtures (5)	2 mg/kg	2 mg/kg
Benzo(a)Pyrene	30 mg/kg	300 mg/kg
Lead	220 mg/kg	220 mg/kg

(1) Source: WAC 173-340-900, Table 749-2

(2) Diesel range organics includes the sum of diesel fuels and heavy oils measured using the NWTPH-Dx method. Mineral oils are essentially non-toxic to plants and animals and do not need to comply with these values.

(3) Must have environmental covenant on property committing it to commercial or industrial use.

(4) Concentration at ground surface cannot exceed residual saturation. The lower end of the range shown is the default residual saturation concentration from Table 747-5. Where information can be provided demonstrating a higher site-specific residual saturation concentration, the screening level may go as high as the upper end of the range.

(5) PCBs are included in this table because they can sometimes be a contaminant in petroleum mixtures, especially heavy oils and transformer fluids.

Table 6.13 Simplified TEE soil screening levels for petroleum products and constituents (1).

6.13.7 Site-Specific Terrestrial Ecological Evaluations

Sites that do not qualify for an exclusion or do not qualify for a simplified terrestrial ecological analysis must do a site-specific terrestrial ecological evaluation.

The requirements for conducting a site-specific terrestrial ecological evaluation are described in WAC 173-340-7493. These evaluations are expected to be conducted by an experienced habitat biologist or ecological risk assessor.

Because conducting a site-specific evaluation can be time consuming and expensive, Ecology has provided an option of using screening level values in Table 749-3 to determine if further analysis is needed. The petroleum-related values are reproduced in Table 6.14. Note that the values are more stringent than the values in Table 6.13 because of the need for a higher level of protection at sites that are ecologically more important. If hazardous substances concentrations at the site do not exceed the values in Table 6.14 then no further evaluation is required. If substances are present at the site that are not listed in Table 749-3, then further site-specific evaluation will be necessary using the other methods specified in WAC 173-340-7493.

The values specified in Table 6.14 may also be used as cleanup levels. Note that when using these values for cleanup levels for commercial and industrial sites, only the wildlife value needs to be considered.

For additional information on site-specific ecological risk assessments see:

Department of Ecology’s Terrestrial Ecological Evaluation Process Website
http://www.ecy.wa.gov/programs/tcp/policies/terrestrial/site-specific.htm

USEPA Ecological Risk Assessment Guidance for Superfund (USEPA 1997)
http://www.epa.gov/oswer/riskassessment/risk_superfund.htm

Table 6.14 Site-Specific TEE Soil Screening Levels for Specific Petroleum Products (1)

	Plants	Soil Biota	Wildlife
Gasoline Range Organics	No value available	100 mg/kg	1,000 to 5,000 mg/kg (3)
Diesel Range Organics (2)	No value available	200 mg/kg	2,000 to 6,000 mg/kg (3)
PCB Mixtures (4)	40 mg/kg	No value available	0.65 mg/kg
Benzo(a)Pyrene	No value available	No value available	12 mg/kg
Lead	50 mg/kg	500 mg/kg	118 mg/kg

(1) Source: WAC 173-340-900, Table 749-3

(2) Diesel range organics includes the sum of diesel fuels and heavy oils measured using method.

Mineral oils are essentially non-toxic to plants and animals and do not need to comply with these values.

(3) Concentration at ground surface cannot exceed residual saturation. The lower end of the range shown is the default residual saturation concentration from Table 747-5. Where information can be provided demonstrating a higher site-specific residual saturation concentration, the screening level may go a high as the upper end of the range.

(4) PCBs are included in this table because they can sometimes be a contaminant in petroleum mixtures, especially heavy oils and transformer fluids.

Table 6.14 Site-specific TEE soil screening levels for specific petroleum products (1).

6.13.8 Required Documentation for Terrestrial Ecological Evaluations

All terrestrial ecological evaluations need to include sufficient documentation to support the decisions made during the evaluation process. This includes justification for proposed conditional points of compliance. If this information is already contained within a site investigation or cleanup report in the department's files, summarize the information and cite the specific locations in the reports where the supporting data can be found.

All sites, including those undergoing independent remedial actions, must conduct terrestrial ecological evaluations. For sites with reviews requested under Ecology’s Voluntary Cleanup Program, Ecology requires submitting documents demonstrating compliance with the TEE evaluation process to receive a determination of “no further action.”

6.14 Regulatory Classifications of Affected Media

When conducting a remedial investigation, it is important to determine the regulatory classifications of affected media as this information will impact which cleanup levels are applied to a site. The following provides a brief summary for each media.

Land Use

The information compiled in Subsection 6.12 of this guidance should be used to determine if the site qualifies as industrial property for the purpose of establishing soil and air cleanup levels.

Surface Water Classifications

The beneficial uses and classification of surface waters in the vicinity of the site should be identified in the remedial investigation.

In Washington State, the classification and beneficial uses of surface waters are defined in water quality law (Chapter 173-201A WAC). Beneficial uses include use of the water for domestic water supply (drinking water), irrigation, fish and shellfish rearing, recreation (such as swimming and sport fishing), commerce and navigation, and wildlife habitat.

Surface waters are designated as either freshwater or marine. In general, the fresh water criteria must be applied where daily salinity values are less than or equal to one part per thousand and salt water criteria where salinity is greater than one part per thousand (WAC 173-201A-260). In estuaries, where there is a constant change in salinity due to tidal action, how the water is classified can be complex. Consult with Ecology's Water Quality Program if there are questions about the classification of the surface waters in these situations.

Groundwater Classifications

The groundwater cleanup level depends on whether groundwater is potable (a current or potential future source of drinking water) or non-potable. Under MTCA, most groundwater is considered potable. The criteria for determining if groundwater can be considered nonpotable under MTCA are set forth in WAC 173-340-720(2) and discussed in Subsection 8.7 of this guidance.

The remedial investigation should identify the classification of the groundwater at the site. If the groundwater is designated as nonpotable, the justification for that classification, including any supporting data, should be provided in the remedial investigation. At some sites there will be multiple water-bearing zones potentially impacted. In these situations, the classification of each water-bearing zone should be identified.

Hazardous Waste Designation

Any waste materials present on a site, as well as any waste materials generated during investigation and cleanup of a site, including contaminated soils, are potentially subject to designation as a hazardous waste under WAC 173-303. [19] It is possible that the volatile components, lead, polychlorinated biphenols and carcinogenic polycyclic aromatic hydrocarbons typically present in petroleum wastes and products, and petroleum contaminated soils, could trigger designation of these materials as a hazardous waste. If so designated, site waste materials are subject to very specific requirements related to their treatment, storage, and disposal. Appropriate testing should be conducted during the remedial investigation to determine if this is likely to be the case. See Subsection 11.2.4 of this guidance for additional information on this topic.

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[19] Hazardous wastes are called "dangerous wastes" and "extremely dangerous wastes" under Washington State law.

6.15 Check for Data Gaps

Once the initial site characterization has been completed, it is important to check for data gaps. In particular, you should assess the adequacy of the investigation to answer the following types of questions:

- Have the major soil layers and water bearing layers been identified?
- Have the predominant horizontal and vertical groundwater flow directions been identified?
- Have fluctuations in the groundwater table over time been identified?
- Have all the contaminants likely to be present at the site been tested for in all of the media of concern?
- Has the area and vertical extent of contaminated soil and entrapped product been sufficiently defined to estimate the volume of contaminated soil and mass of contaminant at the site?
- Have contaminant concentrations vs. depth in the soil and groundwater, both in the source zone and in down gradient areas, been characterized?
- Have contaminant concentrations vs. distance from the source been characterized?
- Has sufficient information been gathered to conduct a terrestrial ecological risk assessment?

If you are not confident that you have characterized the site with enough accuracy to answer these questions, then supplemental investigations will likely be necessary.

KEY POINT – USE A DYNAMIC WORK PLAN TO RESOLVE DATA GAPS!

In most cases, there will be data gaps in the initial site characterization that will need to be addressed. Use experienced personnel to make real time decisions using real time data. Use field screening methods to target key areas and then follow-up with precise measurements. For sites being cleaned up under an order or decree, don't wait until the end of the field work to contact Ecology! Consult with the Ecology Cleanup Project Manager (site manager) as the investigation evolves, keeping them informed of field results and planned adjustments to the investigation.

6.16 Presentation of Site Characterization Results

The results of the remedial investigation must be documented in a comprehensive report. The report should not only provide a written description of the work conducted but also provide an evaluation of that work. Contaminant concentration data can be expensive to collect. It is important to compile and present this data in ways that can facilitate its interpretation.

In addition to the narrative discussion, the findings of the investigation should be presented in maps and cross sections that illustrate the geologic and groundwater conditions and contaminant concentrations. The report should also provide recommendations as to what steps should be taken for further site investigation and remediation.

A description of the information that is recommended to be included in a remedial investigation report is provided in Appendix A.

7.0 Test Recommendations and Analytical Methods

This section provides testing recommendations for common petroleum products encountered at contaminated sites. It also identifies recommended analytical methods.

While groundwater is addressed in this section, it is not necessary to test groundwater at every site. However, as discussed in Section 6.9, Ecology interprets MTCA to require that groundwater be tested at petroleum contaminated sites unless there is clear evidence that the release has not reached groundwater.

This section does not provide recommendations regarding vapor testing. See Ecology's publication *Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action*, Publication No. 09-09-047 (October 2009 Review Draft). Until that guidance is finalized, if vapors are an issue at a site undergoing a remedial action (including independent remedial actions), it is recommended the sampling and analysis plan for vapors be submitted to Ecology for review before proceeding with field work.

All tests, other than field screening tests described in Section 5, must be conducted by an Ecology-accredited laboratory. To find an Ecology-accredited laboratory in your area, go to:

http://www.ecy.wa.gov/programs/eap/labs/index.html

7.1 How to Decide What to Test For

The analytical methods that must be used to test for contaminants at a petroleum release site depend on three factors:

- The products present at the site
- The method to be used to develop cleanup standards
- The remedy selected. Some remedies, like natural attenuation of groundwater, require additional tests.

Step 1. Determine the products present at the site.

Review historical information to determine the types of petroleum products used at the site and where releases are likely to have occurred. Unless definitive information is available, the product types should be confirmed using the Northwest TPH Hydrocarbon Identification (NWTPH-HCID) method and samples that are representative of the releases at the site. Common product types are identified in

Table 7.1. Note that the NWTPH-HCID method is generally not used to determine a sample concentration, only to identify the type of product.

Table 7.1 Categories of Petroleum Products (1)
Gasoline (Gasoline Range Organics generally within C5-C13) includes the following products: • Automotive Gasoline • Aviation Gasoline • Automotive Racing Fuels • Mineral Spirits • Naptha • Stoddard Solvents
Middle Distillates/Oils (Diesel Range Organics generally within C8-C21) includes the following products: • Diesel No. 1 • Kerosene • Diesel No. 2 • Diesel & Biodiesel mixtures • Home heating oil • Jet Fuel (e.g., JP-4, JP-5, JP-7, JP-8) • Light Oil
Heavy Fuels/Oils (Diesel Range Organics generally within C12-C34) includes the following products: • Bunker C • No. 4 Fuel Oil • No. 5 Fuel Oil • No. 6 Fuel Oil • Products included under waste oil **before use**
Mineral Oil is a **subcategory of heavy oil** that is highly refined oil. It includes: • Non-PCB based insulating oil or coolant used in electrical devices such as transformers and capacitors. (Mineral oils containing less than 2 ppm total PCBs)
Waste Oil is any **used heavy oil** and includes the following products: • Engine lubricating oil • Hydraulic fluid • Industrial process oils • Metalworking oils and lubricants • Refrigeration/compressor oil • Transmission/differential fluid
1. Product categories are the same as those used in Table 830-1 in the MTCA rule.

Table 7.1 Categories of petroleum products (1).

Step 2. Match TPH Method with method to be used to develop cleanup standards.

MTCA provides for three methods for establishing cleanup standards:

- Method A – intended for simple sites; generally consists of values obtained from tables and/or applicable state and federal laws.
- Method B – can be used at any site; generally consists of values from applicable state and federal laws and values calculated using formulas in the rule.
- Method C – can be used under limited circumstances, such as for soil cleanup levels at industrial facilities; generally consists of values from applicable state and federal laws and values calculated using formulas in the rule.

If Method A is to be used to develop cleanup standards, then whole product analysis, using the NWTPH Gx and/or NWTPH-Dx methods should be used to determine the concentration of gasoline range compounds (Gx) or diesel and oil range compounds (Dx) present in a sample. If there is a mixture of gasoline range organics and diesel range organics in a sample, then it will be necessary to analyze samples using both methods.

If Methods B or C are used to develop site-specific cleanup standards, then fractionated product testing will be necessary using the volatile petroleum hydrocarbons (VPH) and extractable petroleum hydrocarbons (EPH) methods to determine the concentration of aliphatic and aromatic hydrocarbons in specific carbon ranges or fractions. The VPH method is used for volatile hydrocarbon fractions; the EPH method is used for semi-volatile and non-volatile hydrocarbon fractions. When conducting fractionated testing, it is recommended that whole product analysis using the NWTPH (NWTPH-Gx or Dx) methods also be conducted on split samples.

Step 3. Determine the substances for which to test.

In addition to TPH test methods, different products require testing for additional specific components. Best Management Practices testing recommendations are provided in Table 7.2. If a sample contains a mixture of products, then test for substances likely to be in both products. The analytical methods and recommended practical quantitation limits are provided in Table 7.3. It will not always be possible to achieve these limits, especially in heavily contaminated samples. However, these limits should be achievable for most slightly contaminated samples on the fringe of the area of contamination, which is where these limits become significant in determining compliance with cleanup levels.

7.2 Special Testing Considerations for Natural Attenuation and Sediments

If it is anticipated that natural attenuation of groundwater will be proposed as a component of the remedial actions taken at a site, then additional tests will typically be necessary to characterize the geochemistry of the groundwater at the site and determine whether natural attenuation is feasible. These additional tests are summarized in Table 7.4.

For more information on use of natural attenuation at petroleum contaminated sites, see Ecology Publication No. 05-09-091, *Guidance on Remediation of Petroleum-Contaminated Groundwater by Natural Attenuation*, available at http://www.ecy.wa.gov/biblio/0509091.html.

If surface water is impacted, these recommendations apply to the chemical characterization of surface water and sediment within these water bodies. However, it may also be necessary to conduct water and sediment bioassays to determine safe concentrations for aquatic and benthic organisms. Bioassays can also be used to override TEE table values in some instances. If bioassays are determined appropriate, the recommended test methods are provided in Table 7.5.

KEY POINT: REPORTING LIMITS

The ***method detection limit*** (MDL) means the minimum concentration of a compound that can be measured and reported with 99% confidence that the value is greater than zero. In other words, this is the lowest concentration of a contaminant that can be ***detected*** by an analytical method. Results below the MDL are typically qualified as undetected.[20]

The ***practical quantitation limit*** (PQL) means the lowest concentration that can be reliably measured within specified limits of precision, accuracy, representativeness, completeness, and comparability during routine laboratory operating conditions, using department approved methods. In other words, this is the lowest concentration that can be ***quantified*** by that analytical method with a high degree of certainty. Because PQLs can become cleanup levels in some cases, MTCA sets an upper limit on the PQL of no more than 10 times the MDL.

Many laboratories use the term "***reporting limit***" to describe analytical results. Whereas MDLs and PQLs are typically determined by evaluating the results of inter-laboratory studies using spiked samples, a reporting limit is typically a sample-specific concentration set at the lowest concentration a laboratory is confident they can ***quantify*** for that sample. It is almost always higher than the MDL, and sometimes higher than the PQL, and may vary on a sample-by-sample basis due to matrix interferences or high levels of contamination. If the reporting limit is higher than the cleanup level, and this information is needed to determine compliance at the site, it may be necessary to change sampling protocols or ask the laboratory to alter their sample preparation procedures or instrumentation, so that the reporting limit does not exceed the cleanup level.

Note that laboratories typically add "***qualifiers"*** to test results.[21] Qualifiers are important and should be considered an integral part of the test result. The laboratory that did the analyses should be consulted if the meaning of "reporting limit" or their qualifiers is not apparent.

7.3 Total Petroleum Hydrocarbons (TPH)

As noted in Subsection 7.1 of this guidance, total petroleum concentrations are measured using the NWTPH-Gx method for gasoline range organics and NWTPH-Dx method for diesel and oil range organics. VPH and EPH are used to measure the concentration of aliphatic and aromatic hydrocarbons in specific carbon ranges or fractions. The total TPH concentrations measured using the NWTPH-Gx and Dx methods will not necessarily equal the TPH concentrations

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[20] Labs often use the term "estimated detection limit" or EDL. EPA defines this in their contract lab program as the concentration required to produce a signal with a peak height of at least 2.5 times the background signal ("noise") level *for the sample being analyzed*.

[21] Typical qualifiers are: "U" = analyzed but not detected at stated concentration; "J" = analyzed and positively identified but concentration is estimated; "UJ" = analyzed but not detected at estimated concentration; "R" = data is unusable; and "NJ" = substance tentatively identified but concentration is estimated.

measured using the VPH and EPH methods. This is because the different methods use different sample preparation methods and laboratory equipment to measure concentrations. There is also error introduced when extracting the TPH from the sample and in measurement accuracy. For example, the EPH method allows surrogate recovery rates of 50% to 150% and a method accuracy for the total of all petroleum hydrocarbons of 70% to 130%. And, the VPH method allows surrogate recovery rates of 60% to 140% and a method accuracy for the total of all petroleum hydrocarbons of 70% to 130%. Lack of correlation does not, in itself, invalidate test results.

KEY POINT: READ AND UNDERSTAND THE ANALYTICAL METHODS!

Make sure you read Ecology's petroleum hydrocarbon analytical methods! Data interpretation errors can be avoided by reading and understanding the test methods.

Ecology's petroleum hydrocarbon methods are in: ECY 97-602: *Analytical Methods for Petroleum Hydrocarbons* (June-97), available at http://www.ecy.wa.gov/biblio/97602.html.

Many laboratories, split the results of the NWTPH-Dx method into "diesel" and "oil" values, since there are separate values for diesel and oil in the Method A tables. Where this split occurs can vary between laboratories as this split is not called for in the analytical method. Furthermore, the Method A values were derived using the entire range of TPH fractions present in each type of product, not based on splitting the test results. ***Thus, to split the NWTPH-Dx analytical results into diesel and oil fractions and compare each fraction to the Method A table values is an incorrect use of these tables. Rather, the sample diesel and oil fractions should be added together and compared against either the diesel or heavy fuel oil Method A value.***

For an example illustrating this issue, see Ecology Implementation Memorandum #4: Determining Compliance with Method A Cleanup Levels for Diesel and Heavy Oil, June 17, 2004, available at http://www.ecy.wa.gov/biblio/0409086.html.

Where product matching indicates a sample is clearly a mixture of two products, there are two options:

- Use the most stringent Method A cleanup level to determine compliance, or [22]
- Resample the site and reanalyze the samples using the EPH/VPH methods. Use these results to calculate a Method B TPH cleanup level for the mixture as a whole.

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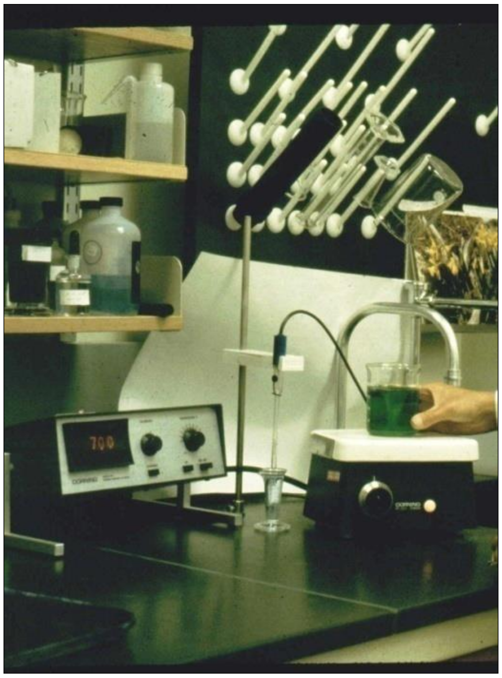
[22] For a diesel and oil mixture, the Method A cleanup levels are identical for diesel and oil, so one could apply *either* the diesel or oil cleanup level to the mixture.



To minimize the potential for interferences by naturally occurring non-petroleum organic matter (such as leaf litter, bark and peat), the NWTPH-Dx method provides for a silica gel cleanup procedure for removing these naturally occurring organics during the extraction process. Silica gel works by attaching to and removing polar organics, which are characteristic of natural organic matter.

Some petroleum products like heavy fuel oils such as #6 fuel oil and Bunker-C contain significant amounts of polar organics, thought to be due to organically bound sulfur. This can result in as much as a 10% to 20% loss when subjected to silica gel cleanup.

Furthermore, over time, as petroleum degrades through microbial and chemical reactions, some petroleum components will be transformed to intermediary degradation by-products that are polar organics. This can result in an unknown amount of product loss during silica gel cleanup. These intermediary by-products are considered part of the petroleum mixture since they are typically not otherwise considered in a petroleum risk evaluation.

Because most soils contain naturally occurring organic matter, use of silica gel cleanup ***for soil extracts*** being analyzed using the NWTPH-Dx method is generally acceptable.

However, most groundwater does not contain significant levels of naturally occurring organic matter. *For this reason,* ***silica gel cleanup should not be used for NWTPH-Dx analyses of groundwater samples*** *unless uncontaminated background samples indicate that naturally occurring organic matter is a significant component of the TPH being detected in the groundwater samples*.[23] If silica gel cleanup is used, groundwater samples should be split and analyzed both with and without silica gel cleanup.

Because the use of silica gel is an integral part of the EPH method, absorption of polar organics that are part of the product, or a by-product of degradation, cannot be avoided. In this case and others where silica gel cleanup has been used, the laboratory should use standards that have undergone the same cleanup/separation technique to calibrate the gas chromatograph.

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[23] Determined by analyzing clean background samples to obtain an estimate of the naturally occurring organics contribution to the TPH totals.

7.4 BTEX and Trimethyl Benzene

Benzene, toluene, ethylbenzene, and xylenes (BTEX) are always present in gasoline and should be tested for at all gasoline contaminated sites. While BTEX is seldom present in home heating oil, it is typically present in diesel fuel and waste oils as a contaminant and may be present at higher levels in some lighter fuels like marine diesel. These compounds also tend to be more toxic and mobile than other fuel components. For these reasons, at diesel contaminated sites (except heating oil), Ecology recommends BTEX be tested for in the product released (if available) and selected soil and groundwater samples (3 to 5 of each) to determine if they are present at the site. If not found, no additional testing should be necessary. If found, additional testing should be conducted to establish the extent of soil and groundwater contamination by these contaminants at these sites.

7.5 MTBE

Use of oxygenates in gasoline is currently not required in Washington State. And, the use of MTBE as a gasoline additive has been banned in Washington State since December 31, 2003 (RCW 19.112.100). However, MTBE was historically used in gasoline in the Spokane and Vancouver areas due to air quality concerns. Until recently, MTBE was still legal to use in some parts of the country, so it is possible delivery trucks and pipelines providing gasoline in Washington State may have small amounts of MTBE present as a contaminant from previous loads.

Because of the high mobility of MTBE and concerns with very low MTBE levels, MTCA requires gasoline-contaminated sites to test for MTBE in the groundwater. Ecology recommends testing be conducted on the product released or, if the product is no longer available, then on selected soil and groundwater samples (3 to 5 of each) to establish whether MTBE is present at a site. If not found, no additional testing should be necessary. If found, additional testing should be conducted to establish the extent of soil and groundwater contamination. Note that MTBE is very mobile and may be present further down gradient than other petroleum components– consider this when selecting testing locations.

7.6 Lead, EDB, and EDC

Leaded gasoline was common before being phased out over a period of several years (1973–1996) under federal law. After 1996, lead and the lead scavengers EDB (ethylene dibromide) and EDC (ethylene dichloride) are unlikely to be present at environmentally significant levels in most gasoline releases. However, leaded gasoline is still allowed for off-road uses such as aviation, farm equipment, marine engines and racing fuels. And, if the truck used to deliver leaded gasoline for these other uses is not completely emptied, there could be cross contamination with the substances. These substances may also be present if an abandoned underground storage tank was not completely emptied of old product.

For these reasons, Ecology recommends lead, EDB and EDC be tested for in the product released (if available), or if the product is no longer available, then on selected soil and groundwater samples (3 to 5 each) to establish whether these contaminants are present at the site. If not found, no additional testing should be necessary. If they are found, additional testing should be conducted to establish the extent of soil and groundwater contamination.[24] Note that EDB and EDC are quite mobile and may be present further down gradient than other petroleum components.

7.7 Carcinogenic Polycyclic Aromatic Hydrocarbons (cPAHs)

All heavy fuel oil and waste oil releases must be tested for cPAHs. The following cPAHs must be included in this analysis: benz(a)anthracene; benzo(b)fluoranthene; benzo(k)fluoranthene; benzo(a)pyrene; chrysene; dibenz(a,h)anthracene; and, indeno(1,2,3-cd)pyrene. Gasoline, diesel No. 1 and 2, home heating oil, kerosene, jet fuels and electrical insulating mineral oils releases generally ***do not*** need to be tested for cPAHs. These fuel types will in most cases contain no detectable amounts or trace levels of cPAHs.

7.8 Naphthalenes

Under the MTCA rule, “naphthalenes” is the total of naphthalene, 1-methyl naphthalene and 2-methyl naphthalene. Where naphthalene testing is recommended in Table 7.2, the analysis should include at least naphthalene and 2-methyl naphthalene. 1-methyl naphthalene is generally a minor component of fuels and is not typically measured using EPA Method 8270. Unless there is reason to believe significant amounts of 1-methyl naphthalene are present, it is not necessary to test for and determine the concentration of 1-methyl naphthalene in the media of concern. If 1-methyl naphthalene is suspected of being present at the site, then work with the laboratory to arrange for modification of EPA Method 8270 to enable quantitation of this compound.

7.9 Polychlorinated Biphenyls (PCBs)

PCBs are not a normal component of most petroleum mixtures and do not need to be tested for except in certain heavier oil products (heavy oils, mineral oils, and waste oils). For releases of these products, footnote 15 of Table 830-1 of the MTCA rule requires PCBs tests be conducted unless it can be demonstrated that:

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[24] Note that lead is a natural component of soils in Washington State. Use Ecology Publication No. 94-115, *Natural Background Soil Metals Concentrations in Washington State* to screen out likely background values.

(1) The release originated from an electrical device manufactured for use in the United States after July 1, 1979;

(2) Oil containing PCBs was never used in the equipment suspected as the source of the release (examples of equipment where PCBs are likely to be found include transformers, electric motors, hydraulic systems, heat transfer systems, electromagnets, compressors, capacitors, switches and miscellaneous other electrical devices); or,

(3) The oil released was recently tested and did not contain PCBs.

Transformers that once contained PCB fluids and have since been flushed and replaced with mineral oil will often contain minor amounts of PCBs. Because of this, Ecology recommends PCBs be included in the suite of contaminants tested in the soil at these sites unless the mineral oil released contained less than 2 mg/liter (ppm) of PCBs. This concentration is based on WAC 173-303-9904 (WPCB). If PCBs are found in the soil above 1 mg/kg (Method A unrestricted use cleanup level), then the groundwater should also be tested for PCBs.

Note that chlorinated paraffin cutting oil has been known to cause false positive PCB readings. If this is suspected at a site, consider analyzing for PCB congeners using EPA Method 1668C.

7.10 Other Additives/Components

Ethanol or methanol are common gasoline additives. While the current Method A cleanup levels do not take these alcohols into account and the lack of a reference dose limits the ability to calculate cleanup levels under Method B, these alcohols can be indicators of where gasoline has come to be located and, at high concentrations, may influence the mobility of other components. Methane can also be generated during decomposition of these alcohols, enhancing vapor intrusion concerns. For these reasons, alcohols should be included in the suite of tests where these additives are present in the product released.

Trimethyl benzene is commonly found in gasoline. However, separate testing for isomers of this compound at gasoline contaminated sites is not required under MTCA because the toxicity of this compound is already accounted for in the Method A TPH cleanup levels and the Method B reference dose assigned to the petroleum fraction within which this compound is present.

The extent of the use in Washington State of other additives like tertiary-butyl alcohol [25] (TBA), tertiary-amyl methyl ether (TAME) and ethyl tertiary-butyl ether (ETBE) is not clear. If the product released is suspected of containing any of these additives Ecology recommends testing of the product released or, if the product is no longer available, then on selected soil and groundwater samples (3 to 5 each), to establish whether these contaminants are present at the site. If not found, no additional testing should be necessary. If found, additional testing should be conducted to establish the extent of soil and groundwater contamination. Consult with Ecology if these compounds are found at significant concentrations at a site.

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[25] Note that TBA is also a degradation by-product of MTBE.

Table 7.2 Best Management Practices Testing Recommendations for Various Petroleum Products (1)

Hazardous Substance OR Chemical of Concern	PETROLEUM PRODUCT (2)					
	Gasoline	Naphtha & Mineral Spirits	Middle Distillates (3)	Heavy Oils	Mineral Oil	Waste Oil & Crude Oil
Total Petroleum Hydrocarbons						
Method A (NWTPH-Gx or Dx)	✓	✓	✓	✓	✓	✓
Method B or C (VPH)	✓	✓	✓			✓
Method B or C (EPH)			✓	✓	✓	✓
Volatile Petroleum Compounds						
Benzene	✓		✓	✓		✓
Toluene	✓		✓	✓		✓
Ethylbenzene	✓		✓	✓		✓
Xylenes (m-, o-, p-)	✓	✓	✓	✓		✓
n-Hexane	✓					✓
Fuel Additives and Blending Compounds						
MTBE	✓					✓
Ethylene Dibromide (EDB)	✓					✓
Ethylene Dichloride (EDC)	✓					✓
Other Additives and Blending Compounds (e.g., ethanol, methanol, TBA, TAME, ETBE)	✓ (See 7.10)					✓
Other Petroleum Components						
Carcinogenic PAHs (4)				✓		✓
Naphthalenes (Naphthalene, 1-Methyl and 2-Methyl)	✓ (See 7.8)	✓	✓	✓		✓
Metals						
Cadmium, Chromium, Nickel and Zinc						✓
Lead	✓					✓
Other Non-Petroleum Contaminants (5)						
PCBs				✓	✓	✓
Halogenated VOCs						✓
Other Site Contaminants	✓	✓	✓	✓	✓	✓

(1) This table presents simplified sampling recommendations based on Table 830-1 in the MTCA rule and practical experience.

(2) See the definitions of products in Table 7.1. If the type of petroleum hydrocarbons present is not known or there is a mixture of petroleum products at the site, then test one or more representative samples using the NWTPH-HCID method to determine the appropriate analytical method(s). For a mixture of products, both methods may need to be used. Consult with Ecology for testing recommendations for petroleum products not identified in this table.

(3) Heating oil does not need to be analyzed for BTEX.

(4) The following cPAHs must be included in this analysis: benz(a)anthracene; benzo(b)fluoranthene; benzo(k)fluoranthene; benzo(a)pyrene; chrysene; dibenz(a,h)anthracene; and, indeno(1,2,3-cd)pyrene.

(5) Analyze for any non-petroleum contaminants that are known or suspected of being present at the site. For example, if the diesel was used as a pesticide carrier in orchard spraying, testing for pesticides should be conducted. Another example is testing to demonstrate natural attenuation is occurring at the site (see Table 7.4 and Ecology Publication No. 05-09-091).

Table 7.2 Best management practices testing recommendations for various petroleum products (1).

Table 7.3 Recommended Analytical Methods (1) (continued next page)

Hazardous Substance OR Chemical of Concern	SOIL/SEDIMENT (2)		GROUNDWATER & SURFACE WATER	
	Analytical Method	PQL (mg/kg)	Analytical Method	PQL (µg/l)
Total Petroleum Hydrocarbons				
Gasoline	Identification using NWTPH-HCID	NA	Identification using NWTPH-HCID	NA
Diesel		NA		NA
Heavy Oil		NA		NA
Method A-Gasoline	NWTPH-Gx	5	NWTPH-Gx	250
Method A-Diesel	NWTPH-Dx	25	NWTPH-Dx	250
Method A-Heavy Oil	NWTPH-Dx	100	NWTPH-Dx	500
Method B or C	VPH	5	VPH	50
Method B or C	EPH	5	EPH	50
Volatile Petroleum Compounds				
Benzene	EPA Method 8260 or 8021	0.005	EPA Method 8260 or 8021	1
Toluene	EPA Method 8260 or 8021	0.005	EPA Method 8260 or 8021	1
Ethylbenzene	EPA Method 8260 or 8021	0.005	EPA Method 8260 or 8021	1
Xylenes (m-, o-, p-)	EPA Method 8260 or 8021	0.005 for each isomer	EPA Method 8260 or 8021	1 for each isomer
n-Hexane	EPA Method 8260	0.005	EPA Method 8260	1
Fuel Additives and Blending Compounds				
MTBE	EPA Method 8260*	0.001	EPA Method 8260	1
Ethylene Dibromide (EDB)	EPA Method 8260* or 8011	0.001	EPA Method 504.1	0.01
Ethylene Dichloride (EDC)	EPA Method 8260* or 8021	0.001	EPA Method 8260 or 8021	1
Ethanol	EPA Method 8260 or 8015	0.05 (estimate)	EPA Method 8260 or 8021	50 (estimate)
Methanol	EPA Method 8015	0.02 (estimate)	EPA Method 8015	20 (estimate)
Tertiary-butyl alcohol (TBA)	EPA Method 8260 or 8015	0.05 (estimate)	EPA Method 8260 or 8021	50 (estimate)
Tertiary-amyl methyl ether (TAME)	EPA Method 8260 or 8015	0.05 (estimate)	EPA Method 8260 or 8021	50 (estimate)
Ethyl tertiary-butyl ether (ETBE)	EPA Method 8260 or 8015	0.05 (estimate)	EPA Method 8260 or 8021	50 (estimate)
Other Additives and Blending Compounds	Chemical-specific	NA	Chemical-specific	NA

Table 7.3 Recommended analytical methods (1).

*Method 8260 may need to be modified (8260 sim) to achieve the necessary PQL.

Table 7.3 Recommended Analytical Methods (continued from previous page) (1)

Hazardous Substance OR Chemical of Concern	SOIL/SEDIMENT (2)		GROUNDWATER & SURFACE WATER	
	Analytical Method	PQL (mg/kg)	Analytical Method	PQL (µg/l)
Other Petroleum Components				
Carcinogenic PAHs	EPA Method 8270 sim	0.05 for each cPAH	EPA Method 8270 sim	0.02 for each cPAH
Naphthalene	EPA Method 8270	0.5	EPA Method 8270	1
1-Methyl Naphthalene	EPA Method 8270	0.5	EPA Method 8270	1
2-Methyl Naphthalene	EPA Method 8270	0.5	EPA Method 8270	1
Metals				
Cadmium	EPA 6000 or 7000 Series	0.1	EPA Method SW 7131	0.1
Chromium (Total)	EPA 6000 or 7000 Series	0.5	EPA 6000 or 7000 Series	0.5
Lead	EPA 6000 or 7000 Series	0.1	EPA 6000 or 7000 Series	0.1
Nickel	EPA 6000 or 7000 Series	0.1	EPA 6000 or 7000 Series	0.1
Zinc	EPA 6000 or 7000 Series	5	EPA 6000 or 7000 Series	5
Other Non-Petroleum Contaminants				
PCBs	EPA Method 8082	0.04	EPA Method 8082	0.1
PCB Congeners	EPA Method 1668C	varies (3)	EPA Method 1668C	varies (3)
Halogenated VOCs	EPA Method 8260 or 8021	0.005 for each VOC	EPA Method 8260 or 8021	5 for each VOC
Other Site Contaminants	Chemical-specific	NA	Chemical-specific	NA

NA = Not applicable

(1) The PQLs recommended in this table were developed in consultation with Ecology's Manchester Lab.

(2) Values are determined on a dry weight basis.

(3) Values vary for different congeners. See the Method for more information.

See also:

Ecology Technical Memorandum #4: Determining Compliance with Method A Cleanup Levels for Diesel and Heavy Oil http://www.ecy.wa.gov/biblio/0409086.html

Ecology Technical Memorandum #5: Collecting and Preparing Soil Samples for VOC Analysis http://www.ecy.wa.gov/biblio/0409087.html

Ecology Technical Memorandum #7: "Soil Moisture Corrected Reporting by EPA Method 8000C" http://www.ecy.wa.gov/biblio/0809042.html

Table 7.4 Supplemental Groundwater Analyses Typically Needed to Support a Natural Attenuation Demonstration

Parameter / Substance	Analytical Method
Dissolved Oxygen	Standard Method 4500-0 (field meter)
Oxidation-Reduction (Redox) Potential (ORP or eh)	Standard Method 2580 (field meter)
pH	EPA Method 150.2 or 9040C (field pH meter)
Specific Conductivity	EPA Method 120.1 or 9050 A (field conductivity meter)
Temperature	EPA Method 170.1 (field thermometer)
Nitrate	4500-NO_3^-I
Soluble Manganese	EPA Method 200.7 (ICP)
Soluble Ferrous Iron	EPA Method 200.7 (ICP)
Sulfate	EPA Method 300.0
Alkalinity	EPA Method 310.2
Methane	Standard Method 6211 (combustible gas meter)

See also: Ecology Publication No. 05-09-091, *Guidance on Remediation of Petroleum-Contaminated Groundwater by Natural Attenuation* found at:

http://www.ecy.wa.gov/biblio/0509091.html

Table 7.4 Supplemental groundwater analyses typically needed to support a natural attenuation demonstration.

Table 7.5 Recommended Bioassay Test Methods for Petroleum Releases	
Medium/Exposure Pathway	**Bioassay Method**
Petroleum-Contaminated Surface Water and Groundwater Discharging to Surface Water	Whole Effluent Toxicity Testing (Ecology Publication No. WQ-R-95-80) (Can be used to help develop a site-specific surface water TPH cleanup level under WAC 173-340-730 (3)(b)(ii).)
Petroleum-Contaminated Soil, terrestrial ecological evaluation (TEE) pathway	• Early Seedling Growth Protocol for Soil Toxicity Screening (Ecology Publication No. 96-324) • Earthworm Bioassay Protocol for Soil Toxicity Screening (Ecology Publication No. 96-327) (Can be used to help develop a site-specific TPH soil cleanup level protective of terrestrial plants & animals.)
Petroleum-Contaminated Marine Sediments	Marine Sediment Biological Tests (Ecology Publication No. 03-09-043) • Amphipod • Larval • Juvenile Polychaete • Microtox • Benthic Macroinvertebrate Abundance
Petroleum-Contaminated Freshwater Sediments	Freshwater Sediment Biological Tests (Appendices C & D in Ecology Publication No. 03-09-043) • Amphipod • Midge • Frog Embryo • Microtox • Benthic Macroinvertebrate Abundance (Marine and freshwater sediment tests can be used to help develop a site-specific TPH sediment cleanup level protective of aquatic life.)

Table 7.5 Recommended bioassay test methods for petroleum releases.

8.0 Establishing Petroleum Cleanup Levels

This section provides a description of the most relevant provisions pertaining to petroleum contaminant cleanup levels. This is not meant to be a comprehensive discussion of all aspects of cleanup levels. More detailed information can be found on Ecology's Toxics Cleanup Program web site. The regulatory requirements can be found in WAC 173-340 and WAC 173-204.

8.1 General Overview

The term "cleanup standard" defines the standards that must be achieved by a cleanup. Cleanup standards consist of three parts:

- The contaminant concentration that is protective of human health and the environment ("cleanup level").
- The location on the site where the cleanup level must be met ("point of compliance").
- Additional regulatory requirements that apply to a cleanup action because of the type of action and/or the location of the site. These requirements are specified in applicable state and federal laws and are generally established in conjunction with the selection of a specific cleanup action. For example, if contaminated soils are to be incinerated on site, the incinerator would have to comply with air quality regulations governing incinerator operations.

The regulatory requirements for establishing cleanup standards are specified in WAC 173-340-720 through 173-340-760.

The MTCA rules provide three methods for establishing cleanup levels. For each of these methods, the MTCA rules set forth criteria for determining the applicability and requirements for use of the method.

- **Method A**—intended for simple sites (most petroleum-contaminated sites can use this method)
- **Method B**—universal method that can be used at any site to develop site-specific petroleum cleanup levels
- **Method C**—can be used only under limited circumstances, such as for soil cleanup levels at industrial facilities

Please note that a direct comparison of these cleanup levels to the contaminant concentrations at the site may not be sufficient to demonstrate compliance with these cleanup levels. See Section 9 for a discussion of establishing a point of compliance and Section 10 for a discussion of measuring compliance with cleanup levels.

8.2 What if the cleanup regulations change during cleanup?

Under MTCA, Ecology must periodically review and update the rules governing cleanups. Changes to the rules may result in cleanup levels that are more or less stringent than those in previous rules.

When cleanup levels change, WAC 173-340-702(12), otherwise known as the “grandfather clause”, describes when the new standards must be applied to a site. In general, this provision can be summarized as follows (consult the MTCA rule for actual requirements):

- Sites undergoing interim cleanup actions must always comply with new standards.
- For sites with cleanup occurring under a MTCA order or decree, the standards in effect at the time Ecology issues a final cleanup action plan apply to the cleanup.
- For independent remedial actions, the standards in effect at the time the final cleanup action (field construction) actually begins apply to the cleanup.[26]

8.3 Are site-specific cleanup levels worth the additional analytical expense?

The Method A soil and groundwater cleanup levels are based on product compositions and exposure assumptions that may not be representative for every site. If a site qualifies for Method A soil and groundwater cleanup levels but these levels are not feasible to achieve at a site, it may be worthwhile to determine site-specific soil cleanup levels using Methods B (or Method C, if the site qualifies). However, to use Methods B or C, samples must be analyzed using the VPH and EPH methods. This is more expensive than using the NWTPH methods.

It may not always be advantageous to develop a site-specific TPH cleanup level as often the results are very similar to, or more stringent than, the Method A cleanup levels. In general, Method B seldom yields groundwater cleanup levels significantly different from Method A. However, Method B is often cost-effective for establishing less stringent site-specific soil cleanup levels for diesel and heavy oil when the leaching pathway is not a concern at a site.

Tables 8.2 and 8.3 can help determine if developing site-specific cleanup levels are worthwhile at a particular site. These tables provide a summary of the range of Method B concentrations derived for selected exposure pathways using the MTCA TPH Spreadsheet for common product types found at petroleum-contaminated sites in Washington State.

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[26] Some site cleanups consist of a series of partial cleanups without a decision document showing how the cleanup standards will ultimately be met. These sites do not qualify under this provision.

In addition to the information in Tables 8.2 and 8.3, when considering which method to use to establish cleanup levels, compare the assumptions upon which the Method A cleanup levels are based against site-specific information. For example:

- **What is the site-specific TPH composition?**

Under Method A, soil and groundwater cleanup levels for TPH are based on typical product compositions measured at petroleum contaminated sites in Washington State. If the product composition at the site is unusual, then consider using Method B instead of Method A. Method B may also be cost-effective where treatment of the soil or groundwater has significantly changed the composition of the petroleum released (such as vapor extraction reducing the lighter fractions).

KEY POINT: TPH SPREADSHEET—A GREAT RESOURCE FOR CALCULATING SITE-SPECIFIC TPH CLEANUP LEVELS

The TPH spreadsheet is a tool developed by Ecology to enable calculation of petroleum cleanup levels based on site-specific analysis of petroleum fractions and components. This spreadsheet may be downloaded at http://www.ecy.wa.gov/programs/tcp/tools/toolmain.html. The following publication provides detailed instructions on the use of the TPH worksheet: Workbook Tools for Calculating Soil and Groundwater Cleanup Levels Under the Model Toxics Control Act Cleanup Regulation: Users Guide 11.1, available at http://www.ecy.wa.gov/biblio/0109073.html.

- **Is the protection of groundwater a concern at the site?**

Method A soil cleanup levels for most hazardous substances were established based on the protection of groundwater quality. If it can be demonstrated that groundwater is not impacted at the site and does not have the potential to be impacted by soil contamination, then consider using Method B to establish soil cleanup levels, instead of Method A.

- **What is the highest beneficial use of the groundwater?**

The groundwater cleanup level depends on whether groundwater is potable (a current or potential future source of drinking water) or non-potable. Under MTCA, most groundwater is considered potable and Method A soil and groundwater cleanup levels are based on this assumption. If it can be demonstrated that groundwater is not a current or potential future source of drinking water based on the criteria set forth in WAC 173-340-720(2), then consider using Method B to establish soil or groundwater cleanup levels, instead of Method A. [27]

- **What are the hydrogeologic characteristics of the site?**

Method A soil concentrations protective of groundwater were established using the equations and default hydrogeologic conditions specified in WAC 173-340-747. If default assumptions in

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[27] See also Subsection 8.7 in this guidance for further discussion of these criteria.

Table 8.1 do not reflect the actual characteristics of the site, then consider using Method B to establish soil cleanup levels, instead of Method A.

Table 8.1 Four Phase Model Key Default Assumptions

Parameter	Value
Dilution Factor	20 (for soil above the water table)
Soil Organic Carbon Content	0.001 gm soil organic/gm soil (0.1%)
Soil bulk dry density	1.5 kg/L
Soil Moisture Content	0.3 (30%)

Source: Equations 747-6 & 747-7 in WAC 173-340-747.

Table 8.1 Four phase model key default assumptions.

Table 8.2 Range of Calculated Soil Concentrations for Various Exposure Pathways and Petroleum Products Using Method B

Product Type	Method A Cleanup Level (mg/kg)	Method B Soil Direct Contact (mg/kg)	Soil Leaching Conc. (mg/kg)		Soil Vapors Conc. (mg/kg)	
			Dilution Factor		Dilution Factor	
			1	20	1,000	10,000
Gasoline	30 or 100*					
Average		2,800	2	50	0.3	3
Median		2,900	2	40	0.3	3
Lower 10th percentile		1,300	0.1	2	0.1	1
Upper 90th percentile		3,700	4	100	0.6	6
Diesel	2,000					
Average		2,700	RS	RS	6	RS
Median		2,600	40	RS	2	RS
Lower 10th percentile		1,900	8	260	1	10
Upper 90th percentile		3,400	RS	RS	10	RS
Heavy Oil	2,000					
Average		2,900	RS	RS	RS	RS
Median		1,700	380	RS	120	RS
Lower 10th percentile		20	30	RS	20	RS
Upper 90th percentile		7,600	RS	RS	RS	RS
Mineral Oil	4,000					
Average		6,100	RS	RS	RS	RS
Median		5,600	510	RS	120	RS
Lower 10th percentile		5,100	50	RS	10	RS
Upper 90th percentile		7,800	RS	RS	RS	RS

* 100 mg/kg applies to sites with weathered product as defined in Table 740-1;
30 mg/kg applies to all other sites.

RS = These values are well in excess of residual saturation. Residual saturation would control the soil leaching concentration in these instances (see WAC 173-340-747(10) and WAC 173-340-900, Table 747-5).

NOTE: This table was derived using the MTCA TPH10 Spreadsheet and petroleum fraction data from a wide variety of sites. It is intended to provide comparison values to help determine if the additional expense of deriving Method B soil cleanup levels is cost-effect at a site. A newer version of this spreadsheet is currently available (MTCA TPH11.1) that may result in somewhat different values.

DO NOT USE THIS TABLE TO ESTABLISH CLEANUP LEVELS FOR A SITE.

Table 8.2 Range of calculated soil concentrations for various exposure pathways and petroleum products using Method B.

Table 8.3 Range of Calculated Groundwater Concentrations for Various Petroleum Products Using Method B (Drinking Water)*

Product Type	Method A Groundwater Cleanup Level (µg/l)	Method B Groundwater Concentration (µg/L)
Gasoline	**800 or 1,000****	
Average		430
Median		450
Lower 10th percentile		80
Upper 90th percentile		770
Diesel	**500**	
Average		510
Median		530
Lower 10th percentile		400
Upper 90th percentile		640
Heavy Oil	**500**	
Average		520
Median		560
Lower 10th percentile		300
Upper 90th percentile		710
Mineral Oil	**500**	
Average		480
Median		480
Lower 10th percentile		450
Upper 90th percentile		500

* The Method B values in this table are based on protection of groundwater for drinking water purposes. For groundwater discharging to surface water, concentrations necessary to protect the surface water and sediment may result in more or less stringent cleanup levels.

** 800 µg/l applies to samples containing benzene as discussed in Table 720-1;
1000 µg/l applies to samples with no detectable levels of benzene.

NOTE: This table was derived using the MTCA TPH10 Spreadsheet and petroleum fraction data from a wide variety of sites. It is intended to provide comparison values to help determine if the additional expense of deriving Method B groundwater cleanup levels is cost-effect at a site. A newer version of this spreadsheet is currently available (MTCA TPH11.1) that may result in somewhat different values.

DO NOT USE THIS TABLE TO ESTABLISH CLEANUP LEVELS FOR A SITE.

Table 8.3 Range of calculated groundwater concentrations for various petroleum products using Method B (Drinking Water)*.

8.4 Method A Soil Cleanup Levels

Method A is intended to be used at relatively simple sites with few hazardous substances. In general, if petroleum and petroleum components are the only contaminants, then Method A can be used to establish soil cleanup levels.

There are two types of Method A soil cleanup levels:

- Unrestricted Land Use – concentrations protective for any land use
- Industrial Land Use – concentrations protective for industrial land use

In general, property must be used and zoned for heavy industrial use to be able to use industrial soil cleanup levels. Commercial uses such as gas stations or retail areas do not qualify as industrial uses unless they are part of a broader industrial area. For additional information on how to determine if a property qualifies as industrial use, see WAC 173-340-745.

Table 8.4 summarizes the Method A soil cleanup levels most applicable to petroleum-contaminated sites. ***In addition to meeting cleanup levels in Table 8.4, the site investigator must also conduct an assessment of potential impacts to upland plants and animals.*** This is done through a "terrestrial ecological evaluation," described in Subsection 6.12 of this guidance.

Ecology may also require more stringent cleanup levels on a site-specific basis if necessary to protect human health or the environment. For example, these cleanup levels do not consider vapor hazards or surface water and sediment impacts. If these are issues at a site, additional evaluation and cleanup may be necessary.

Table 8.4 Method A Soil Cleanup Levels for Petroleum Contamination

	Method A Soil Cleanup Level (mg/kg) (1)	
Parameter	**Unrestricted Land Use**	**Industrial Land Use**
Individual Substances		
Benzene	0.03	0.03
Ethylbenzene	6	6
Ethylene Dibromide (EDB)	0.005	0.005
Lead	250	1,000
MTBE	0.1	0.1
Naphthalenes (2)	5	5
Carcinogenic PAHs (3)	0.1	2
PCB Mixtures (4)	1	10
Toluene	7	7
Xylenes (5)	9	9
Total Petroleum Hydrocarbons		
Weathered Gasoline (6)	100	100
Gasoline Range Organics	30	30
Diesel Range Organics (7)	2,000	2,000
Heavy Oils (7)	2,000	2,000
Mineral Oil (7)	4,000	4,000

(1) Source: Tables 740-1 and 745-1 in WAC 173-340-900. **Does not consider potential impacts on plants and animals. See Subsection 6.12 of this guidance.**

(2) Total of naphthalene, 1-methyl naphthalene and 2-methyl naphthalene (see Subsection 7.4)

(3) Toxic equivalent concentration of all carcinogenic PAHs. See Appendix C for how to calculate a toxic equivalent concentration.

(4) Total of all PCBs

(5) Total of o, p & m xylenes

(6) This value can only be used if no benzene is present in the soil at the site and the total of ethylbenzene, toluene and xylene do not exceed 1% of the gasoline mixture.

(7) Select a cleanup level most closely matching the product at the site. Do no split the NWTPH-dx results into diesel and heavy oil / mineral oil fractions.

NOTE: A direct comparison of these cleanup levels to the contaminant concentrations at the site may not be sufficient to demonstrate compliance with these cleanup levels. See Section 9 for a discussion of determining compliance with soil cleanup levels.

Table 8.4 Method A soil cleanup levels for petroleum contamination.

8.5 Method B Soil Cleanup Levels

The MTCA cleanup regulation allows the use of site specific petroleum composition to calculate site-specific Method B TPH cleanup levels. Under this Method, petroleum contaminated samples are analyzed for the concentration of twelve petroleum fractions (six aromatic and six aliphatic). This information, the concentrations of several specific chemicals (e.g. BTEX), and toxicity information for the fractions and the specific chemicals is then used to determine the appropriate cleanup level for the TPH mixture as a whole. This method is based on concepts initially developed by the National TPH Criteria Working Group (1999).

Figure 8.1 provides an overview of the procedure for calculating Method B soil TPH cleanup levels. **A more detailed description of this step-by-step procedure follows.** [28]

Establishing cleanup levels using Method B presents a challenge. Petroleum mixture composition will vary between samples depending on how much weathering has occurred and variability introduced during sampling and analysis. ***Ecology believes the most practical approach is to use data from multiple soil or product locations to calculate a median soil cleanup level that is representative of the site (or portion of the site contaminated by the same product). That concentration is then used for evaluating compliance.*** The following procedure uses this approach.

Step 1: Characterize the site.

Review the site history to determine what types of products are likely to be present. Review previous soil and groundwater analyses to estimate the volume of petroleum contaminated soil still present at the site. If a site has not been previously investigated, use soil borings or test pits to collect reconnaissance subsurface soil samples. As a borehole or test pit is made, use one or more of the field screening methods described in Chapter 5 to estimate which samples have the highest apparent TPH concentration. Preserve these samples for potential NWTPH and VPH/EPH analysis.

For the purposes of developing a site-specific TPH cleanup level, Ecology recommends that samples be obtained from areas of the site expected to have the highest TPH concentrations (typically source areas). This will minimize the potential for TPH fraction values below the reporting limit skewing the sample compositions.

Once sufficient field work has been conducted so that an estimate of the contaminated soil volume can be made, use Table 8.5 to estimate the number of soil samples to be analyzed using the VPH/EPH methods. At sites where there are multiple source areas with different product types, analyze a minimum of two (2) samples from each source

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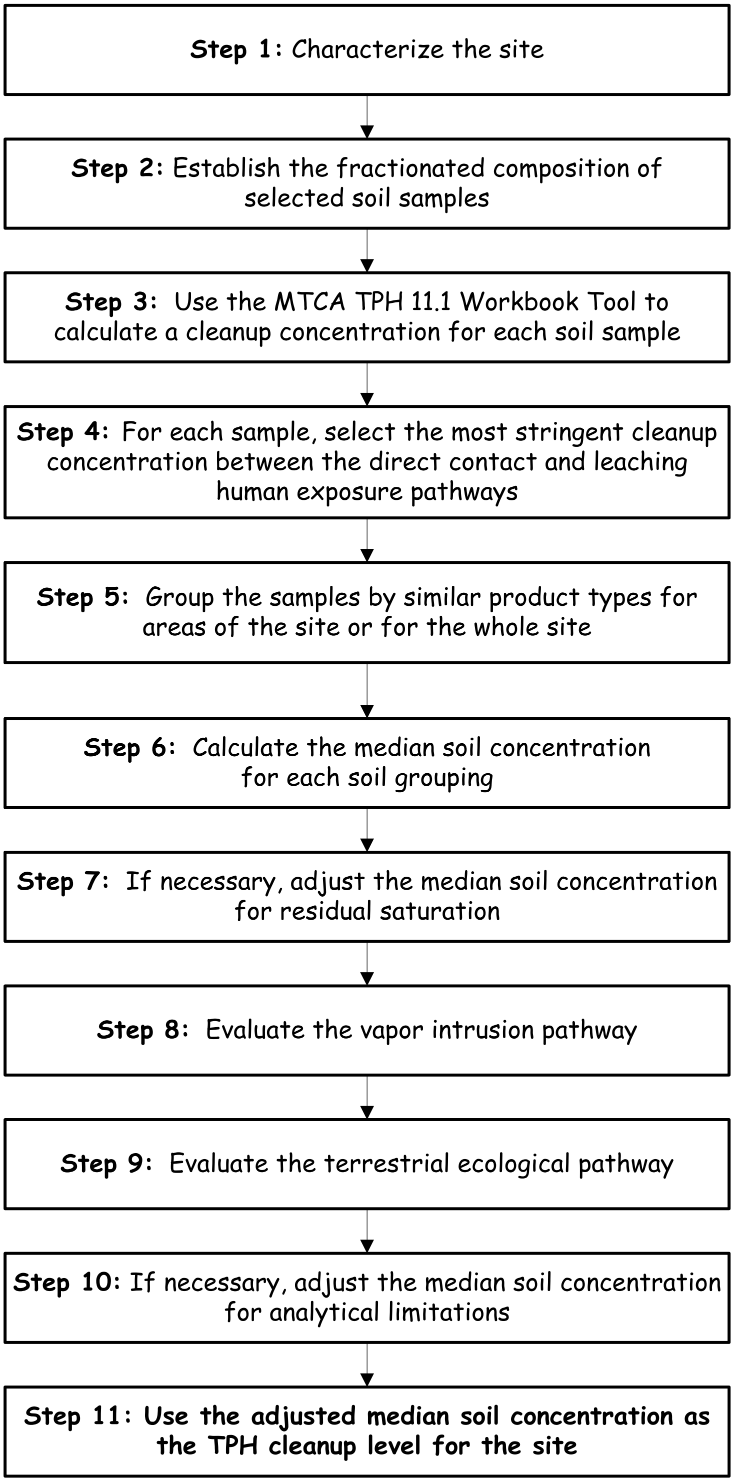
[28] The processes described in this subsection and Subsection 8.9 of this guidance take into account the most common exposure pathways likely to be encountered at a site. There may be a need to address additional exposure pathways (such as surface water) beyond those discussed in this guidance.

area. Extract and preserve at least two additional samples from each source area in case the analytical results from these first two samples are significantly different from each other and further testing is needed to refine source area(s) composition.

Note that the VPH/EPH methods have a 14 day holding time. If the holding time will be exceeded before the initial laboratory results are received, the samples should be extracted and the extract preserved for future analysis.

Figure 8.1: An Overview of the Procedure for Calculating Method B Soil TPH Cleanup Levels



Step 1: Characterize the site

Step 2: Establish the fractionated composition of selected soil samples

Step 3: Use the MTCA TPH 11.1 Workbook Tool to calculate a cleanup concentration for each soil sample

Step 4: For each sample, select the most stringent cleanup concentration between the direct contact and leaching human exposure pathways

Step 5: Group the samples by similar product types for areas of the site or for the whole site

Step 6: Calculate the median soil concentration for each soil grouping

Step 7: If necessary, adjust the median soil concentration for residual saturation

Step 8: Evaluate the vapor intrusion pathway

Step 9: Evaluate the terrestrial ecological pathway

Step 10: If necessary, adjust the median soil concentration for analytical limitations

Step 11: Use the adjusted median soil concentration as the TPH cleanup level for the site

Figure 8.1 Overview of the procedure for calculating Method B soil TPH cleanup levels.

Table 8.5 Recommended Number of Soil Samples for Characterizing Petroleum Contaminated Soil using the VPH and EPH Methods

Soil Volume (cubic yards) (1)	Number of Soil Samples to be Tested
0 to 100	2
101 to 1,000	3
1,001 to 50,000	5
50,001 to 100,000	10
>100,000	10 + 1 for each additional 50,000 cubic yards

(1) Estimated soil stockpile volume or in situ volume of petroleum contaminated soil.

NOTE: Samples need to also be tested for the required hazardous substances in addition to analyzing for equivalent carbon (EC) fractions using the EPH and VPH methods. See Section 7 for testing recommendations. It is recommended that each sample also be analyzed using the appropriate NWTPH method for future compliance monitoring purposes.

Table 8.5 Recommended number of soil samples for characterizing petroleum contaminated soil using the VPH and EPH methods.

Step 2. Establish sample compositions.

For each sample with fractionated data, establish a sample composition. The composition may be expressed on a mg/kg or percentage basis. There are several ground rules for doing this:

a. If the sample has been analyzed using both the VPH and EPH methods, some equivalent carbon (EC) fractions will have results from both methods. When this is the case, use the higher value. Table 8.6 identifies the EC fraction overlaps in the VPH and EPH methods.

Example 1:

A laboratory reports the aliphatic EC>10-12 fraction has a VPH result of 40 mg/kg and an EPH result of 20 mg/kg for the aliphatic EC>10-12 fraction.

For the purposes of establishing a sample composition, assign a value of 40 mg/kg to the aliphatic EC>10-12 fraction.

Example 2:

A lab reports the aromatic EC>12-13 fraction has a VPH result of 171 mg/kg. The aromatic EC>12-16 fraction has an EPH result of 198 mg/kg.

For the purposes of establishing a sample composition, assign a value of 198 mg/kg to the aromatic EC>12-16 fraction.

Table 8.6 Equivalent Carbon (EC) Fraction Overlaps Between VPH and EPH Methods

VPH Method	EPH Method
Aliphatic EC 5-6	
Aliphatic EC>6-8	
Aliphatic EC>8-10	Aliphatic EC>8-10
Aliphatic EC>10-12	Aliphatic EC>10-12
	Aliphatic EC>12-16
	Aliphatic EC>16-21
	Aliphatic EC>21-34
Aromatic EC>8-10	
Aromatic EC>10-12	Aromatic EC>10-12
Aromatic EC>12-13	Aromatic EC>12-16
	Aromatic EC>16-21
	Aromatic EC>21-34

Table 8.6 Equivalent Carbon (EC) fraction overlaps between VPH and EPH methods.

b. If a hazardous substance or EC fraction has been tested for and never been detected at the site in any of the media tested and is not suspected of being present at the site based on site history or other knowledge, a value of zero may be assigned to that substance or EC fraction. Otherwise, for a hazardous substance or EC fraction detected above the method detection limit but below the practical quantitation limit (or reporting limit if PQL is not identified), use the value as reported. Alternatively, if the MDL isn't available, assign ½ the reporting limit. Note that for samples with light levels of contamination, assigning ½ the reporting limit could significantly skew product composition and affect cleanup level calculations. In these cases, consult with the department.

c. If the EC fraction was analyzed using both methods, and the result reported was less than the reporting limit for both methods, use the lowest reporting limit for that fraction when deciding what value to assign under b, above. One exception to this is the overlapping AR 12-13 (VPH) and AR 12-16 (EPH) fractions. If both of these EC fractions are reported to be below the reporting limit, use the reporting limit for AR 12-16 when deciding what value to assign under b, above.

Example 3:

A laboratory reports the aromatic EC>10-12 fraction as <10 mg/kg for the VPH method and <5 mg/kg for the EPH method.

For the purposes of establishing a sample composition, assign a value of 2.5 mg/kg (½ of 5) to the aromatic EC>10-12 fraction.

Example 4:

A laboratory reports the aromatic EC>12-13 fraction as <10 mg/kg using the VPH method and <7 mg/kg for the aromatic EC>12-16 fraction using the EPH method.

For the purposes of establishing a sample composition, assign a value of 3.5 mg/kg (½ of 7) to the aromatic EC>12-16 fraction.

Example 5:

A mineral oil release has occurred at a site. All soil, product and water samples analyzed were less than the reporting limit of 5 mg/kg for the aromatic EC>10-12 fraction. Literature analyses of mineral oils indicate there should not be any significant amount of light fractions present in this product.

For the purposes of establishing a sample composition, a value of "0" may be assigned to the aromatic EC>10-12 fraction.

d. To avoid double counting, subtract hazardous substance concentrations from the appropriate EC fraction as described in Table 8.7. If the result after subtraction is less than zero, assign zero to that EC fraction.

Table 8.7 Adjustments to Equivalent Carbon Fractions to Avoid Double Counting
AL EC>5-6 corrected total = (Reported AL EC>5-6) – (hexane concentration)
AR EC>8-10 corrected total = (Reported AR EC>8-10) – (ethylbenzene + total xylenes concentration)
AR EC>10-12 corrected total = (Reported AR EC>10-12) – (naphthalene concentration)
AR EC>12-16 corrected total = (Reported AR EC>12-16) – (1-methyl + 2-methyl naphthalene concentration)
AR EC>21-34 corrected total = (Reported AR EC>21-34) – (total cPAH concentration)
AL EC = Aliphatic Equivalent Carbon Fraction AR EC = Aromatic Equivalent Carbon Fraction

Table 8.7 Adjustments to equivalent carbon fractions to avoid double counting.

Example 6:

The laboratory reports AR EC>8-10 as 86 mg/kg; ethylbenzene as less than a reporting limit of 0.05 mg/kg; total xylenes is 4.3 mg/kg.

The value assigned to the EC> 8-10 fraction for the purposes of the calculation would be as follows:

AR EC>8-10 corrected total = (86) – (0.025 + 4.3) = 81.675 rounded to 82 mg/kg

e. For xylene, assign a value that is the total of the results reported for th o, p and m-xylene isomers. If all three xylene isomer test results are below the reporting limit, assign ½ the lowest reporting limit as the total xylene concentration. If one form of xylene is detected but the other two are not, assign a value equal to the detected xylene concentration plus ½ the reporting limit for each of the other forms of xylene. Use this same approach when the laboratory reports a combined m & p-xylene analysis and a separate o-xylene analysis.

When the laboratory reports only a total xylene analysis, use this total in place of individual xylene isomers to establish a sample composition.

Example 7:

A laboratory reports o-xylene = 3.5 mg/kg; p-xylene = 1.3 mg/kg; m-xylene = <0.1 mg/kg.

The value assigned to xylene for the purposes of the calculation would be:

Total xylenes = 3.5 + 1.3 + 0.05 = 4.85 rounded to 4.8 mg/kg.

Note that in this example, a value of ½ the reporting limit was assigned to m-xylene for the purposes of this calculation.

Example 8:

A laboratory reports m & p-xylene = 3.8 mg/kg; and o-xylene = <0.3 mg/kg. The value assigned to xylene for the purposes of the calculation would be:

Total xylenes = 3.8 + 0.15 = 3.95 mg/kg.

Note that in this example a value of ½ the reporting limit was assigned to o-xylene.

f. If a hazardous substance has been analyzed using two different analytical methods, consult with the laboratory that did the analysis on which result is most accurate and should be used. If the laboratory is unavailable for consultation, the following general rules can be applied.

1. If both Methods 8021 and 8260 have been used for volatile substances, use the results from Method 8260.

2. If both Methods 8270 and 8270 SIM have been used for cPAHs, use the results from 8270 SIM.

Step 3. Calculate a Method B soil concentration for each pathway.

For each sample with fractionated data, use the sample composition and Ecology's TPH worksheet to calculate TPH cleanup concentrations for each relevant exposure pathway at the site (e.g., direct contact & leaching). See the following publication for detailed instructions on the use of the TPH worksheet: "Workbook Tools for Calculating Soil and Groundwater Cleanup Levels Under the Model Toxics Control Act Cleanup Regulation: Users Guide 11.1."
http://www.ecy.wa.gov/biblio/0109073.html

Step 4. Select the most stringent pathway as the preliminary cleanup level.

Select the most stringent TPH cleanup concentration of the direct contact and leaching values calculated using the worksheet as the preliminary soil TPH cleanup level for each sample. If the leaching pathway has been eliminated through, for example, an empirical demonstration under WAC 173-340-747(9), the direct contact value can be used as the preliminary cleanup level. This value may need to be adjusted later for residual saturation, vapor impacts, terrestrial ecological risk or PQLs and so is referred to as "unadjusted" soil TPH cleanup level until such adjustments have been considered.

Step 5. Group the samples by similar product types.

Compare the location of the preliminary soil TPH cleanup levels for the various samples to the location of product types known to be located at the site and the vertical location within the soil profile. If there are significant differences in preliminary cleanup levels between different areas or vertical zones of the site, it may be appropriate to divide up the site into sectors and establish a preliminary soil TPH cleanup level for each sector. If there is no reliable history on products used at the site and the preliminary soil TPH cleanup concentrations appear to have no pattern, it would be appropriate to group all the TPH results at the site together.

Example 9:

The northeast quadrant of a site was used for gasoline storage tanks and the soil in this area is contaminated with gasoline. The southwest corner behind the building is contaminated with waste oil. The unadjusted soil TPH cleanup levels are in the range of 50-200 mg/kg in the gasoline contaminated area and 2000-3000 mg/kg in the waste oil-contaminated area. Should the results be combined or kept separate?

Answer: It would be appropriate to separate the results from these two areas and establish different soil cleanup levels for these two sectors of the site (gasoline sector and waste oil sector).

Step 6. Calculate the median concentration for each soil grouping.

Compile the preliminary TPH soil cleanup concentrations for all the samples for the site or, if appropriate, each sector of the site. To facilitate subsequent adjustments, Ecology recommends calculating the median TPH soil cleanup concentration for the site or for each sector of the site.

Step 7. Adjust the median soil concentration for residual saturation.

For the site as a whole or each sector with similar product types, compare the median TPH soil cleanup level to the residual saturation maximum allowed screening concentrations in Table 8.8.

Table 8.8 TPH Residual Saturation Screening Levels

Petroleum Product	Screening Level (mg/kg)
Weathered Gasoline	1,000
Middle Distillates	2,000
Heavy Oils	2,000
Mineral Oil	4,000
Unknown Composition	1,000
Source: Table 747-5 in WAC 173-340-900	

Table 8.8 TPH residual saturation screening levels.

This comparison should be made to the appropriate product type present at the site or sector of the site. ***If the median soil cleanup level exceeds these screening concentrations, the median cleanup level must be adjusted downward to the screening concentration or site-specific data must be presented demonstrating that higher concentrations will be protective of the groundwater.***

A site-specific demonstration can be made two ways:

a. One method is to examine soil TPH concentrations with depth and groundwater testing results to look for evidence of product migration. If the product release occurred several years ago and there has been no significant movement of the product in the soil or any NAPL found in or on the groundwater, then it is unlikely there will be significant future product migration. See example 10 for an illustration of an empirical demonstration.

<u>Example 10</u>: Residual Saturation Demonstration using Soil and Groundwater Data

A gas station operated in the 1970s and early 1980s but has been closed since 1984. The tanks were removed and a cleanup was done in the early 1990s. In the process of doing the cleanup, an area of waste oil contaminated soil was discovered behind the gas station but the owner ran out of money to complete the cleanup. The building is now being considered for purchase and remodel into a small retail store.

Several test pits were dug to define the area of waste oil contaminated soil and several soil samples were analyzed using the NWTPH-Dx method. It was discovered that the waste oil extends under the building foundation at concentrations exceeding the Method A heavy oil soil cleanup level of 2,000 mg/kg. No other contaminants of concern have been identified to be remaining at the site. To remove the soil would require removing the building, so a consultant has been retained to develop a Method B soil cleanup level, with the expectation that this level will be higher than the concentrations under the building so that the soil will not have to be removed.

Test pits were dug in the most contaminated portion of the waste oil contaminated area and three (3) soil samples were analyzed using the VPH & EPH methods. Unadjusted soil cleanup levels were calculated for each sample and the median preliminary Method B soil cleanup level for the waste oil sector is 3,740 mg/kg. This concentration is based on direct contact and exceeds the heavy oil screening level for residual saturation of 2,000 mg/kg in Table 747-5.

Monitoring wells were installed at the site. Groundwater is approximately 15 feet beneath the ground surface at the site. Sampling these wells indicates there is no evidence of free product ever reaching the groundwater as the water from these wells contains no detectable levels of TPH, and the soils at the soil-water interface and likely smear zone contain no detectable levels of TPH.

Two of the test pits dug earlier in this same area of highest contamination had the following results for total TPH in the soil using NWTPH-Dx:

Test Pit	Depth (feet)	TPH (mg/kg)
2W	0.5	560
	2.0	4,320
	5.0	<100
	10.0	<100
	15.0	<100
2E	0.5	470
	2.0	5,710
	3.5	4,224
	5.0	<100
	10.0	<100
	15.0	<100

The soil and groundwater test results indicate that the waste oil has not migrated deeper than 5 feet below the ground surface. Based on this information and the fact that the site has been closed for several years it can be concluded that the current soil concentrations are not above residual saturation. Thus the preliminary soil cleanup level of 3,740 mg/kg can be used.

Note that because the building may be limiting infiltration, an environmental covenant requiring further evaluation should be building be removed would likely be required.

b. A second method for determining residual saturation that has been used at some sites is a modification of ASTM D425-88. This is a centrifuge test where the soil sample is spun at a high RPM to simulate accelerated free product migration. If this method is used, it should be modified to use water as the extraction fluid to simulate infiltration events and a fluctuating ground water table. If this method is used, it should be used in a weight of the evidence approach where it is one factor, along with groundwater and soil test data from a site, to demonstrate that the product has not migrated to the water table and is unlikely to do so in the future.

Step 8. Evaluate the vapor intrusion exposure pathway.

Evaluate vapor intrusion for the site as a whole or, if appropriate, for each sector of the site. Evaluation of vapor intrusion is beyond the scope of this guidance. If vapor intrusion is an issue at the site, consultation with Ecology is highly recommended. See Subsection 6.11 of this guidance for additional discussion and references related to vapor intrusion.

Step 9. Evaluate the Terrestrial Ecological Exposure pathway.

Conduct a terrestrial ecological evaluation for the site as a whole or, if appropriate, for each sector of the site. If the site is exempt no adjustment needs to be made to the preliminary TPH soil cleanup level. Otherwise, proceed with a terrestrial ecological evaluation. Use the procedures in WAC 173-340-7492 & 7493, as appropriate, to adjust the median soil cleanup level to a concentration that will be protective of terrestrial ecological receptors (e.g., soil biota, plants and animals). See Subsection 6.12 of this guidance for more information on how to conduct a terrestrial ecological evaluation.

Step 10. Adjust the median soil concentration for analytical limitations.

If the calculations result in a Method B calculated value below the PQL in Table 8.9, adjust the median TPH soil cleanup level upward to the Method PQL. This step is only necessary if the NWTPH method is to be used for compliance monitoring.

Table 8.9 NWTPH Method Soil PQLs	
Method and Product Type	**Soil PQL (mg/kg)**
NWTPH-Gx	5
NWTPH-Dx (Middle Distillates)	25
NWTPH-Dx (Heavy fuels/oil)	100
NWTPH-Dx (Mineral oil)	100
Source: Analytical Methods for Petroleum Hydrocarbons (1997), Ecology Publication No. ECY 97-602	

Table 8.9 NWTPH Method soil PQLs.

Step 11. Use of the adjusted median soil cleanup level as the soil TPH cleanup level for the site or, if appropriate, sector of the site.

Even subtle differences in the petroleum composition will typically result in calculation of different cleanup levels for different samples. This is illustrated in Table 8.2 which shows the range of calculated values for various exposure pathways from sites contaminated with similar products. If this is the case for the site, Ecology recommends that a median soil cleanup level be derived from the values calculated at the site and that this median value be used to determine compliance during cleanup.

8.6 Method C Soil Cleanup Levels

Method C soil cleanup levels can only be used at sites that qualify as industrial property. In general, property must be used and zoned for heavy industrial use to be considered industrial property. Commercial uses such as gas stations or retail areas generally do not qualify as industrial uses. See the criteria in WAC 173-340-745(1) for determining if a site qualifies as industrial property. Sites that use Method C must place an environmental covenant on the property title restricting future uses of the property to industrial uses (WAC 173-340-440).

Once a property has been determined to qualify for Method C soil cleanup levels, the process to develop a soil cleanup level is similar to that described in Subsection 8.5 of this guidance for Method B soil cleanup levels. The principle difference will be for the direct soil contact exposure pathway, which is based on healthy workers being exposed to the soil contamination instead of children being exposed in a residential setting. This is automatically taken into account in Ecology's TPH worksheet by selecting the Method C option on that worksheet.

When developing Method C soil cleanup levels for industrial properties, follow the procedure described in Subsection 8.5 of this guidance but use the Method C option in the TPH worksheet.

KEY POINT: QUALIFYING FOR A METHOD C SOIL CLEANUP LEVEL DOESN'T NECESSARILY QUALIFY A SITE FOR USE OF METHOD C FOR OTHER MEDIA

A determination that Method C may be used to establish cleanup levels for one medium (e.g. soil) does not mean that Method C can be used to establish cleanup levels for other media (e.g. groundwater) at the site. To determine the applicability of Method C, each medium must be evaluated separately, using the criteria applicable to that medium.

8.7 Groundwater Classification

Groundwater cleanup levels depend on whether the groundwater is classified as potable (a current or potential future source of drinking water) or non-potable. Under MTCA, it is presumed that all groundwater is fit for human consumption until proven otherwise. The criteria for determining whether groundwater is potable or non-potable are provided in the MTCA regulation. To determine that groundwater is non-potable, it must first be demonstrated that the groundwater is not currently being used for human consumption. Next, it must be demonstrated that it is extremely unlikely that humans will consume or use the groundwater in the future based on quantity, quality or location (WAC 173-340-720(2)):

Quantity: The formation yield is less than 0.5 gallons per minute (gpm) on a sustainable basis to a well constructed using normal domestic water well construction practices.

Sustainable basis means the formation can yield 0.5 gpm over a 24 hour period or 720 gallons per day. This represents the amount of water used by a family of four. This is roughly equivalent to a formation permeability of 1×10^{-4} cm/sec permeability.

Quality: The groundwater contains ambient or naturally high concentrations of organic or inorganic constituents that make it impractical for current or future human consumption.

One example cited in MTCA of poor natural water quality is water with total dissolved solids (TDS) greater than 10,000 mg/L. There may be other situations where the natural water quality is so bad that it is impractical to use for drinking water purposes. For example, older connate or “fossil” groundwater may contain substantially elevated levels of iron and manganese that make it unsuitable to even treat for use as drinking water.

KEY POINT: QUALITY

High metals concentrations that are the result of petroleum biodegradation may not be used to deem groundwater unfit for human consumption!

Also, just because groundwater exceeds drinking water standards for naturally occurring contaminants does not mean it qualifies for this exemption. To qualify, it must be demonstrated that the water quality is so bad that it is impractical to treat for use.

Location: Even if the groundwater meets quantity and quality criteria, it may still be declared unfit for future human consumption based on location. For example, groundwater that is located near marine surface water where salt water intrusion makes use of the water impractical as a source of drinking water.

KEY POINT: LOCATION

Surface land use cannot be used to deem groundwater non-potable! For example, if the land is zoned industrial, then you cannot automatically assume that the groundwater is non-potable. There are many industrial areas throughout the state that are underlain by highly productive aquifers. Examples of industrial areas over highly productive aquifers are those over the Spokane-Rathdrum sole source aquifer in Spokane County and the Chambers-Clover Creek area in Pierce County.

Ecology expects that the groundwater beneath most contaminated sites will be classified as potable and the following sections assume this is the case. Determining groundwater cleanup levels for non-potable groundwater requires a site-specific risk assessment and is beyond the scope of this guidance. Users wanting to develop non-potable groundwater cleanup levels should contact Ecology to determine appropriate exposure assumptions to use in the analysis.

8.8 Method A Groundwater Cleanup Levels

Method A groundwater cleanup levels are based on drinking water use. Table 8.10 summarizes the Method A groundwater cleanup levels most applicable to petroleum-contaminated sites.

Table 8.10 Method A Groundwater Cleanup Levels for Petroleum-Contaminated Sites (µg/liter) (1)

Hazardous Substance/Product	Cleanup Level
Benzene	5
Ethylbenzene	700
Ethylene Dibromide (EDB)	0.01
Lead	15
MTBE	20
Naphthalenes (2)	160
Carcinogenic PAHs (3)	0.1
PCB Mixtures (4)	0.1
Toluene	1,000
Xylenes (5)	1,000
Total Petroleum Hydrocarbons	
Gasoline Range Organics	800
Gasoline Range Organics—Weathered Gasoline (6)	1,000
Diesel Range Organics (7)	500
Heavy Oils (7)	500
Mineral Oil (7)	500

(1) Source: Tables 720-1 in WAC 173-340-900

(2) Total of naphthalene, 1-methyl naphthalene and 2-methyl naphthalene (see Subsection 7.4)

(3) Total B(a)P toxic equivalent concentration of all carcinogenic PAHs. See Appendix C for how to calculate a toxic equivalent concentration.

(4) Total of all PCBs

(5) Total of o, p & m xylenes

(6) This value can only be used if no benzene is present in the soil at the site and the total of ethylbenzene, toluene and xylene do not exceed 1% of the gasoline mixture

(7) Select a cleanup level most closely matching the product at the site. Do no split the NWTPH-dx results into diesel and heavy oil / mineral oil fractions.

NOTE: A direct comparison of these cleanup levels to the contaminant concentrations at the site may not be sufficient to demonstrate compliance with these cleanup levels. See Section 9 for a discussion of determining compliance with cleanup levels.

Table 8.10 Method A groundwater cleanup levels for petroleum-contaminated sites (µg/liter) (1).

8.9 Method B Groundwater Cleanup Levels

This subsection describes a step by step procedure for determining site-specific Method B groundwater cleanup levels protective of drinking water use (see Figure 8.2).

There are two methods Ecology will generally accept for developing a site-specific Method B groundwater cleanup level.

- **Method 1:** Use VPH/EPH soil or product analyses and Ecology's TPH worksheet to calculate a predicted groundwater fractionated composition and then a groundwater cleanup level from this fractionated composition.
- **Method 2:** Use data from groundwater samples tested using the VPH/EPH methods from the site and Ecology's TPH worksheet to calculate a groundwater cleanup level.

Step 1. Characterize the site.

If soil data is to be used to calculate a groundwater cleanup level, use the procedures described in Subsection 8.5 of this guidance to characterize the petroleum-contaminated soils at the site.

If product or groundwater data (Method 1) is to be used to calculate the groundwater cleanup level, collect a minimum of three (3) to five (5) groundwater or free product samples from the most contaminated monitoring wells at the site. Analyzing several samples will ensure the range of groundwater conditions present at the site are represented in the calculations. The samples should be tested as specified in Section 7.

Step 2. Establish sample composition.

For both Methods 1 and 2, establish the fractionated composition of each sample using the procedures described in Subsection 8.5 of this guidance, Step 2.

Step 3. Calculate a Method B groundwater concentration for each sample.

Step 3a: If using Method 1, for each soil or product sample with fractionated data, use the sample composition and Ecology's TPH worksheet to predict a groundwater composition. This can be found in the column titled "predicted concentration@ well" in worksheet 2.2. Then use this predicted composition and worksheet B to calculate a preliminary groundwater TPH cleanup level.

Step 3b: If using Method 2, for each groundwater sample with fractionated data, use worksheet B to calculate a preliminary groundwater TPH cleanup level for each sample.

Note that the worksheet automatically takes into account applicable drinking water standards. Unlike for soil, the TPH worksheet takes into account only one exposure pathway--drinking water. Further adjustments may need to be made later for surface water impacts, vapors, PQLs, NAPL (non-aqueous phase liquid) or biodegradation impacts. Therefore, a calculated value is referred to as "preliminary" groundwater TPH cleanup level until such adjustments are made.

Figure 8.2: *An Overview of the Procedure for Calculating Method B Groundwater TPH Cleanup Levels*

Step 1: Characterize the site

Step 2: Establish the fractionated composition of selected samples

Step 3: For each sample, use the MTCA TPH 11.1 Workbook Tool to calculate a preliminary groundwater cleanup level

Step 4: Group the samples by similar product types for sub-areas of the site or for the site as a whole

Step 5: Calculate the median preliminary groundwater cleanup level for each grouping

Step 6: If necessary, adjust the median preliminary groundwater cleanup level to prevent NAPL forming

Step 7: If necessary, adjust the median groundwater concentration for surface water impacts

Step 8: If necessary, adjust the median groundwater concentration for vapor intrusion

Step 9: If necessary, adjust the median groundwater concentration for biodegradation

Step 10: If necessary, adjust the median groundwater concentration for analytical limitations

Step 11: Use the adjusted median groundwater concentration as the groundwater TPH cleanup level for the site or sector of the site

Figure 8.2 Overview of the procedure for calculating Method B groundwater TPH cleanup levels.

Step 4. Group the samples by similar product types.

Compare the location of the preliminary groundwater TPH cleanup levels to the location of product types known to be located at the site. If there are significant differences in preliminary cleanup levels between different areas of the site, it may be appropriate to divide up the site into sectors and establish a preliminary groundwater TPH cleanup level for each sector. If there is no reliable history on what went on at the site and the preliminary groundwater TPH cleanup levels appear to have no pattern, it would be appropriate to group all the TPH results at the site together.

Step 5. Calculate the median concentration for each grouping.

Compile the preliminary groundwater TPH cleanup levels for all the samples for the site or, if appropriate, each sector of the site. Calculate the median groundwater TPH cleanup level for the site or for each sector of the site. A median concentration is recommended to avoid outlier values overly influencing the cleanup level.

Step 6. Adjust for Non-aqueous Phase Liquid (NAPL) limitation.

A groundwater cleanup level cannot result in the formation of NAPL in or on the groundwater [WAC 173-340-720(7)(d)]. NAPL is when the petroleum product is present as a liquid not dissolved in the groundwater. Use the values in Table 8.11 to screen for the likely presence of NAPL.

If the preliminary groundwater TPH cleanup level is less than the concentrations in this table, then NAPL is unlikely to be present in the groundwater and there is no need for downward adjustment of the preliminary groundwater TPH cleanup level for this limitation.

If the preliminary groundwater TPH cleanup level exceeds the concentrations in Table 8.11, then the groundwater cleanup level should be adjusted downward to the concentration in this table. If it is demonstrated with laboratory or field data that NAPL does not form at the preliminary groundwater TPH cleanup level, no adjustment is necessary.

Step 7. Adjust for surface water impacts.

If contaminants in the groundwater have already reached surface water or are likely to reach surface water, the groundwater cleanup level must be protective of surface water and sediment within that surface water body. This may require the groundwater TPH cleanup level to be adjusted downward. See Subsections 8.10–8.12 of this guidance for information on how to determine if a groundwater cleanup level is protective of surface water.

Step 8. Adjust for vapor intrusion.

Evaluate vapor intrusion for the site as a whole or, if appropriate, for each sector of the site. Evaluation of vapor intrusion is beyond the scope of this guidance. If vapor intrusion is an issue at the site, consultation with Ecology is highly recommended. See Subsection 6.11 of this guidance for additional discussion and references related to vapor intrusion.

Table 8.11 Solubility Limits for Various Petroleum Products

Product Type (1)	**Solubility Limit (μg/l) (2)**
Gasoline Range Products	100,000
Middle Distillates	<1,000 – 5,000
Heavy Fuels/Oils	<1,000 – 6,300
Mineral Oil	1,000 – 1,700

(1) See Table 7.1 for a description of these products.

(2) Source: Concise Explanatory Statement—Appendix D; Ecology Publication No. 01-09-04, February 12, 2001.

Table 8.11 Solubility limits for various petroleum products.

Step 9. Adjust for biodegradation.

Most petroleum products are biodegradable. The biodegradation process will quickly deplete dissolved oxygen levels in the groundwater, resulting in a chemically "reducing" condition. Under this condition, naturally occurring metals in the aquifer matrix are biologically and chemically transformed into more soluble and toxic forms. This is common for metals such as arsenic, manganese and iron. Concentrations of these metals in the groundwater may exceed drinking- or surface-water standards or cause aesthetic problems (e.g., taste, odor, or staining). To fully restore the groundwater, it may not be enough to reduce petroleum hydrocarbon concentrations to acceptable levels; the elevated metals may also need to be addressed.

A suggested approach to addressing this issue is to identify monitoring wells with petroleum concentrations meeting the preliminary groundwater TPH cleanup level and sample those wells for metals. If the metal concentrations in these wells do not exceed applicable groundwater or surface water cleanup levels, then no further adjustment to the preliminary groundwater TPH cleanup level is needed to account for biodegradation. If these wells do exceed applicable groundwater or surface water cleanup levels for metals, then the preliminary groundwater TPH cleanup level may need to be adjusted downward sufficiently to prevent a reducing groundwater condition. An alternative to making this adjustment up-front would be to measure for compliance with the relevant metals cleanup levels after restoration of the groundwater to TPH cleanup levels.

Step 10. Adjust for analytical limitations.

If necessary, adjust the preliminary groundwater TPH cleanup level upward to the Method practical quantitation limit (PQL). The NWTPH Method PQLs are identified in Table 8.12. This step is only necessary if the NWTPH method will be used for compliance monitoring.

Table 8.12 NWTPH Method Groundwater PQLs

Method and Product Type	Water PQL (µg/L)
NWTPH-Gx	250
NWTPH-Dx (Middle Distillates)	500
NWTPH-Dx (Heavy fuels/oil)	500
NWTPH-Dx (Mineral oil)	500
Source: Analytical Methods for Petroleum Hydrocarbons, Ecology Publication No. 97-602, June 1997.	

Table 8.12 NWTPH method groundwater PQLs.

Step 11. Use the adjusted median groundwater TPH cleanup levels as the groundwater TPH cleanup level for the site or, if appropriate, sector of the site.

Even subtle differences in the petroleum composition will typically result in calculation of different cleanup levels for different samples. This is illustrated in Table 8.3 which shows the range of calculated values for various exposure pathways from sites contaminated with similar products. If this is the case for the site, Ecology recommends that a median groundwater cleanup level be derived from the values calculated at the site and this median value be used to determine compliance during cleanup.

8.10 Surface Water Cleanup Levels

As was noted in Subsection 8.9.6 of this guidance, if contaminants in the groundwater have already reached surface water or are likely to reach surface water, then the groundwater cleanup level must be protective of surface water and sediment within that surface water body. Similarly, if the remedy chosen for the site results in a discharge to surface water (e.g. pump and treat with surface water discharge), then a surface water cleanup level must be established.

Surface water cleanup levels must be set at a concentration that would allow the water to be used for those beneficial uses identified under Washington State’s water quality laws (Chapter 173-201A WAC). Beneficial uses include use of the water for domestic water supply, irrigation, fish and shellfish rearing, recreation (such as swimming and sport fishing), commerce and navigation, and wildlife habitat.

If the surface water is classified as suitable for use as a domestic water supply under state law (Chapter 173-201A WAC), then the cleanup level must be at least as stringent as the potable groundwater cleanup level established to protect drinking water beneficial uses under WAC 173-340-720.

Under MTCA, surface water cleanup level must be at least as stringent as all applicable State and Federal laws and must be protective of all of the following exposure pathways:

- Aquatic organisms living in the surface water
- Benthic organisms living in the sediment[29]
- Wildlife feeding on aquatic and benthic organisms
- Persons eating fish and other aquatic organisms harvested from the surface water or sediment
- Persons using the surface water as a source of drinking water

Tables 8.13 and 8.14 provide a compiled list of applicable State and Federal surface water quality standards for marine and fresh waters in Washington State. For fresh water, Table 8.14 assumes the surface water is suitable for drinking water use. This table includes arsenic and selected metals that, while not typically present in significant amounts in petroleum mixtures, may be released to the surface water during the decomposition of the petroleum, and thus may also need to be addressed. Note that Washington State is in the process of updating the State's water quality criteria to account for high amounts fish consumption by some segments of our population, especially tribes. The proposed updates are not reflected in these tables.

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[29] Sediment is defined in WAC 173-204-505 as settled particulate matter located at or below the high water mark, where water is present for a minimum of six consecutive weeks.

Several substances do not have any promulgated standards. For these substances a cleanup level will need to be developed using the procedures in WAC 173-340-730.

In addition to the toxicity of the petroleum mixture and components, conventional water quality standards [30] must be met. These standards can be found in WAC 173-340-201A.

Sediment quality criteria (WAC 173-204) are not addressed in this table. Where a sediment cleanup standard has been established at a site, it will be necessary to also demonstrate the groundwater cleanup levels will be protective of sediment. This is typically done using a groundwater model, such as those in WAC 173-340-747.

The complexity of developing cleanup levels protective of surface water and sediments makes this exposure pathway beyond the scope of this guidance. If this exposure pathway is an issue at your site, consult with the Ecology Cleanup Project Manager responsible for the site.

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[30] Conventional water quality criteria include temperature, dissolved oxygen, pH and aesthetics.

Table 8.13 Applicable, Relevant and Appropriate Surface Water Quality Standards under WAC 173-340-730 for Petroleum-Related Toxic Substances in *Marine* Waters

Substance	CAS Number	ARARs (all values µg/L)					Most Stringent ARAR (µg/L)
		Human Health		Aquatic Life			
		40 CFR 131.36 NTR	Section 304 NRWQC	40 CFR 131.36 NTR	WAC 173-201A	Section 304 NRWQC	
Metals and Selected Organics							
Arsenic, inorganic	7440-38-2	0.14 (c)	0.14 (c)	36	36	36	0.14
Iron	7439-89-6						
Lead	7439-92-1			8.1	8.1	8.1	8.1
Manganese	7439-96-5		100				100
Benzene	71-43-2	71 (c)	16-58 (c)**				58
Ethylbenzene	100-41-4	29,000	130				130
Ethylene Dibromide (EDB)	106-93-4						
MTBE	1634-04-4						
Naphthalene	91-20-3						
Toluene	108-88-3	200,000	520				520
Xylenes (total)	1330-20-7						
Carcinogenic PAHs							
Benzo(a)anthracene	56-55-3	0.031 (c)	0.0013 (c)				0.0013
Benzo(a)pyrene	50-32-8	0.031 (c)	0.00013 (c)				0.00013
Benzo(b)fluoranthene	205-99-2	0.031 (c)	0.0013 (c)				0.0013
Benzo(k)fluoranthene	207-08-9	0.031 (c)	0.013 (c)				0.013
Chrysene	218-01-9	0.031 (c)	0.13 (c)				0.031
Dibenzo(a,h)anthracene	53-70-3	0.031 (c)	0.00013 (c)				0.00013
Indeno(1,2,3-cd)pyrene	193-39-5	0.031 (c)	0.0013 (c)				0.0013
Polychlorinated Biphenyls							
PCBs (total)***	1336-36-3	0.00017 (c)	0.000064 (c)		0.03	0.03	0.000064
(each) Aroclor				0.03			0.03
Total Petroleum Hydrocarbons							
Gasoline Range Organics	See note						
Diesel Range Organics	See note						
Heavy Oils	See note						
Mineral Oil	See note						

A blank cell means no value has been promulgated or published under the authority cited.

NTR = National Toxics Rule (40 CFR 131.36), last updated in 1992.

NRWQC = National Recommended Water Quality Criteria developed under Section 304 of the Federal Clean Water Act, last updated in June, 2015.

"Aquatic life" means the standard is based on aquatic toxicity. This is also considered protective of marine mammals and wildlife.

(c) = based on a carcinogenic risk of 1 X 10^{-6}; all other human health based NTR and WQC values are based on noncancer risk.

Arsenic, iron and manganese, while not major petroleum constituents, have been included as they are common biodegradation by-products.

** A range of values is provided for benzene under the NRWQC, reflecting the cancer slope factor recommended range of 0.015 to 0.055. EPA recommends the upper end of the recommended range be used (58 µg/L).

*** Under WAC 173-201A total PCBs equals the sum of Aroclors 1016, 1221, 1232, 1242, 1248, 1254, 1260. Under the NTR and NRWQC, total PCBs equals the sum of all congener or all isomer or homolog or Aroclor analyses. The NTR also has a separate but identical value for each Aroclor.

No numeric standards exist for petroleum products. 40 C.F.R. Part 110 prohibits discharges of oil that are harmful to the public health, welfare or the environment and defines harmful discharges to include discharges that "…Cause a film or sheen upon or discoloration of the surface of the water or adjoining shorelines or cause a sludge or emulsion to be deposited beneath the surface of the water or upon adjoining shorelines." WAC 173-201A-260(2)(b) states: "Aesthetic values must not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste..."

Table 8.13 Applicable, Relevant and Appropriate Surface Water Quality Standards under WAC 173-340-730 for petroleum-related toxic substances in marine waters.

Table 8.14 Applicable, Relevant and Appropriate Surface Water Quality Standards under WAC 173-340-730 for Petroleum-Related Toxic Substances in *Fresh* Waters

Substance	CAS Number	ARARs (all values µg/L)					Most Stringent ARAR (µg/L)
		Human Health		Aquatic Life			
		40 CFR 131.36 NTR	Section 304 NRWQC	40 CFR 131.36 NTR	WAC 173-201A	Section 304 NRWQC	
Metals and Selected Organics							
Arsenic, inorganic	7440-38-2	0.018	0.018	190	190	150	0.018
Iron	7439-89-6		300			1,000	300
Lead *	7439-92-1			2.5	0.54	2.5	0.54
Manganese	7439-96-5		50				50
Benzene	71-43-2	1.2 (c)	0.58-2.1 (c)				1.2
Ethylbenzene	100-41-4	3,100	68				68
Ethylene Dibromide (EDB)	106-93-4						
MTBE	1634-04-4						
Naphthalene	91-20-3						
Toluene	108-88-3	6,800	57				57
Xylenes (total)	1330-20-7						
Carcinogenic PAHs							
Benzo(a)anthracene	56-55-3	0.0028	0.0012 (c)				0.0012
Benzo(a)pyrene	50-32-8	0.0028	0.00012 (c)				0.00012
Benzo(b)fluoranthene	205-99-2	0.0028	0.0012 (c)				0.0012
Benzo(k)fluoranthene	207-08-9	0.0028	0.012 (c)				0.0028
Chrysene	218-01-9	0.0028	0.12 (c)				0.0028
Dibenzo(a,h)anthracene	53-70-3	0.0028	0.00012 (c)				0.00012
Indeno(1,2,3-cd)pyrene	193-39-5	0.0028	0.0012 (c)				0.0012
Polychlorinated Biphenyls							
PCBs (total)***	1336-36-3	0.00017 (c)	0.000064 (c)		0.014	0.014	0.000064
(each) Aroclor				0.014			0.014
Total Petroleum Hydrocarbons							
Gasoline Range Organics	See note						
Diesel Range Organics	See note						
Heavy Oils	See note						
Mineral Oil	See note						

A blank cell means no value has been promulgated or published under the authority cited.

NTR = National Toxics Rule (40 CFR 131.36), last updated in 1992.

NRWQC = National Recommended Water Quality Criteria developed under Section 304 of the Federal Clean Water Act, last updated in June, 2015.

"Aquatic life" means the standard is based on aquatic toxicity. This is also considered protective of marine mammals and wildlife.

(c) = based on a carcinogenic risk of 1 X 10^{-6}; all other human health based NTR and WQC values are based on noncancer risk.

Arsenic, iron and manganese, while not major petroleum constituents, have been included as they are common biodegradation by-products.

The freshwater aquatic life standard for lead is hardness dependent. The value shown is based on a hardness of 100 mg/l.

* The standards for lead are hardness dependent. A hardness of 100 mg/L was assumed for these values.

** A range of values is provided for benzene under the NRWQC, reflecting the cancer slope factor recommended range of 0.015 to 0.055. EPA recommends the upper end of the recommended range be used (2.1 µg/L).

*** Under WAC 173-201A total PCBs equals the sum of Aroclors 1016, 1221, 1232, 1242, 1248, 1254, 1260. Under the NTR and NRWQC, total PCBs equals the sum of all congener or all isomer or homolog or Aroclor analyses. The NTR also has a separate but identical value for each Aroclor.

No numeric standards exist for petroleum products. 40 C.F.R. Part 110 prohibits discharges of oil that are harmful to the public health, welfare or the environment and defines harmful discharges to include discharges that "…Cause a film or sheen upon or discoloration of the surface of the water or adjoining shorelines or cause a sludge or emulsion to be deposited beneath the surface of the water or upon adjoining shorelines." WAC 173-201A-260(2)(b) states: "Aesthetic values must not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste..."

Table 8.14 Applicable, Relevant and Appropriate Surface Water Quality Standards under WAC 173-340-730 for petroleum-related toxic substances in fresh waters.

8.11 Air Cleanup Levels

If petroleum products have been released to the ground or groundwater near buildings, utility vaults or other enclosed structures, these structures should be checked immediately for the accumulation of these vapors to potentially explosive levels. Heavier oils are generally not sufficiently volatile to build up to explosive levels unless mixed with other products. However, some of the components of diesel, heating oil, and heavy fuel oils, such as naphthalene, are quite toxic, have a very low odor threshold, and can cause discomfort and nausea.

If vapors or petroleum odors are encountered in structures, utility vaults or other enclosed structures; the local fire department should be summoned to check vapor levels and ventilate these areas.

Developing TPH air cleanup levels is beyond the scope of this guidance. If vapor intrusion is an issue at the site, consultation with Ecology is highly recommended. See Subsection 6.11 of this guidance for additional discussion and references related to vapor intrusion.

9.0 Establishing Points of Compliance

This section provides an overview of establishing a point of compliance (POC) for each medium at a site. The "point of compliance" is the location within a particular medium (e.g., groundwater) where cleanup levels must be met. This term includes both standard and conditional points of compliance (WAC 173-340-200).

In general, a standard point of compliance means the cleanup level must be met for every location sampled (throughout the site). A conditional point of compliance means the cleanup level only needs to be met at some locations sampled, provided certain conditions are met. The specific regulatory requirements for establishing a point of compliance for each medium are described at the end of each section of the rule discussing how to develop cleanup standards for a particular medium (WAC 173-340-720 through 173-340-760).

Where a conditional point of compliance is proposed for a site, the feasibility study should present a cleanup alternative using the standard point of compliance and one or more alternatives using a conditional point of compliance. The cost and benefits of each alternative should be evaluated using the remedy selection criteria in WAC 173-340-360. This evaluation must demonstrate that it is not practical to use a standard point of compliance at the site to justify use of a conditional point of compliance.

KEY POINT: CLEANUP LEVELS DO NOT ALWAYS HAVE TO BE MET AT EVERY LOCATION SAMPLED AT A SITE!

While in most cases it is desirable and simpler to meet a cleanup level throughout the site (at every location sampled), Ecology recognizes this may not be practical at every site. The MTCA rule provides flexibility for not meeting cleanup levels at all locations sampled, provided certain conditions are met. When this is done, it is called establishing a "conditional point of compliance." Sites that establish a conditional point of compliance must place an environmental covenant on affected properties limiting future uses that could lead to exposure to contamination. See WAC 173-340-440 for the requirements for environmental covenants.

9.1 Soil Point of Compliance

The regulatory requirements for establishing a soil point of compliance are described in WAC 173-340-740(6). The point of compliance for soil depends on the exposure pathway that is the basis for the soil cleanup level. The point of compliance for soil does not depend on the designated land use (unrestricted or industrial) or the classification of the underlying groundwater.

- For soil cleanup levels **based on direct contact**, the point of compliance is defined as throughout the site from the ground surface to 15 feet below the ground surface. In practice this means compliance monitoring typically consists of analyzing samples of soil taken from the bottom and sides of the excavation from which the contaminated soils have been removed for treatment or disposal. See Subsection 6.8.3 in this guidance for sampling recommendations in this case.

- For soil cleanup levels **based on leaching (protection of groundwater**), the point of compliance is defined as throughout the site. This means that the point of compliance extends throughout the soil profile and may extend below the water table. In practice, this means compliance monitoring typically consists of analyzing samples of soil taken from borings throughout the site at the completion of the remedial action. Groundwater monitoring will also typically be conducted to confirm leaching of residual soil contamination levels is no longer adversely impacting groundwater.
- For soil cleanup levels **based on vapors**, the point of compliance is defined as throughout the site from the ground surface to the uppermost groundwater saturated zone (e.g., water table). In practice, this means compliance monitoring typically consists of analyzing samples of air from vapor probes at the site and from within structures on the site where vapors have the potential to accumulate.[31]
- For soil cleanup levels **based on protection of plants, animals and soil biota**, the standard point of compliance is defined as throughout the site from the ground surface to 15 feet below the ground surface. For sites with institutional controls to prevent excavation of deeper soil, a conditional point of compliance may be set at the depth of the biologically active soil zone. This zone is assumed to extend to six (6) feet. Ecology may approve a different depth based on site-specific information. In practice, this means compliance monitoring typically consists of analyzing samples of soil taken from excavations conducted during remedial actions or borings taken at the site at the completion of the remedial action.

See Figure 9.1 for a visual depiction of these points of compliance.

9.2 Groundwater Point of Compliance

The regulatory requirements for establishing a point of compliance for groundwater are described in WAC 173-340-720(8). In contrast with cleanup standard selection, the point of compliance for groundwater does not depend on the highest beneficial use of the groundwater or whether the groundwater is classified as potable.

- **Standard point of compliance:** The standard point of compliance is defined as throughout the site from the uppermost level of the saturated zone extending vertically to the lowest depth that could potentially be affected by the site. In practice, this means compliance

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[31] Vapor monitoring within occupied structures can be complicated by many factors. Anyone considering this approach should consult the references cited in Subsection 6.11 of this guidance.

monitoring consists of analyzing water samples taken from groundwater monitoring wells installed throughout the aerial and vertical zone of contamination at the site.

- **Conditional point of compliance:** Where it can be demonstrated that it is not practical to meet the groundwater cleanup levels throughout the site within a reasonable restoration time frame, Ecology can approve a conditional point of compliance as close as practical to the source of the contamination, not to exceed the property boundary (except as provided below). In practice, because most TPH contaminated properties are relatively small, this typically means compliance monitoring consists of analyzing water samples taken from groundwater monitoring wells installed within the source property and along the property boundary down gradient from the source of contamination.

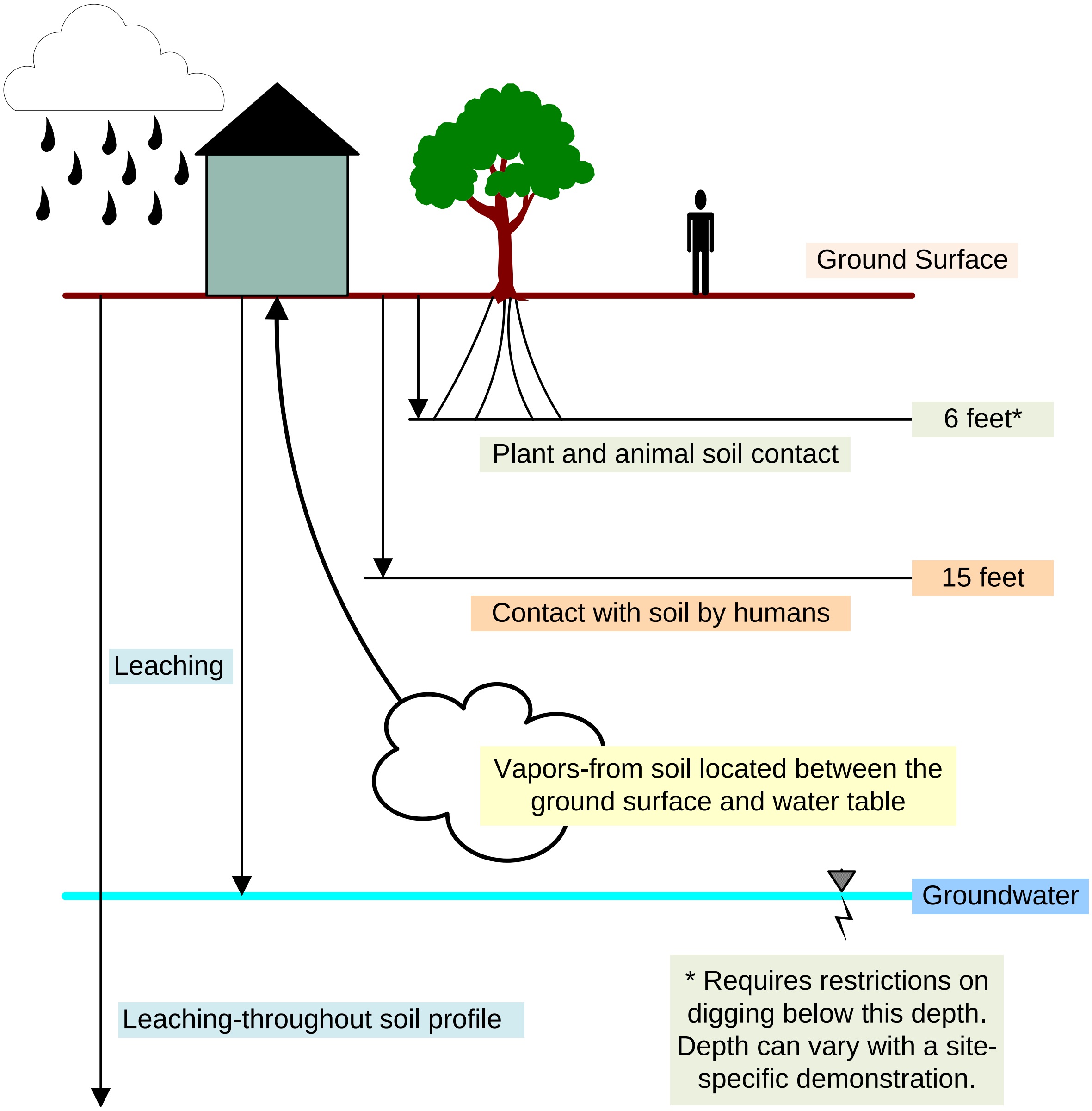


Figure 9.1 Soil points of compliance for various exposure pathways.

To be eligible to use a conditional point of compliance, satisfaction of numerous conditions must be demonstrated including:

- ➢ That all practicable methods of treatment have been used per WAC 173-340-720(8)(c). This means treatment has been used to reduce the contamination levels in the soil and groundwater at the site to the maximum extent practicable.
- ➢ The remedy meets the requirements for nonpermanent groundwater cleanup actions specified in WAC 173-340-360(2)(c) as well as the other remedy selection requirements in WAC 173-340-360.
- ➢ An environmental covenant is placed on the affected property to limit exposure to the contaminated groundwater (WAC 173-340-440).

Furthermore, any site that uses a conditional point of compliance is subject to periodic reviews under WAC 173-340-420 and may be required by Ecology to post financial assurance (WAC 173-340-440).

- **Off-property conditional point of compliance:** A conditional point of compliance may be set beyond the property boundary in the following **three (3) specific situations**, subject to the same conditions as above for a conditional point of compliance plus several additional conditions discussed below:

(1) **Properties abutting surface water:** Where the groundwater cleanup level is based on protection of surface water and the property containing the source of contamination abuts surface water, Ecology may approve a conditional point of compliance located within the surface water as close as technically possible to point or points where groundwater flows into the surface water. This is subject to numerous conditions described in WAC 173-340-720(8)(d)(i).

In practice, this means compliance monitoring typically consists of analyzing water samples taken from groundwater monitoring wells installed along the shoreline between the source and surface water, with additional monitoring of any seeps discharging into the surface water. Ecology may also require monitoring of the receiving waters and sediments and organisms within those waters.

(2) **Properties near, but not abutting surface water:** Where the groundwater cleanup level is based on protection of surface water and the property containing the source of contamination is near, but does not directly abut the surface water, Ecology may approve a conditional point of compliance located as close as practical to the source of contamination, not to exceed the point or points where the groundwater flows into the surface water.

Use of this option is subject to the same conditions as (1) above plus conditions such as the affected property owners between the source of contamination and the surface water must agree in writing to the conditional point of compliance as described in WAC 173-340-720(8)(d)(ii). Additionally, the point of compliance cannot extend beyond the extent of groundwater contamination at the time of Ecology approval of the conditional point of compliance.

In practice, this means compliance monitoring typically consists of analyzing water samples taken from monitoring wells located between the source and the surface water. Ecology may also require monitoring of the receiving waters and sediments and organisms within those waters.

(3) **Area-wide conditional point of compliance:** Where there are multiple sites with commingled plumes of contamination that are not practical to address separately, Ecology may approve an area-wide conditional point of compliance. This point of compliance must be located as close as practicable to each source of contamination, not to exceed the extent of groundwater contamination at the time the department approves of the conditional point of compliance. There are numerous conditions that must be met as described in WAC 173-340-720(8)(d)(iii).

Compliance monitoring at these sites can be quite complex with monitoring wells installed on several properties and at various locations to account for the different mobility of various contaminants.

Figures 9.2 and 9.3 provide a visual depiction of the available options for establishing a groundwater point of compliance when protecting surface water and highlight several of the conditions for use of a conditional point of compliance. Note that, in addition to meeting the conditions for use of a conditional point of compliance, the remedy must also meet the requirements for remedy selection in WAC 173-340-360, including a demonstration that a more permanent remedy is not feasible.

9.3 Surface Water Point of Compliance

The regulatory requirements for establishing a point of compliance for surface water are described in WAC 173-340-730(6). Establishing a point of compliance for surface water is necessary if contaminants are discharging to surface water such as through surface water runoff or discharge from a treatment plant. Where groundwater is discharging to surface water, the point of compliance for groundwater should be set under WAC 173-340-720, not 730.

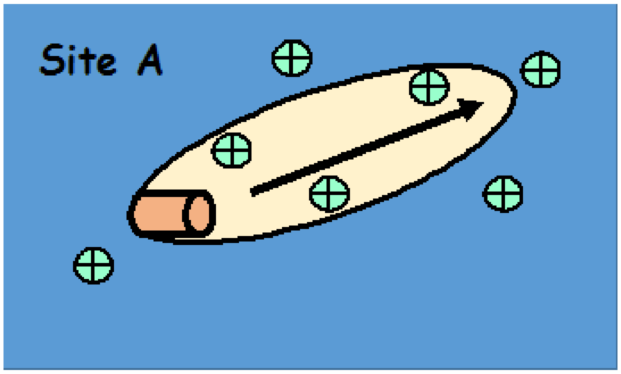
The point of compliance for surface water does not depend on what uses the surface water is classified for such as drinking water, fishing, swimming, etc.

- **Standard point of compliance:** The standard point of compliance for surface water is all locations where site contaminants are released to the surface water.
- **Conditional point of compliance:** MTCA does not provide for the use a conditional point of compliance for surface water cleanup levels.

Note that if a pretreatment or discharge permit is required for the site, then additional monitoring requirements may apply (such as monitoring of the influent and effluent for a groundwater treatment system).

Standard Point of Compliance (Property A) (WAC 173-340-720(8)(b)

- Throughout the site (all locations monitored) from the uppermost level of the saturated zone to lowest depth potentially affected by site.



Conditional Groundwater Point of Compliance—Selected conditions (Property B) (WAC 173-340-720(8)(c)

- Not practicable to meet standard POC within reasonable restoration timeframe.
- All practicable methods of treatment must be used.
- Must be as close as practicable to source.
- Cannot exceed property boundary.
- Extends from the uppermost level of the saturated zone to lowest depth potentially affected by site.

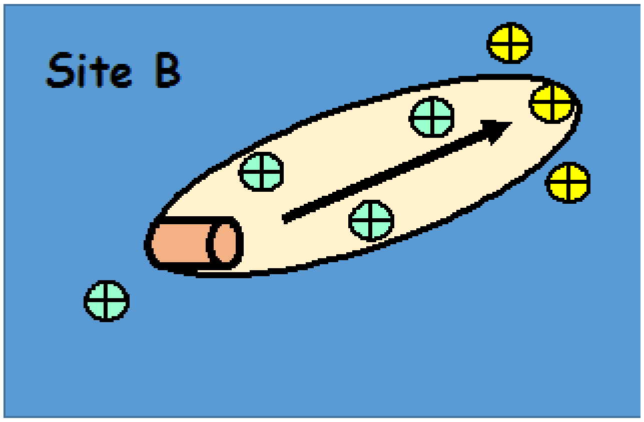
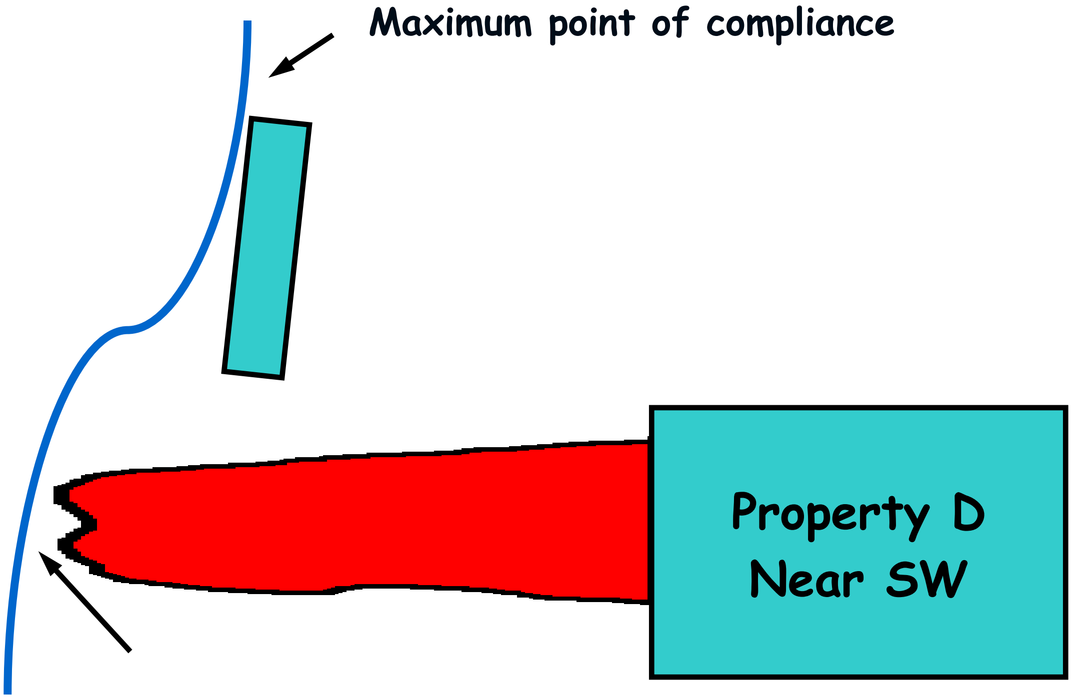


Figure 9.2 Groundwater points of compliance.

Selected conditions for sites adjacent to surface water (Property C):

- Not practicable to meet standard POC within reasonable restoration timeframe.
- All practicable methods of treatment must be used.
- Must be as close as practicable to source.
- Not practicable to meet cleanup level within groundwater before entering surface water.
- Contaminated ground water enters or will likely enter surface water & will continue after remedy in-place.
- No mixing zone allowed.
- Must use "all known, available and reasonable methods of treatment" for groundwater.
- Sediment standards cannot be violated.
- Groundwater and surface water monitoring to assess performance.
- Notify Natural Resource Trustees, Dept. of Natural Resources, Army Corps of Engineers.



Selected conditions for sites "near" surface water (Property D):

All of the above conditions for sites adjacent to surface water plus:

- Affected property owners must agree in writing.
- Can't exceed current extent of plume.

Figure 9.3 Groundwater points of compliance for groundwater discharging to surface water (WAC 173-340-720(8)(d)(i) and (ii)).

9.4 Air Point of Compliance

The regulatory requirements for establish a point of compliance for air are described in WAC 173-340-750(6).

- **Standard point of compliance:** The standard point of compliance is in the ambient air throughout the site – both ambient outdoor air and air within structures. In practice this means compliance monitoring typically consists of analyzing air samples from several locations in the ambient air at the site and from vapor probes and/or inside buildings and structures where vapors have the potential to accumulate.
- **Conditional point of compliance:** For sites that meet the definition of an industrial property under WAC 173-340-745, Ecology may approve a conditional point of compliance. The conditional point of compliance can be in the ambient air up to the property boundary provided this would not pose a threat to human health or the environment. In practice, this means compliance monitoring would consist of analyzing air samples from several locations in the ambient air at the site and from vapor probes and/or inside buildings and structures where vapors have the potential to accumulate to ensure workers are not exposed to potentially harmful concentrations. See Subsection 6.11 of this guidance for additional discussion and references related to vapor intrusion and monitoring vapors within occupied structures. Air monitoring would also likely be required along the property boundary to ensure human health in off-property areas is not threatened.

Note that if an air permit is required for a discharge from the site (such as for the discharge from a vapor extraction system), then additional monitoring requirements may apply.

9.5 Sediment Point of Compliance

Sediment cleanup levels must be met throughout the site down to a depth that is protective of both aquatic life and human health. For aquatic life, this depth is equal to the biologically active zone which, in general, is 10 to 15 cm, after the contaminated sediment has been removed and/or capped with clean sediment. In some cases, particularly along beaches, it may be necessary to establish a deeper point of compliance to account for potential human intrusion.

For an active outfall, it may be allowable to establish a sediment impact zone. In these cases, compliance with sediment standards is measured at locations specified in the discharge permit, provided certain conditions are met.

A detailed discussion of sediment compliance monitoring is beyond the scope of this guidance. For further information on sediment point of compliance, see Chapter 173-204 WAC, Ecology's Sediment Cleanup User's Manual (SCUM II), and contact Ecology's Aquatic Lands Cleanup Unit.

10.0 Determining Compliance with Cleanup Standards

This section describes how to determine compliance with the cleanup standards derived under Sections 8 and 9.

10.1 Determining Compliance with Soil Cleanup Standards

Environmental consultants and laboratories commonly compare soil contaminant concentrations in individual samples measured at a site to the Method A soil cleanup levels to determine if a cleaned up site complies with MTCA. This may or may not comply with MTCA depending on the conditions at the site. The following describes the correct process for determining compliance with soil cleanup levels.

Step 1. Identify the cleanup levels against which compliance is to be measured.

Cleanup levels should have been established for all contaminants listed in Table 7.2 for the products present at the site, unless site investigations have not found these substances at the site or the substances have been eliminated using the criteria in WAC 173-340-703. ***Cleanup levels must consider all potential exposure pathways as discussed in Section 8 of this guidance. Merely using the Method A soil values in Tables 740-1 or 745-1 may be insufficient.***

Step 2. Identify the point of compliance where the cleanup level must be met.

For soil, the point of compliance depends on which exposure pathway is driving the cleanup level. See Figure 9.1 for an illustration of the points of compliance for the various soil exposure pathways. For example, if Method A is being used to establish a soil cleanup level and that cleanup level is the value in Table 740-1, then in general this cleanup level must be met throughout the site if the property owner wants to avoid restrictions on future uses of the site. If the Method A soil cleanup level is based on protection of plants and animals, then there may be two cleanup levels and points of compliance at a site—a more stringent cleanup level for the biologically active zone of soil at the site, and a different cleanup level for the deeper soils at the site.

Similarly, if the soil cleanup level has been established under Method B, then there may also be more than one cleanup level and point of compliance for the site.

Step 3. Identify the method to be used to demonstrate compliance.

MTCA provides two methods for determining compliance with the soil cleanup standards:

- Direct Comparison: Allowed only under some conditions (see Subsection 10.1.1)
- Statistical Evaluation: All other circumstances (see Subsection 10.1.2)

Step 4. Conduct compliance sampling.

After completion of remedial actions, the site soils need to be sampled to demonstrate that the cleanup level(s) have been met at the point of compliance. All samples should be analyzed for all parameters for which cleanup levels have been established. Where the contaminated soil has been removed, prior to backfilling the excavation, soil samples should be obtained from all of the side walls and bottom of the excavation (including pipe corridors) for analysis. If direct comparison is planned to be used, soil samples should be taken within areas where previous testing or field observations found contamination and to bracket these areas of known contamination. If a statistical evaluation is to be used, a grid pattern should be laid out and samples taken from random locations within the grid, as well as from locations known from earlier sampling to be contaminated. See Subsection 6.8.3 for additional guidance on post-cleanup sampling of excavations.

If the excavated contaminated soil has been treated and is intended to be used for backfilling the excavation, then the treated soil should be tested according to the schedule provided for soil stockpiles in Table 6.9. This also applies to treated soil brought in from other contaminated sites.

If an in-situ treatment process is being used to treat the soil, the vertical and lateral extent of the treated soil should be estimated using site characterization and performance monitoring soil samples. This soil should then be tested at the conclusion of the treatment process. The number of samples to be tested should be according to the schedule provided for soil stockpiles in Table 6.9 using the volume of contaminated soil before treatment to determine the number of samples.

10.1.1 Direct Comparison:

In this method, the test results for each soil sample are compared to the soil cleanup level. If even one (1) sample exceeds the soil cleanup level, the site does not comply with MTCA. Direct comparison can only be used at sites where there is documented, reliable information that the soil compliance samples have been taken from locations where the contamination is likely to be present. Direct comparison should only be used at sites where the source of the contamination is known (e.g., a leaking UST) and the contaminant migration can be easily tracked using visual observation (stained soil) or field screening methods (see Chapter 5).

10.1.2 Statistical Evaluation:

If a site is not eligible for direct comparison, a statistical evaluation of compliance sampling data must be conducted. Under MTCA there are three parts to demonstrating compliance through a statistical evaluation:

- The upper 95th percentile confidence limit on the true mean concentration at the site must be less than the soil cleanup level.
- Less than 10% of the samples can exceed the soil cleanup level.
- No single sample can be greater than two (2) times the soil cleanup level.

If there is more than one cleanup level established within a medium (as is possible with soil), this evaluation will need to be conducted for each point of compliance applicable to the different cleanup levels.

KEY POINT: THE TRUE MEAN IS NOT THE SAME AS THE SAMPLE AVERAGE

The true mean is not the average of the samples analyzed. Rather, it is the average value that would be obtained if the entire contaminated soil volume could be analyzed. Because it is impractical to send the entire soil mass to a laboratory for analysis, the true mean (true average) concentration is estimated using the sample data and statistical methods.

See the following publications for additional guidance on sampling and data analysis:

- "Statistical Guidance for Ecology Site Managers," Ecology Publication No. 92-54, August 1992, https://fortress.wa.gov/ecy/publications/SummaryPages/9254.html.
- "MTCAStat," an Excel-based statistical package, available under "Workbook for calculating compliance statistics," http://www.ecy.wa.gov/programs/tcp/tools/toolmain.html.
- The MTCAStat tools have also now been incorporated into Ecology's Information Management System, http://www.ecy.wa.gov/eim/.
- "Guidance on Sampling and Data Analysis Methods," Ecology Publication No. 94-49, January 1995, https://fortress.wa.gov/ecy/publications/SummaryPages/9449.html.
- EPA's "Pro UCL" statistical package and a wealth of other guidance, http://www.epa.gov/land-research/proucl-software.

10.2 Special Considerations for Method B Soil Cleanup Standards

Cleanup levels established using Method B present a challenge for determining compliance. Petroleum mixture composition will vary from sample to sample depending on how much weathering of the sample has occurred and variability introduced during sampling and analysis.

Ecology believes the most practical approach is to use data from multiple soil or product locations to calculate a median soil cleanup level that is representative of the site (or portion of the site contaminated by the same product). This median value is then used to evaluate compliance. A median concentration is recommended to avoid outlier values overly influencing the cleanup level.

There are several possible alternative methods for evaluating confirmational monitoring data (post-remediation data) to determine if a medium Method B soil cleanup level has been met. See Table 10.1 for a description of several recommended methods.

Table 10.1 Recommended Alternatives for Determining Compliance with Method B Soil Cleanup Levels

Alternative 1: Determining compliance using TPH concentrations measured with the NWTPH method

In this method, the post-remediation samples are analyzed for residual TPH concentrations using the appropriate NWTPH method (NWTPH-Gx or Dx). These values are then compared to the total TPH cleanup level calculated using EPH/VPH data. The comparison uses either the direct comparison or the statistical methods to determine if the TPH cleanup level has been met. *

This method is the least expensive and most straight-forward for demonstrating compliance.

Alternative 2: Determining compliance using TPH concentrations measured with the NWTPH method correlated to EPH/VPH measurements

This alternative should only be used if there is a reasonably good correlation between NWTPH and EPH/VPH analyses (using the Pearson correlation coefficient or a similar method).

In this method, data developed during the site investigations is used to develop a correlation between the NWTPH TPH measurements and the EPH/VPH total TPH measurements. After completion of the remedial action, the post-remediation samples are analyzed using the appropriate NWTPH method. The correlation developed during site investigations is then used to convert the measured NWTPH concentrations to an equivalent EPH/VPH total TPH concentration.

Either the direct comparison or statistical methods are then used to determine if the TPH cleanup level has been met. *

Experience at a limited number of sites has found that it is difficult to establish a good correlation between EPH/VPH concentrations and NWTPH concentrations. This may make this method a challenge to use at most sites.

Alternative 3: Determining compliance using the EPH/VPH methods to calculate new TPH cleanup levels

This alternative is appropriate for treatment methods that change the composition of the TPH mixture to render it less toxic. It is also expensive because each post remediation sample must be analyzed using the EPH/VPH methods. However, because treatment often removes the most toxic components of a petroleum mixture, the added analytical expense may be worthwhile.

In this method, the post-remediation samples are analyzed using the EPH/VPH. A new cleanup level is established for the site (or portion of a site) using the process described in Section 8. Then, with the same samples, either the direct comparison or statistical methods are used to determine if the new TPH cleanup level has been met throughout the site. *

A variation of this method would be to collect and analyze a limited number of samples to monitor changes in the petroleum composition until it stabilizes. Then re-characterize the contaminated area with an appropriate number of VPH/EPH samples (as per Table 8.5) to develop a new cleanup level and determine compliance using alternative 1.

* **NOTE:** Individual substances (such as BTEX, naphthalenes, and cPAHs) must also be analyzed for and checked for compliance with their respective cleanup levels.

Table 10.1 Recommended alternatives for determining compliance with Method B soil cleanup levels.

10.3 Determining Compliance with Groundwater Standards

At sites where a groundwater cleanup level has been established, WAC 173-340-720(9)(a) requires sampling of the groundwater, typically using groundwater monitoring wells, to determine compliance.[32] Normally, several years (or more) of groundwater monitoring are needed before there is enough data to establish statistically whether cleanup levels are met at the point of compliance. This is not practical at many cleanup sites. In addition, at many petroleum-contaminated sites, groundwater is not contaminated or only has minor contamination. At these sites, Ecology allows a compliance demonstration using more limited groundwater sampling results. The following discussion provides for this approach.

Step 1. Insure the site is adequately characterized.

If not already present, install sufficient groundwater monitoring wells to fully characterize the groundwater quality throughout the plume, including any off property areas contaminants have migrated to.

Step 2. Identify the cleanup levels against which compliance is to be measured.

Cleanup levels should have been established for all contaminants listed in Table 7.2 for the products present at the site, unless site investigations have not found these substances at the site or the substances have been eliminated using the criteria in WAC 173-340-703. Cleanup levels must consider all potential exposure pathways as discussed in Chapter 8 of this guidance.

Step 3. Identify the point of compliance where the cleanup level must be met.

There are several options for establishing a groundwater point of compliance. See Chapter 9 for a discussion of options. When only some of the existing groundwater monitoring wells are being used for compliance monitoring, document why these particular monitoring wells were selected.

Step 4. Identify the method to be used to demonstrate compliance.

This guidance provides two methods for determining compliance with the groundwater cleanup standards:

- Direct Comparison: Allowed only under some conditions (see Subsection 10.3.1)
- Statistical Evaluation: All other circumstances (see Subsection 10.3.2)

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[32] NOTE: While there is a strong expectation that most sites will conduct groundwater sampling as part of site characterization, not all sites need to sample groundwater and establish groundwater cleanup standards. See Subsection 6.9.1 of this guidance for a discussion of factors to consider when evaluating the need for installing groundwater monitoring wells.

Step 5. Conduct compliance monitoring.

After completion of the remedial action, the groundwater needs to be sampled to demonstrate that the cleanup level(s) have been met at the point of compliance. This typically consists of sampling of a representative subset of groundwater monitoring wells where contamination was detected in the remedial investigation and other appropriate locations where contamination is likely to be present. All samples should be analyzed for all the parameters for which cleanup levels have been established.

10.3.1 Determining Groundwater Compliance using Direct Comparison [33]

Direct comparison to the groundwater cleanup levels should be used only if the following pre-conditions are met:

- The site characterization has provided a thorough understanding of the site and groundwater system, including sources of contamination, extent of soil contamination, and direction of groundwater flow.
- Sufficient monitoring wells have been installed where potential contamination is most likely to be found;
- For the products present at the site, the samples are analyzed for all relevant parameters in Table 7.2.
- Sufficient time has elapsed for contamination to reach the groundwater; [34]
- A standard point of compliance (throughout the site plume) is being used; and
- There are no other conditions at the site indicating that future groundwater contaminant levels have the potential to be higher than measured concentrations. For example, the following conditions will typically require more frequent sampling events and/or an extended sampling timeframe:
    - Sustained unusually dry or wet climatic conditions.
    - Current surface infiltration conditions are different from those expected to be present in future years after site redevelopment. (for example, the site is currently paved or largely covered with buildings and this will be removed upon redevelopment; or a storm water infiltration system is to be installed within the release area)

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[33] Based on *Guidance on Sampling and Data Analysis Methods*, Ecology Publication No. 94-49, January, 1995.

[34] This is intended to be a qualitative evaluation. For example, if the release occurred within a year of when the monitoring was done and residual soil contamination remains at the site, additional monitoring beyond the minimums specified in this subsection may be warranted to assure delayed impacts to the groundwater have not been overlooked.

  - The site is located in an area of high groundwater fluctuations or directional changes caused by either natural (tides) or manmade (dam, irrigation, pumping wells) conditions.

If these pre-conditions are met, there are three "stages" of monitoring that can be used to demonstrate compliance. Stages 1 and 2 can be used when contamination hasn't been found in the groundwater at the site. Stage 3 monitoring is for sites where groundwater contamination has been found and direct comparison is being used to demonstrate compliance with cleanup standards after the cleanup is completed. The following provides a discussion of these monitoring stages, with a summary provided in Table 10.2.

- **STAGE 1 MONITORING: No groundwater contamination during site characterization.**

  This is intended to provide a means for establishing that groundwater contamination is not a concern at the site with only a limited amount of sampling. It can be used during site characterization to determine if further remedial action is needed or for determining compliance with groundwater cleanup standards after a soil cleanup is complete. To use this method, the above pre-conditions plus the following conditions must be met:

  - Soil testing with depth indicates it is unlikely significant contamination has reached the groundwater;
  - The site is not a large site with potentially extensive contamination (e.g. tank farms, and industrial facilities); and
  - At least two (2) samples are collected from each groundwater monitoring point, three (3) to six (6) months apart, representative of high and low groundwater conditions. Groundwater samples collected during site characterization can be used to meet the monitoring requirements for Stage 1 monitoring. The two (2) samples may be reduced to one (1) sample from each groundwater monitoring point collected during high groundwater conditions (April or May) for lower risk sites.[35]

  The site is in compliance if none of the contaminants of concern have been detected above the practical quantitation limits specified in Table 7.3 in any of the samples from any monitoring point.

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[35] Lower risk sites are sites with limited soil contamination, and not located within a the 10-year wellhead protection area of a public water supply well, within 1,000 feet of any public or private water supply well, or within 300 feet of any surface water or wetland.

☐ STAGE 2 MONITORING: Groundwater contamination found but below cleanup levels.

This stage can be used to establish compliance if the conditions for use of Stage 1 monitoring are not met, or when contaminants are detected at low levels in the groundwater during site characterization or Stage 1 monitoring. This method can be used either during site characterization to determine if further remedial action is needed or for determining compliance with groundwater cleanup standards after a soil cleanup is complete. To use this method, the above pre-conditions plus the following conditions should be met:

- All contaminants detected were below cleanup levels in all groundwater monitoring samples during site characterization;
- The groundwater concentrations are stable or decreasing over time;
- At least four (4) samples are collected from each compliance monitoring point, three (3) months apart (quarterly for one year). The sampling dates should include high and low groundwater conditions. Groundwater samples collected during site characterization can be used for this purpose; and
- A standard point of compliance (i.e. throughout the site) is being used.

The site is in compliance if none of the contaminants of concern have been detected above the cleanup levels in any of the samples from any monitoring point.

☐ STAGE 3 MONITORING: Groundwater contamination found above cleanup levels.

This stage can be used to establish compliance if the conditions for use of Stages 1 or 2 monitoring are not met, or contaminants are detected in the groundwater above cleanup levels during Stage 1 or 2 monitoring. It should be used after the cleanup has been completed. To use this method, the above pre-conditions plus the following conditions should be met:

- After remediation, at least eight (8) samples are collected from each compliance monitoring point, collected in consecutive quarters, over a period of at least two (2) years. The sampling dates should include high and low water table conditions;
- The groundwater concentrations are stable or decreasing over the two (2) year time period being evaluated.[36]

The eight (8) samples may be reduced to four (4) samples collected after remediation from each compliance monitoring point, and collected in consecutive quarters, over a period of one (1) year if the following conditions are met:

- The groundwater concentrations are stable or decreasing over the one (1) year time period being evaluated;
- The initial four (4) sample results are not highly variable (i.e. the highest concentration above the PQL is no more than three (3) times the lowest concentration above the PQL);
- The site is a lower risk site; and [37]
- Other site-specific conditions as determined by Ecology.

The site is in compliance if at least the last eight (8) consecutive quarterly samples (or four (4), if eligible for a reduction) from all monitoring points, are below cleanup levels.

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[36] The trend analysis can be qualitative or use the plume stability test in Appendix D.4 of Ecology's *Natural Attenuation Guidance,* Publication No. 05-09-091). Other peer-reviewed methods of plume stability analysis may also be used.

[37] Lower risk sites are sites with limited soil contamination, and not located within a the 10-year wellhead protection area of a public water supply well, within 1,000 feet of any public or private water supply well, or within 300 feet of any surface water or wetland.

Table 10.2 TPH Groundwater Compliance Monitoring at a Glance
(This is a summary. See text for additional explanation.)

Stage of Investigation	Minimum # of samples per well	Pass criteria for all wells	Comments
Stage I	Use this Stage if no contamination was detected above PQLs in any well during site characterization and after soil remediation. It can be used to demonstrate groundwater remediation is unnecessary OR that the site is in compliance with groundwater cleanup levels after cleanup.		
	• 2 samples/well, 3 to 6 months apart, covering seasonal fluctuations (high/low water table) • May be reduced to 1 sample per well during April or May for lower risk sites [38]	All samples below PQL	Samples must be during high groundwater conditions Not suitable for large sites
Stage 2	Use this Stage if contaminants found above PQL but below CULs in one or more monitoring wells during site characterization, during Stage 1 monitoring, or after soil remediation. It can be used to demonstrate groundwater remediation is unnecessary OR that the site is in compliance with groundwater CULs after cleanup.		
	• 4 samples/well (quarterly)	All samples below CUL	Plus stable or decreasing trend
Stage 3	Use this Stage if contaminants found in any well above cleanup levels during site characterization, during Stage 1 or 2 monitoring, or after soil and/or groundwater remediation. It can be used to demonstrate that site is in compliance with groundwater CULs after cleanup.		
	• 8 samples/well (quarterly) - all after remediation. • May be reduced to 4 samples/well (quarterly) after remediation in the following conditions: ➢ The first 4 samples do not show increasing trend ➢ First 4 samples are not highly variable (highest > 3 X lowest) ➢ The site is a lower risk site	All samples below CUL	Plus stable or decreasing trend

Overall conditions for all stages (if any of these conditions are not met, more monitoring may be needed):

- Good site characterization defining sources and extent of soil & groundwater contamination (if any)
- Monitoring wells installed where contamination most likely to be found
- Samples analyzed for all relevant parameters for the products likely released
- Sufficient time has elapsed for contamination to reach groundwater (qualitative evaluation)
- Standard point of compliance is being used (i.e. compliance measured throughout the site plume)
- Samples are representative - not under sustained unusually wet or dry conditions
- Current surface infiltration conditions similar to that expected in the future
- Site not located in area of high groundwater fluctuations (e.g. tidal, dam, irrigation, pumping wells)

CUL = Cleanup level. PQL = Practical quantitation limits specified in Table 7.3.

Table 10.2 TPH groundwater compliance monitoring at a glance (summary).

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[38] As used in this table, lower risk sites are sites with limited soil contamination, and not located within a the 10-year wellhead protection area of a public water supply well, within 1,000 feet of any public or private water supply well, or within 300 feet of any surface water or wetland.

10.3.2 Determining Compliance Using Statistics

This method can be used at any site. **In this method, the latest three (3) years of sampling data for <u>each compliance monitoring point</u> must meet the MTCA required three-part statistical test. This method can be used at sites using a standard point of compliance (throughout the site) or a conditional point of compliance:**

- The upper 95th percentile confidence limit on the true mean of the test results from the monitoring point must be less than the groundwater cleanup level. (NOTE: True mean is not the sample mean; it is a statistical estimate of the actual average water quality in a monitoring point.)
- Less than 10% of the samples exceed the groundwater cleanup level.
- No single sample is greater than two (2) times the groundwater cleanup level.

If a monitoring well is replaced during the compliance monitoring timeframe, or a new well added, at least eight (8) consecutive quarters of monitoring data should be acquired from the new well and worked through this evaluation procedure. Additional monitoring beyond eight quarters may be necessary when the new data is inconsistent with past data.

Additional requirements for evaluating compliance using statistical tests are specified in WAC 173-340-720(9). Guidance on use of statistical methods for determining compliance can be found in Ecology Publication No. 92-54, *Statistical Guidance for Ecology Site Managers*, and various EPA publications.

When natural attenuation is used as a component of a groundwater cleanup remedy, see also Ecology Publication No. 05-09-091, *Guidance on Remediation of Petroleum Contaminated Groundwater by Natural Attenuation*. This publication describes the appropriate use of natural attenuation, how to evaluate plume status, and what documentation is needed for natural attenuation sites.

10.4 Determining Compliance with Surface Water Cleanup Standards

For point source discharges (such as a treatment plant), the discharge permit will specify the monitoring locations, frequency and evaluation procedures. Where a discharge permit has not been issued for the site but the impact of the site on nearby surface water is a concern, the monitoring locations, frequency, and evaluation procedures should be described in conceptual terms in the cleanup action plan and in detail in the operation and maintenance plan.

At a minimum, surface water monitoring should consist of monthly collection and analysis of surface water samples. Samples should be obtained from locations likely to be impacted by the site as well as from one or more locations not impacted by the site (background). Data analysis should include at least:

- A comparison between background contaminant concentrations and concentrations at potentially impacted locations
- A comparison of potentially impacted locations to the surface water cleanup levels
- Plotting of contaminant concentrations over time for each location

Under Washington State Water Quality Law (WAC 173-201A-240), sample results for determining compliance with chronic criteria are averaged over a period of time that varies from 24 hours to 4 days, depending on the contaminant. In most cases, any single violation of a surface water standard in three (3) years constitutes a violation of ambient water quality criteria.

10.5 Determining Compliance with Air Cleanup Standards

Evaluation of compliance with air cleanup standards is beyond the scope of this guidance. If vapor intrusion is an issue at the site, consultation with Ecology is highly recommended. See Subsection 6.11 of this guidance for additional discussion and references related to vapor intrusion.

10.6 Determining Compliance with Sediment Cleanup Standards (WAC 173-204)

Evaluation of compliance with sediment cleanup standards is beyond the scope of this guidance. For additional information on sediment cleanup standards and requirements go to Ecology's sediment cleanup website, at http://www.ecy.wa.gov/programs/tcp/smu/sediment.html.

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11.0 Remedial Action Alternatives and Permit Requirements

This section provides guidance for selecting remedial technologies for treating contaminated soil and groundwater at petroleum-contaminated sites, and outlines specific requirements, applicability, and limitations of recommended remedial technologies.

11.1 Requirements for the Selection of Cleanup Remedies

In general, MTCA requires cleanup actions to be taken at a site where ***any*** of the following conditions exist:

- Free product is found;
- Whenever hazardous substances are present in the groundwater in excess of the MTCA groundwater cleanup standards established for the site;
- Whenever hazardous substances are present in the soil in excess of the MTCA soil cleanup standards established for the site; and
- Whenever hazardous substances are present in any other medium in excess of applicable MTCA cleanup standards for that medium.

Cleanup actions at petroleum-contaminated sites must comply with the cleanup standards described in WAC 173-340-700 through 173-340-760 and the requirements for the selection of cleanup actions in WAC 173-340-350 through 173-340-390.

The MTCA cleanup regulations specify certain threshold and other requirements as the minimum requirements that all cleanup actions must meet. Cleanup actions must (WAC 173-340-360):

- Protect human health and the environment;
- Comply with cleanup standards
- Comply with applicable state and federal laws
- Use permanent solutions to the maximum extent practicable
- Provide for a reasonable restoration time frame
- Provide for compliance monitoring; and
- Consider public concerns.

WAC 173-340-360 also establishes several narrative standards that remedies must meet. Appendix B provides a general description of the remedy selection process under MTCA and the recommended contents of a feasibility study.

11.2 Permits and Other Regulatory Requirements

The MTCA cleanup regulations do not require a permit from Ecology to cleanup a site. [39] However, excavations, soil treatment, and other activities related to petroleum-contaminated site cleanups may require permits from local planning, building, health, or fire departments, as well as regional air pollution control authorities and state agencies other than Ecology. The Governor's Office of Regulatory Assistance has prepared a guide titled *Permit Handbook* that provides more information on permits, which is available in web form at http://apps.oria.wa.gov/permithandbook/.

The time to process permits can vary from days to months depending on the type of permit, state and local government procedures, and complexity of the site. Any necessary permits must be obtained prior to beginning site remediation. In emergencies, contact the permitting agency for guidance on how to proceed.

Sites being cleaned up under a MTCA order or consent decree are exempt from having to obtain certain permits. See WAC 173-340-710(9) and Ecology Policy 710A for additional information on these exemptions.

The following is a summary of some of the permits or requirements that may be applicable to petroleum contaminated sites:

11.2.1 State Environmental Policy Act (SEPA)

Whenever a cleanup is conducted or USTs are replaced that requires a permit or approval from Ecology or other state or local agency, the environmental impact of the proposal usually needs to be evaluated under SEPA. If significant environmental impact is anticipated during the cleanup, an environmental impact statement (EIS) may be required (see Chapter 43.21C RCW and Chapter 197-11 WAC). Contact the agency providing the permit or written approval for the cleanup for specific requirements. Chapter 10 of Ecology's SEPA handbook and Policy 130A addresses SEPA/MTCA integration and how these two processes can be coordinated. A copy of the handbook can be obtained at http://www.ecy.wa.gov/programs/sea/sepa/handbk/hbtoc.html. Policy 130A can be obtained at http://www.ecy.wa.gov/programs/tcp/policies/tcppoly.html.

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[39] For site owners wanting approval of a cleanup from Ecology for financing or other reasons, see Subsection 1.4 of this guidance for a discussion of Ecology approval processes under MTCA.

11.2.2 Air

Cleanup methods most likely to trigger an air permit are incinerators/thermal desorption units, vapor and dual phase extraction systems, and water treatment systems using air stripping towers. Dust generated during large excavations or soil mixing projects could also trigger an air permit if dust isn't anticipated and accordingly controlled.

While most petroleum cleanup projects are unlikely to have emissions in quantities great enough to trigger a permit, determining the applicability of the different air permits is quite complicated. Air regulations are enforced by either local air agencies or the Department of Ecology, depending on the location of the emission source in the state. A map illustrating the air authority for the different counties in Washington State can be found at http://www.ecy.wa.gov/programs/air/local.html.

Owners or operators of petroleum contaminated sites should contact the appropriate air offices for possible permits and/or actions necessary to meet air regulatory requirements. Applications or inquiries should be made several months prior to the intended cleanup, if possible, to allow time for agency review and public notice. For additional information on air regulatory requirements in Washington State, go to http://www.ecy.wa.gov/programs/air/airhome.html.

11.2.3 Solid Waste

Petroleum-contaminated soils that are not dangerous wastes are regulated under the Solid Waste Handling Standards, Chapter 173-350 WAC. This rule applies to the handling of contaminated soil when removed from a MTCA site. Petroleum contaminated soils are regulated just like any other solid waste under most circumstances. County health departments and districts are responsible for any necessary solid waste permitting for petroleum-contaminated soils treatment and disposal facilities. These local departments/districts may have additional handling and permitting requirements that are more stringent than state law. For a link to local health departments/district web sites, go to http://www.doh.wa.gov/AboutUs/PublicHealthSystem/LocalHealthJurisdictions.

Excavation of petroleum contaminated soils for off-site disposal.

In addition, treatment and disposal companies typically have their own testing and handling requirements. For this reason, early consultation with the operator of the facility anticipated to treat or dispose of petroleum-contaminated soils is recommended.

For additional information on Ecology's solid waste regulations, see also Subsection 11.3 of this guidance and go to http://www.ecy.wa.gov/programs/swfa/index.html.

11.2.4 Dangerous (Hazardous) Waste

When soil is highly contaminated, the owner or operator will need to determine whether the soil is a hazardous waste (called "dangerous waste" under Washington State law). Generation, treatment, transportation, and disposal of dangerous wastes are subject to the state dangerous waste regulations, Chapter 173-303 WAC. Dangerous wastes can be transported only to specifically permitted facilities for treatment, storage, or disposal.

It is possible that gasoline vapors, lead, benzene, polycyclic aromatic hydrocarbons, or polychlorinated biphenyls could trigger dangerous waste designation. Soils and groundwater contaminated by releases from regulated underground storage tanks are exempt from most of the dangerous waste regulations under WAC 173-303-071(3)(t). However, the contents of tanks, and petroleum contaminated soils generated by other petroleum cleanups, are not exempt from the dangerous waste regulations.

For additional information on Ecology's hazardous waste regulations, go to http://www.ecy.wa.gov/programs/hwtr/index.html.

11.2.5 Toxic Substances Control Act

The federal Toxic Substances Control Act is administered by USEPA. In general, this act is applicable to cleanups of wastes, including contaminated soils, containing PCBs greater than one part per million (1 ppm). Under 40 CFR 761.61(a) the USEPA must be notified of any cleanup of PCB contamination 30 days prior to beginning the cleanup.

In addition to any cleanup requirements under MTCA, and the above notification requirement, EPA has numerous regulatory requirements for PCB cleanups that are too extensive to summarize here. Persons cleaning up PCB contaminated petroleum products should consult EPA's PCB website, available at http://www.epa.gov/epawaste/hazard/tsd/pcbs/index.htm.

11.2.6 Water Quality Permits

State law requires a water quality discharge permit when water from a petroleum contaminated site is discharged to surface water or groundwater. There are four options for discharge of contaminated water from cleanup sites:

(a) Treatment and discharge to surface water
(b) Pretreatment and discharge to sanitary sewer
(c) Treatment and discharge to ground and groundwater
(d) Transport to a permitted industrial wastewater treatment facility

Most of these permits are issued by Ecology's regional offices and require payment of an annual fee (Chapter 173-223 WAC). Ecology's Water Quality staff should be contacted early in the project-planning phase to allow sufficient time for review. The following provides a general overview of potential water discharge permits. For additional information on Ecology's Water Quality Program and regulatory requirements, go to http://www.ecy.wa.gov/programs/wq/wqhome.html.

a) Surface Water Discharge

If contaminated water will be discharged from a point source to state surface waters (including storm drains), the owner or operator will need to obtain a National Pollutant Discharge Elimination System (NPDES) permit (regulated under Chapter 173-220 WAC). Applications are available from regional offices and should be submitted no later than 180 days prior to the planned commencement of discharge. Unfortunately, current permitting workloads are such that 180 days may not be adequate time to prepare an NPDES permit. No discharge will be allowed prior to issuance of a permit. Rules governing these types of discharges require monitoring and reporting of effluent quality and providing treatment for wastewater. Contact Water Quality staff in the appropriate Ecology regional office for permitting requirements and application forms.

If cleanup activity at the site will disturb the land and result in stormwater leaving the site and discharging to surface water, a construction stormwater permit is required for the site. Go to the following web page for additional information on construction stormwater permits: http://www.ecy.wa.gov/programs/wq/stormwater/construction/.

If the cleanup work will result in a short-term violation of water quality standards, it may be possible to obtain a short-term water quality modification order permitting the violation. These modifications are most commonly issued for in-water work such as disturbance of sediments during cleanup causing temporary turbidity violations. For more information on short-term water quality modifications, see WAC 173-201A-420, available at http://apps.leg.wa.gov/WAC/default.aspx?cite=173-201A.

Stormwater runoff can cause significant water quality issues if not properly controlled.

b) Sanitary Sewer Discharge

A pretreatment permit is required if water is discharged to a municipal sewer system (Chapter 173-216 WAC). These permits are either issued by Ecology, or by the local treatment system operator, when they have an approved ("delegated") pretreatment program.

- King County (Seattle metropolitan area), Everett, LOTT (greater Olympia Area), Lynnwood, Pierce County, Puyallup, Richland, Spokane, Tacoma, Vancouver, Walla Walla and Yakima have been delegated authority to write permits for discharge to their own sewage systems. Check Ecology’s PARIS database for additional treatment plants that are in the process of gaining approval, available at http://www.ecy.wa.gov/programs/wq/permits/paris/index.html.
- Ecology regional staff issue a pretreatment permit for discharges to other publicly owned wastewater treatment plants.

Application and permit requirements and time frames vary depending on the situation and the receiving wastewater treatment plant. Some wastewater treatment plants are discouraging discharges to the plant from groundwater cleanups due to hydraulic overloading and lack of treatment for the contaminants of concern by the processes used at the plant. Contact the appropriate local entity and the Ecology regional office Water Quality staff for permitting requirements and application forms.

A complete and accurate application for a pretreatment permit must be submitted to the appropriate Ecology regional office at least 60 days prior to discharge. Ecology can then determine if a permit is necessary based on the specific activity and effluent quality. These discharge permits typically require treatment of the wastewater prior to discharge and monitoring and reporting of influent and effluent quality.

c) Discharge to Ground and Groundwater

Discharges to ground and groundwater, whether contained on-site or released off-site, may require a State Waste Discharge Permit. These permits are issued by Ecology's regional offices. Local conditions and the method of discharge and containment will determine the need for the permit. Complete and accurate applications must be submitted at least 60 days prior to discharge. Contact the appropriate regional office Water Quality staff for application forms and information. (Also see Subsection 11.2.8 of this guidance on injection wells.)

d) Transport to a Permitted Industrial Water Treatment Facility

The fourth option for disposing contaminated pump water, purge water, or extracted groundwater is storage and transport to a facility permitted to receive industrial wastewaters. For water designated as Dangerous Waste, a permitted, hazardous waste treatment facility must be used. Contact the appropriate facility for further information.

11.2.7 Shoreline Management and Wetlands

If excavation or construction at a petroleum-contaminated site is within 200 feet of a water body over 20 acres (including associated wetlands) or within the floodplain of a river or certain streams, a Shoreline permit may be required (see Chapter 90.58 RCW, Chapters 173-14 through 173-28 WAC, and local master plans). Owners or operators must apply for the permit from the local jurisdiction, usually the county or city planning or building department.

If soils on or near the site are saturated with water at least part of the year, the local jurisdiction should be contacted to determine if the area is regulated by local wetland ordinances.

For additional information on Ecology's Shoreline Management Program and wetland regulatory requirements, see http://www.ecy.wa.gov/programs/sea/shorelan.html.

11.2.8 Water Resources

Resource protection wells, as defined under Chapter 18.104 RCW, are regulated under Chapter 173-160 WAC. This includes soil borings, soil gas sampling wells, groundwater monitoring wells, groundwater extraction wells, product recovery wells and vapor extraction wells. These wells must be constructed in compliance with these regulations.

If pumping during well development, sampling or treatment is expected to exceed 5,000 gallon from all wells on the site on any single day, a temporary "water right" permit under RCW 90.03.250 may be necessary. Contact Ecology's regional Water Resources Section to find out if a water right permit will be required. In general, pump and treat systems do not require a water right permit if the treated water is completely returned to the environment without disrupting existing water rights. For additional information on Ecology's Water Resources Program and regulatory requirements, see http://www.ecy.wa.gov/programs/wr/wrhome.html.

11.2.9 Underground Injection Wells

The Washington Department of Ecology has regulatory authority over the Underground Injection Control (UIC) program for Washington State. Injection of chemicals for groundwater treatment is subject to strict limitations under Ecology's UIC rule (WAC 173-218). This program also requires **all injection wells** in the state to be registered. Registration is free, but requires completing a registration form, which designates the location and use of the well, among other items. It is the responsibility of the site owner or designee to keep Ecology informed of the status of the well, e.g., active, closed, change in ownership or change in use, among others.

See the following web page for additional information on Ecology's Underground Injection Control Program and regulatory requirements:
http://www.ecy.wa.gov/programs/wq/grndwtr/uic/index.html

KEY POINT: UIC WELLS ARE BROADLY DEFINED.

Underground injection wells are broadly defined to include nearly any system that injects chemicals or contaminants in liquid into the ground, including: (1) A bored, drilled, or driven shaft, or dug hole with a depth greater than the largest surface dimension; (2) an improved sinkhole; and (3) a subsurface fluid distribution system with perforated pipes, tile drains or similar distribution systems.

11.2.10 Zoning and Local Permits

Nearly all local jurisdictions in Washington State have adopted zoning ordinances. These ordinances govern allowable land uses within designated areas. The zoning ordinances may not allow soil or water treatment facilities in certain zones. Sometimes, facilities are allowed subject to certain conditions identified in the ordinance. Land uses approved in this manner are called "conditional" uses. Also, most zoning codes allow uses that are accessory to the primary use of the property without a land use permit. Temporary cleanup facilities may fall within these "accessory" uses.

Most jurisdictions require fill and grading permits when large quantities of soil are being brought into a site or excavated from a site. The typical threshold for these permits is 100 cubic yards but may be as large as 1,000 cubic yards.

Most jurisdictions also require a street use permit or permission of the public works director whenever any activity is to occur within a public right of way or easement.

To determine the zoning and local permitting requirements for a cleanup site, contact the local jurisdiction responsible for land use permitting, typically the City development services department (or County, if the site is not located within an incorporated City).

11.3 Handling of Contaminated Soils and Water

11.3.1 Contaminated Material Characterization

All excavated petroleum-contaminated soil and extracted groundwater should be characterized before and after treatment. The purpose of this sampling is to determine:

- Treatment or disposal methods
- Compliance with the cleanup standards
- If treatment is complete and what the final disposition of the material can be

Representative sampling should be used to determine the minimum, maximum and average concentrations of petroleum product(s). Interim monitoring may also be needed to check the progress of the treatment and guide any necessary changes to the treatment process. All petroleum contaminated soil and groundwater should be characterized for the parameters specified in Table 7.2, using the analytical methods in Table 7.3. Permitted discharges will need to comply with sampling and analysis requirements specified in the permit.

11.3.2 Containment and Storage of Contaminated Soils and Water

Short-term Containment and Storage (three months or less)

Material may be stored on-site during investigations. All investigative wastes (drill cuttings and purge water) should be contained in drums or tanks until tested. For larger amounts of contaminated soil or waste materials, a bermed storage area, lined and covered with a scrim-reinforced geomembrane, should be adequate if it is carefully installed and not damaged during material placement. Check and maintain the containment area during storage to ensure that there are no releases to the environment. State and local solid waste requirements apply to any petroleum-contaminated soil removed from the site. See Subsection 4.7 of this guidance for additional discussion of handling of investigative wastes.

KEY POINT: GEOMEMBRANES

Geomembranes are thick sheets of plastic used to contain liquids. Geomembranes are made of a wide variety of materials. Always check with the manufacturer for compatibility with your particular application. Site-specific compatibility testing by exposing the geomembrane to the particular petroleum products present at a site may need to be done if inadequate information is available.

The thickness of geomembranes is typically specified in mils, or thousandths of an inch. Most geomembranes used in waste containment applications are 20 to 60 mils thick. Some are reinforced with a grid of threads imbedded in the geomembrane (scrim-reinforced). Some geomembranes will break down with extended exposure to sunlight, a consideration in long-term cover applications.

The Geosynthetic Institute, http://www.geosynthetic-institute.org/, is a useful source for information on geomembranes.

Long-term Containment or Storage (longer than three months)

Long-term storage applies to soils that are being held for longer than three months for treatment or storage prior to treatment. Long term on-site storage of contaminated soil may be subject to local health department solid waste regulations. State and local solid waste requirements apply to any petroleum-contaminated soil removed from the site. The following guidelines, developed in consultation with Ecology's Waste to Resources Program, are intended to supplement these regulations.

The goal of containment is to prevent further releases to the environment. The storage area should consist of a bermed area that is lined with a relatively impervious material such as cement, a geomembrane compatible with hydrocarbons, or native clay. The storage area should be located away from excavated pits or steep natural slopes to minimize potential slope failure. Where insufficient space is available to locate a storage facility away from a slope, a slope failure analysis should be conducted to determine safe loading conditions. The liner and underlying foundation soils should be designed to handle the loading of the soil being stored plus any equipment that will be used to place the soil. Three types of liners that are commonly used, and some common construction considerations for their use are:

- Pavement. For cement, any cracks that could allow leakage should be sealed with a petroleum compatible caulk. Most asphalt is relatively permeable and not compatible with petroleum products, and thus asphalt is not recommended as a liner for petroleum contaminated soils. However, both cement and asphalt in good condition can be a suitable subsurface for a geomembrane liner.
- Geomembranes. Use at least a 20 mil scrim-reinforced geomembrane material that is resistant to petroleum. The surface under the geomembrane should be free of any sticks, debris, or rocks greater than ½ inch in size to minimize the potential for punctures. If equipment will drive on the geomembrane, the geomembrane should be protected by covering it with at least a 12-inch protective layer of sand free of rocks, sticks and debris.
- Soils. For liners constructed with native silts or clay, a compacted 12-inch lift (permeability less than 1×10^{-6} cm/sec) should be suitable for light to moderate contamination. For heavily contaminated soils, increase the liner thickness to two feet. If an in-situ native silt or clay is being used, scarify and recompact the soil to the desired lift thickness to ensure any channels or cracks are disrupted.

Berms should be constructed around soil storage areas to prevent runoff of free liquids, to separate the storage area from stormwater, and to physically confine the material. Berms can be straw bales, mounded soil, wooden shoring, concrete blocks, or any material that will create a physical barrier. These berms should be covered with a geomembrane if there is any chance of leachate migration through the berms. Long, narrow containment beds are recommended as these beds are easier to cover and maintain and material can be loaded into them without driving into the storage area.

The containment bed should be covered to: 1) minimize releases of windblown dust or hydrocarbon fumes to the air, 2) minimize leachate generation and contaminated runoff, and 3) control moisture levels for subsequent treatment or disposal. Covers typically consist of a geomembrane, shed-type roof, or enclosed structure. If an enclosed structure is used, it should be well ventilated to prevent vapors from accumulating to minimize the chance of a fire or explosion.

When containment will extend into the wetter months of the year (October through February), a leachate collection system should be installed. A leachate collection system typically consists of a liner and drainage layer of coarse sand sloped at a minimum of 2-5% to direct runoff and infiltration to a collection trench that subsequently drains to a sump. The leachate can then be pumped from the sump and reapplied to the pile or removed for treatment/disposal. Runoff controls should be checked (especially prior to, during, and after storm events) to ensure they are operating properly. Any excess leachate needs to be characterized and disposed of in accordance with all applicable local, state, and federal laws. Surface impoundments and tanks holding leachate-contaminated water may be subject to solid waste permit requirements. Check with the local health department/district for specific regulatory requirements.

11.3.3 Transportation of Contaminated Material

Transportation of contaminated soil or water to another location for disposal or treatment often occurs for one or more of the following reasons:

- Material could cause a threat to human health or the environment if treated on site
- Treatability studies will be conducted at another location
- Material is being transported to a landfill or regional treatment facility
- It is more convenient to treat the material at another site

It is critical that no further release to the environment occurs during transport and subsequent treatment. For soil, the requirements in WAC 173-350-300, collection and transportation standards for solid waste, apply. Details on collection and transportation standards, such as no littering or spilling material, covering trucks, and inspecting and cleaning equipment are specified in this rule. Unless the local health department states otherwise, they should be notified when contaminated soils are planned to be moved off site. Receipts documenting off-site treatment/disposal should be retained by the person responsible for the cleanup (typically the owner/operator or their environmental consultant).

11.3.4 Maintenance and Operation

Many storage or treatment systems are well designed and installed, but poorly operated and maintained. Proper operation and maintenance is as important to the effectiveness of the treatment system as the design. A plan describing these activities should be prepared. Frequent, regular checks should be made of the storage area to ensure that no further releases occur and that all equipment and containment systems are properly operating. In particular, checks should be made immediately before, during, and after high winds or heavy rainfall. One person should be assigned the responsibility for ensuring that these checks are made and to keep a log of these activities. Environmental consultants and contractors that fail to properly operate and maintain storage or treatment facilities may be subject to fines under the local solid waste regulations and could become a potentially liable person under MTCA (as an operator).

11.4 Technical Factors to Consider When Selecting a Remedy

In addition to regulatory requirements, a number of technical factors need to be considered and evaluated in the initial screening and subsequent remedy selection. These factors should be addressed during the remedial investigation, thereby resulting in a more focused and less expensive remedy selection process.

These critical factors can be grouped into three main categories: site characteristics, soil characteristics, and contaminant characteristics. [40]

11.4.1 Site Characteristics

There are numerous site characteristics that can influence the practicality and effectiveness of remedial technologies. Major factors to consider include:

Site topography: Many petroleum-contaminated sites are developed properties that are relatively flat. However, if contamination has migrated out of the developed area, there may be steep slopes with contamination. These slopes may constrain the cleanup methods that can be used at the site. A detailed topographic map of the contaminated area and likely staging areas should be prepared prior to remedy selection.

Site surface and subsurface structures and utilities: The location of surface and subsurface structures and utilities may constrain the cleanup methods if these structures or utilities cannot be demolished or relocated. All above-ground and underground utilities and structures should be

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[40] Most of this discussion is a summary of information in *How to Evaluate Alternative Cleanup Technologies for Underground Storage Tank Sites: A Guide for Corrective Action Plan Reviewers (EPA 510-B-95-007),* and associated references. See http://www.epa.gov/ust/how-evaluate-alternative-cleanup-technologies-underground-storage-tank-sites-guide-corrective.

located and identified on a site map. For utilities, contact the utility company to find out the cost and practicality of relocation if this is anticipated. Any proposed redevelopment plans should be reviewed to identify current and future structures and utilities.

Site size: The physical size of the property may also affect the practicality of applying some remedial technologies to a site. Some technologies will require substantial land surface for staging and handling of materials. Constraints imposed by operating businesses should be identified and noted.

Depth to groundwater and flow direction: The depth to groundwater is an important factor when choosing between remedial alternatives for soil remediation within the vadose zone (soil above the groundwater). For example, in-situ remedies such as soil vapor extraction and bioventing are usually not considered viable options for sites with shallow groundwater (generally less than 3 feet). Shallow vapor extraction and bioventing systems have a problem with short-circuiting of ambient air into the system, reducing their effectiveness. The vacuum created by these systems may also cause upwelling of shallow groundwater, plugging soil pores and preventing air movement.

It is important to characterize both the horizontal and vertical components of groundwater flow as part of the remedial investigation. This is necessary to determine where to place monitoring wells to monitor treatment performance.

11.4.2 Soil Characteristics

In Washington State, soil texture can vary greatly within a short distance. The effectiveness of most remedial technologies is greatly affected by the type of soil. Important hydraulic properties, such as permeability and water holding capacity, are related to soil type. Even subtle differences in soil texture can make major differences in these properties. Reliance on generic references for soil properties, such as permeability estimates from grain size, is discouraged as this can often lead to erroneous conclusions. Test and document soil properties during the remedial investigation to minimize potential for such error. Suggested properties include:

Grain size: Samples of soil from each major soil horizon should be tested for grain size and classified using the Unified Soil Classification System.

Total organic carbon: High organic carbon content increases the adsorption of petroleum compounds, resulting in a reduction of solubility and volatilization of these compounds. This can adversely affect the effectiveness of remedies such as soil vapor extraction and soil washing. High organic content may also exert an excessive oxygen demand, inhibiting bioremediation and chemical oxidation.

Soil pH: Soil pH affects many treatment technologies. Extreme pH ranges can affect microbial diversity and activity in bioremediation processes. A pH between 6 and 8 is normally required to sustain microbial growth.

Soil moisture: Soil moisture impacts the effectiveness of many remedial technologies. For example, high soil moisture may hinder the movement of air through the soil in vacuum extraction systems, and may cause excavation and soil transport problems. High soil moisture also affects thermal treatment by increasing energy requirements, thereby increasing costs. In contrast, biological treatment processes need moist soil to work well.

Soil temperature: Soil temperature is an important factor in controlling microbial activity and the rate of organic contaminant degradation. The optimal temperature range for microbial activity responsible for the biodegradation of petroleum hydrocarbon is 50–113 ^{o}F (10–45 ^{o}C). Soil temperature also affects vapor extraction by influencing the rate of volatilization of compounds from the soil, with higher soil temperatures resulting in more volatilization. While the below ground temperature remains fairly constant, controlling temperature can be particularly important for above ground soil treatment technologies. Special efforts may be needed to control soil pile temperature during colder seasons, such as by constructing an enclosed structure around the soil pile, insulating the soil pile, or preheating air introduced into the soil pile to enhance biodegradation.

Soil permeability: Soil permeability is a measure of soil’s ability to transmit air and vapors. It is an important factor in controlling the effectiveness of in-situ treatment technologies. Low permeability greatly reduces the ability of soil-flushing fluids (e.g., water, steam, solvents) to contact and remove contaminants. Low permeability can also inhibit vapor extraction and bioventing processes. Similarly, conveyance of nutrient solutions, used to accelerate in-situ bioremediation, may be hindered in low-permeability soils. Variations in the permeability of different soil layers can also affect these processes.

11.4.3 Contaminant Characteristics

The characteristics of the petroleum product and contaminant location can greatly influence the suitability of available remedial technologies at a site. Factors that should be evaluated and considered during the remedy selection process include:

Extent of contamination: The vertical and aerial extent of contamination should be defined. This information is needed to identify practical remediation alternatives and estimate the cost of cleanup.

Contaminant concentration: Average and maximum concentrations of contaminants should be considered in the selection of a remedy. Very high concentrations of petroleum hydrocarbons and other constituents can be toxic to microorganisms responsible for biodegradation and may impede their growth. Petroleum saturated soils may require treatment to eliminate free liquids prior to disposal.

Depth of contaminant: The depth of contamination can greatly impact the cost of remediation. This impact can be very significant for technologies where excavation of contaminated soil is required. The maximum practical depth of excavation depends on the type of equipment, whether shoring is required, and depth to groundwater (shallow groundwater will often require installation of a dewatering system). Whatever method of excavation is used, the cost per unit volume typically becomes much higher at depths greater than 20 to 25 feet.

Contaminant biodegradability: Biodegradability of a compound is a measure of its ability to be metabolized by microorganisms through microbial respiration. Generally, petroleum products and most of their components are biodegradable. Degradation is most rapid when adequate oxygen, moisture, and nutrients are present. This does not mean that biodegradation will not occur if optimum conditions aren't present (such as under anaerobic conditions), however, the rate of biodegradation will be much slower.

Contaminant volatility: Volatility is the tendency of a compound to vaporize from the liquid phase or soil-adsorbed phase to the vapor phase. It is the physical basis for the successful application of remedial technologies that involve contaminant mass transfer to the vapor phase, such as soil vapor extraction and air stripping. Vapor pressure is the most important factor that contributes to volatility. Compounds with high vapor pressures (> 0.5 mm Hg), and therefore high volatility, are generally considered amenable to removal by soil vapor extraction and air stripping. Other indicators of volatility are boiling point and the Henry's constant. Compounds with boiling points less than 572 ^{o}F (300 ^{o}C) or a Henry's Constant greater than 100 atmospheres are generally considered amenable to removal by soil vapor extraction and air stripping. [41]

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[41] Wisconsin Department of Natural Resources (DNR). 1993. *Guidance for Design, Installation and Operation of Soil Venting Systems*. Madison, WI: Emergency and Remedial Response Section. PUB-RR-185. June 2002 update. Available at: http://dnr.wi.gov/files/PDF/pubs/rr/RR185.pdf.

11.5 Cost Evaluations

The cost to implement a remedial alternative is a major factor to consider in remedy selection. In general, remediation costs are site-specific and based on factors such as: site characteristics; soil and contaminant characteristics; the type and number of chemical analyses required; the targeted cleanup standards; and any long-term actions required. Costs can generally be categorized as capital costs, annual operation and maintenance (O&M) costs, and periodic costs. Examples of elements for the various types of costs are listed in Table 11.1:

Capital costs: Capital costs consist primarily of one-time costs incurred at the beginning of a project. This includes all labor, equipment, and material costs associated with construction and installation of the remedial action. Capital costs also include expenditures for professional and technical services that are necessary to support construction of the remedial action.

Annual operation and maintenance (O&M) costs: O&M costs are recurring expenditures that are necessary to ensure or verify the continued effectiveness of a remedial action. These costs are usually estimated on an annual basis.

Annual O&M costs include all labor, equipment, and material costs that are associated with the operation and maintenance of extraction, containment, and treatment systems, and related activities such as monitoring and disposal. Annual O&M costs also include expenditures for professional and technical services necessary to support O&M activities, and overhead costs such as permit fees, insurance and contingencies.

Periodic costs: Periodic costs are expenditures that occur only once every few years or only once during the entire O&M period or remedial timeframe (such as site closeout costs). These costs may be either capital or O&M costs, but are typically considered separately from other capital or O&M costs in the estimating process because of their periodic nature. For example, the design life of major components of the cleanup action (such as caps and treatment equipment) should be estimated and the cost of replacement or repair included as periodic cost. So too should periodic review and reporting costs be estimated.

Total Costs: Estimated total costs are typically determined by adding the capital costs, net present value of annual operation and maintenance costs, net present value of periodic costs, and any contingency costs associated with unforeseen difficulties or unanticipated conditions impossible to evaluate from existing data. The basis for the project duration and discount rate used in the net present value analysis should be documented. If a present worth analysis is used for future costs, a conservative (low) rate of return should be assumed, and construction costs adjusted for inflation using an appropriate construction cost index. [42]

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[42] A suggested source for a conservative rate of return is Appendix C of OMB Circular A-92 and for construction cost inflation is the *Engineering News Record* construction cost inflation index. These indices can be found at: https://www.whitehouse.gov/omb/circulars_a094/a94_appx-c and http://www.economics.nrcs.usda.gov/cost/priceindexes/index.html and http://www.enr.com/economics.

Table 11.1 Elements of a Cost Evaluation		
Capital Cost	**Annual O&M Cost**	**Periodic Cost**
Professional/Technical Services	**Professional/Technical Services**	**Professional/Technical Services**
• Project Management • Remedial Design • Construction Management • Institutional controls	• Project Management • Technical Support • Institutional controls	• Performance & Optimization Studies • Periodic Reviews (for sites with institutional controls)
Construction Activities	**O&M Activities**	**Construction & O&M Activities**
• Mobilization/Demobilization • Demolition & Removal • Testing & Analysis • Site Preparation • Construction/Excavation • Equipment and Installation • Well Drilling • Startup • Off-site treatment/Disposal • Contingency	• Inspections, Monitoring, Sampling & Analysis • Operation & Maintenance • Off-site Treatment/Disposal • Contingency	• Remedy component replacement costs • All relevant activities listed under construction and O&M

Table 11.1 Elements of a cost evaluation.

11.6 Institutional Controls/Environmental Covenants

MTCA requires institutional controls be put in place that limit or prohibit activities that may interfere with the integrity of a remedy or that may result in exposure to contamination that has been left behind after a cleanup (typically under a building or engineered cap). Typically these take the form of an environmental covenant that is placed on the property title. Under WAC 173-340-440(4) institutional controls are required whenever:

- The cleanup level is established under Method A or B and contamination remains on the property above these cleanup levels after remediation
- A Method C cleanup level is used
- An industrial soil cleanup level is used
- The groundwater cleanup level is based on other than a drinking water standard
- A conditional point of compliance is used
- Any time an institutional control is required to protect plants animals and soil biota under WAC 173-340-7490 through 7494 (terrestrial ecological risk protection)
- Where Ecology determines that such controls are necessary to assure the continued protection of human health and the environment or the integrity of the cleanup

Environmental covenants commonly address the following issues:

- Restricting changes in use of a property from industrial or commercial use if these land uses have been assumed in the development of cleanup standards or selecting a remedy
- Protection and maintenance of a cap when one is used to limit exposure to residual soil contamination or minimize infiltration
- Limiting where stormwater infiltration facilities can be built to avoid enhanced leaching of soil contamination or interference with a groundwater containment or treatment system
- Requirements for vapor control systems to be installed and maintained to protect persons living or working in nearby structures
- Limits on drilling of water supply wells or using dewatering systems to prevent exposure to residual groundwater contamination
- Provisions protecting monitoring devices (monitoring wells, vapor probes) from damage

Ecology has prepared *Procedure 440A, Establishing Environmental Covenants under the Model Toxis Control Act*, available at http://www.ecy.wa.gov/programs/tcp/policies/tcppoly.html, to guide the establishment of environmental covenants under MTCA and the Uniform Environmental Covenants Act, Chapter 64, 70 RCW.

11.7 Technologies for the Cleanup of Petroleum-Contaminated Sites

Remedial technologies commonly used at petroleum-contaminated sites are compiled in Table 11.2. **Please note that this list is not all-inclusive and does not preclude the use of other remedial technologies.** Numerous websites, publications and journal articles are available discussing the merits and limitations of various cleanup technologies. Users should refer to these other sources when selecting an appropriate technology for a site. A good place to start is:

How to Evaluate Alternative Cleanup Technologies for Underground Storage Tank Sites: A Guide for Corrective Action Plan Reviewers (EPA 510-R-04-002), available at http://www.epa.gov/ust/how-evaluate-alternative-cleanup-technologies-underground-storage-tank-sites-guide-corrective.

Soil Vapor Extraction and Bioventing. EM 1110-1-4001, U.S. Army Corps of Engineers. June 2002. Available at: http://www.publications.usace.army.mil/Portals/76/Publications/EngineerManuals/EM_1110-1-4001.pdf.

Table 11.2 Commonly Used Technologies for the Cleanup of Petroleum-Contaminated Sites

Soil	Free Product	Groundwater
Soil Excavation • Off-site Disposal • Landfarming	Skimming Systems	Enhanced Bioremediation • Groundwater Circulation • Peroxide Injection • Air/Oxygen Injection
Thermal Desorption	Dual-Phase Recovery	Air Sparging with Soil Vapor Extraction
Soil Vapor Extraction	Bioslurper	
Bioventing		

Table 11.2 Commonly used technologies for the cleanup of petroleum-contaminated sites.

11.8 Cleanup Documentation

Whatever method of cleanup is implemented, it is important to prepare a report that documents all aspects of the cleanup. This should include at least the following information:

- Record drawings indicating areas cleaned up, areas with contamination remaining above cleanup levels and areas with caps and other structures.
- All soil, groundwater and construction materials test data and interpretive analysis.
- Labeled photographs documenting the cleanup construction and final site condition.
- All legal documents such as environmental covenants, records of waste disposal and documentation of compliance with permits.

- Other information as required by the approved plans and specifications, permits and Ecology approvals.
- Under WAC 173-340-400(6)(b)(ii) cleanup documentation must be accompanied by an opinion by a professional engineer, based on testing results and inspections, as to whether the cleanup has been conducted in substantial compliance with the plans and specifications and related documents. The cleanup of minor soil contamination may be accompanied by a statement from an experienced environmental professional.

11.9 Model Remedies

To help streamline and accelerate the pace of cleanups, Ecology is developing standardized cleanup methods called "model remedies." Model remedies are intended to help speed up the selection of cleanup actions that protect human health and the environment, with a preference for permanent solutions to the maximum extent practicable.

In response to 2013 legislative changes to the Model Toxics Control Act (MTCA), Ecology has developed seven model remedies for sites with petroleum-contaminated soils, and is developing additional model remedies for sites with groundwater impacts from petroleum.

Advantages to using model remedies can be substantial. If a site meets the eligibility criteria and individual provisions for a particular model remedy, that cleanup method can be selected and implemented. Once the requirements for using a model remedy are met, it is not necessary to conduct a Feasibility Study or Disproportionate Cost Analysis. In addition, Ecology has the authority to waive fees for providing a written opinion on the cleanup if the facility qualifies for, and appropriately uses, a model remedy.

Model remedies are most appropriate for routine cleanup projects at lower-risk sites, and are generally more applicable to independent cleanups. This includes cleanups conducted by those seeking a No Further Action (NFA) letter under the Voluntary Cleanup Program (VCP) or situations where the potentially liable person (PLP) is implementing the cleanup with no Ecology oversight. However, these model remedies can also apply to Ecology-supervised cleanups.

For more information, see:

Model Remedies for Sites with Petroleum Contaminated Soils, Ecology Publication Number 15-09-043: https://fortress.wa.gov/ecy/publications/SummaryPages/1509043.html

Ecology expects to develop more model remedies for sites with groundwater impacts from petroleum. For updates, visit TCP's MTCA Model Remedies website at http://www.ecy.wa.gov/programs/tcp/policies/model-remedies/index.html

12.0 Re-use of Petroleum-Contaminated Soils

Ecology recognizes that cleanup of petroleum-contaminated sites is expensive. Landfilling contaminated soils and associated transportation costs greatly increase cleanup costs and contribute to greenhouse gas production. Heavily contaminated soils must be properly treated or disposed of at a facility permitted to accept these soils to ensure that human health and the environment remain protected. However, for moderately or lightly contaminated soils, or soils with most of the contamination removed by treatment, a number of alternatives exist.

Under Washington State's solid waste and hazardous waste laws, one of the highest priorities for managing waste is to recycle or reuse waste materials. MTCA also states that remedial actions should provide for permanent solutions to the maximum extent practical. Consistent with these statutory priorities, Ecology offers guidelines for best management practices in this section to facilitate the productive reuse of petroleum-contaminated soils generated by petroleum-contaminated site cleanups. Soils managed consistently with these guidelines will most likely be protective of human health and the environment based on Ecology's past experience. Soils with contaminants other than petroleum-related are not addressed by these guidelines and these guidelines should not be used for these soils.

Petroleum-contaminated soils are considered solid waste and, as such, are regulated by local health departments/districts. Some local health departments/districts may require a permit for reuse of these soils or have more restrictive reuse regulations. Use of petroleum-contaminated soils in public rights of way or easements is typically controlled by the local public works department or the Washington State Department of Transportation (for State highways). Use of these soils may also be subject to local land-use laws and shoreline regulations. The appropriate agencies should be consulted before reusing the soil in accordance with these guidelines.

Petroleum-contaminated soils generated by the cleanup of regulated UST facilities are exempt from most of the dangerous waste management requirements under WAC 173-303-071(3)(t). But other types of petroleum-contaminated soil are not exempt. While the values in Table 12.1 are generally well below concentrations that are likely to trigger regulation of the soil as a hazardous waste, even a soil that has low contaminant levels may still be a regulated hazardous waste if the soil was classified as a hazardous waste prior to treatment or contains a listed waste. Consult with Ecology's Hazardous Waste & Toxics Reduction Program in these cases. For more information see http://www.ecy.wa.gov/programs/hwtr/index.html.

The general guidance in this section should not be construed as an endorsement of the reuse of any particular soils or a guarantee that any particular soils can be safely reused. All reuse decisions need to be made in the context of the individual site in compliance with all applicable laws. This section does not override state or local regulatory requirements. Furthermore, reuse of petroleum-contaminated soils consistent with this section does not relieve any party of any resulting liability, including but not limited to MTCA liability, common law liability for nuisance conditions or a reduction in property value caused by aesthetic issues like odors, should a subsequent problem arise.

Persons may propose another site-specific basis for the reuse of petroleum-contaminated soil. This will require detailed site-specific characterization of the soil composition and variability (including testing for equivalent carbon fractions) and bioassays. A risk assessment evaluating all potential exposure pathways would also need to be conducted. This information will need to be submitted to Ecology's Waste 2 Resources Program and the local Health Department/District.

12.1 Factors Considered in the Development of Soil Re-use Categories

Table 12.1 provides recommended categories for reuse of petroleum contaminated soils. These values are based on evaluation of multiple potential exposure pathways and other considerations. Several values in Table 12.1 are more stringent than the Method A MTCA soil cleanup levels. There are several reasons for this:

- The solid waste handling standards, Chapter 173-350 WAC, apply to soils containing "harmful substances" removed during a cleanup. As noted below, petroleum-contaminated soils can cause harm in ways not considered under the MTCA Method A cleanup levels.
- For a variety of reasons, the Method A table values do not consider all potential exposure pathways and assume exposure conditions that may not be protective at all sites. For example, under Method A the soil is assumed to not impact surface water and terrestrial ecological risk is addressed separately. Under MTCA, Ecology has the authority to require more stringent cleanup levels than the Method A values on a site-specific basis. It is not practical to apply that level of site-specific judgment to reuse.
- Cleanup sites are typically cleaned to concentrations below the Method A cleanup levels to ensure the cleanup levels are met. However, the reuse categories set maximum not-to-exceed concentrations. Thus, for a given concentration, a soil reused under these guidelines is likely to have a higher TPH concentration than soil remaining after cleanup.
- At cleanup sites, it is possible to find out if the site was once contaminated through a site assessment or review of historical uses and cleanup records. However, because soil meeting these reuse categories can be reused on uncontaminated properties, property owners and workers will most likely not have similar information available and thus are unlikely to take any precautions regarding exposure.
- There is no state-wide permitting process controlling where soils meeting the reuse categories are used or requiring institutional controls to limit exposures.
- More data is available now than was available when the Method A soil cleanup levels were developed. This data indicates there is considerable product variability which has been taken into account in developing these reuse categories.
- PCB-contaminated soils are not recommended for any reuse because of the persistence, toxicity and bioaccumulation potential of these compounds. This is consistent with Ecology's approach to regulation of these chemical mixtures under other authorities.

12.2 How to Determine Compliance with Soil Re-use Categories

Soils proposed for reuse should be tested for the parameters specified in Table 12.1, consistent with Table 7.2 for the product being cleaned up. The frequency of testing should be consistent with Table 6.9 for stockpiled soil, with the volume consisting of the amount of soil planned for reuse in any given reuse project, or a suitable alternative sampling plan submitted to the local regulatory agency for approval. To conform with these reuse categories, no sample should exceed the recommended values. If one or more samples exceed the recommended values, Ecology recommends that portion of the soil represented by that test result be separated from the other soil and appropriately disposed of. Soil samples bracketing the area should be taken to confirm whether the remainder of the soil qualifies for the selected category.

12.3 Soil Re-use Categories

Table 12.1 identifies four categories for re-use of petroleum contaminated soil. Table 12.2 describes uses and limitations for the four categories of soil. The footnotes to Table 12.1 are considered part of this Table and must be considered when reusing soils as specified in these tables.

While it is expected most petroleum contaminated soils will have been subjected to treatment prior to reuse, this is not a prerequisite for use of these guidelines. It may be possible, for example, through careful field screening using the methods described in Section 5 and segregation during excavation, to separate soils on the outer fringe of contamination or above the release that are only slighted contaminated. These soils may meet a particular soil reuse category without treatment.

Table 12.1 Guidelines for Reuse of Petroleum-Contaminated Soil

Parameter	**Analytical Method**	**Soil Category (8)(9)(10)**			
		1 No detectable Petroleum Components (mg/kg)	**2 Commercial Fill Above Water Table (mg/kg)**	**3 Paving Base Material & Road Construction (mg/kg)**	**4 Landfill Daily Cover or Asphalt Manufacturing (mg/kg)**
Total Petroleum Hydrocarbons (1)(2) See Table 7.1 for petroleum products that fall within these categories.					
Gasoline Range Organics	NWTPH-Gx	<5	5 - 30	>30 - 100	>100
Diesel Range Organics	NWTPH-Dx	<25	25 - 200	>200 - 500	>500
Heavy Fuels and Oils*	NWTPH-Dx	<100	100 - 200	>200 – 500	>500
Mineral Oil	NWTPH-Dx	<100	100 - 200	>200 – 500	>500
Volatile Petroleum Components					
Benzene	SW8260B	<0.005	0.005 - 0.03	0.03 or less	See Table 12.2
Ethylbenzene	SW8260B	<0.005	0.005 - 6	6 or less	>6
Toluene	SW8260B	<0.005	0.005 - 7	7 or less	>7
Xylenes **(3)**	SW8260B	<0.015	0.015 - 9	9 or less	>9
Fuel Additives & Blending Components					
(MTBE) Methyl Tert-Butyl Ether	SW8260B	<0.005	0.005 - 0.1	0.1 or less	>0.1
Lead	SW6010A	<17	17 - 50	>50 - 220	See Table 12.2
Other Petroleum Components					
Polychlorinated **(4)** Biphenyls (PCBs)	SW8082	<0.04	<0.04	<0.04	See Table 12.2
Naphthalenes **(5)**	SW8260B	<0.05	0.05 - 5	5 or less	>5
cPAHs **(6)**	SW8270C	<0.05	0.05 - 0.1	>0.1 - 2	>2
Other Petroleum Characteristics (Applies to soils contaminated with any petroleum product.)					
Odors	Smell	No detectable odor			
Staining	Visual	No unusual color or staining			
Sheen Test	See Footnote **# 7**	No visible sheen			

IMPORTANT: See Table 12.2 and the footnotes to this Table on the following pages!
Test soil for the parameters specified in Table 7.2.
****Does NOT include waste oil contaminated soils, which should be disposed of in a landfill.***
"<" means less than; ">" means greater than

Table 12.1 Guidelines for reuse of petroleum-contaminated soil.

Table 12.2 Description and Recommended Best Management Practices for Soil Categories in Table 12.1 (continued next page)

Category	Acceptable Uses	Limitations
Category 1 Soils: Soils with no detectable/ quantifiable levels of petroleum hydrocarbons or constituents using the analytical methods listed in Table 7.3 and are not suspected of being contaminated with any other hazardous substances.	• Can be used anywhere the use is allowed under other regulations. • Any use allowed for Category 2, 3 & 4 soils.	• These soils should be odor-free.
Category 2 Soils: Soils with residual levels of petroleum hydrocarbons that could have adverse impacts on the environment in some circumstances.	• Any use allowed for Category 3 & 4 soils. • Backfill at cleanup sites above the water table. • Fill in commercial or industrial areas above the water table. • Road and bridge embankment construction in areas above the water table.	• These soils may have a slight petroleum odor, depending on the sensitivity of the individual. This should be considered when reusing these soils. • Should be placed above the highest anticipated high water table. If seasonal groundwater elevation information is not available, place at least 10 feet above the current water table. • Should not be placed within 100 feet of any private drinking water well or within the 10 year wellhead protection area of a public water supply well. • Should not be placed in or directly adjacent to wetlands or surface water where contact with water is possible. • Should not be placed under a surface water infiltration facility or septic drain field. • Any other limitations in state or local regulations.
Category 3 Soils: Soils with moderate levels of residual petroleum contamination that could have adverse impacts on the environment unless re-used in carefully controlled situations.	• Any use allowed for Category 4 soils. • Use as pavement base material under public and private paved streets and roads. • Use as pavement base material under commercial and industrial parking lots.	• Should be placed above the highest anticipated high water table. If seasonal ground water elevation information is not available, place at least 10 feet above the water table. • Should be a maximum of 2 feet thick to minimize potential for leaching or vapor impacts. • Should not be placed within 100 feet of any private drinking water well or within the 10 year wellhead protection area of a public water supply well. • Should not be placed in or directly adjacent to wetlands or surface water. • Should not be placed under a surface water infiltration facility or septic drain field. • When exposed, runoff from area in use should be contained or treated to prevent entrance to storm drains, surface water or wetlands. • Any other limitations in state or local regulations.

Table 12.2 Description and recommended best management practices for soil categories in Table 12.1 (continued next page).

Table 12.2 (continued) Description and Recommended Best Management Practices for Soil Categories in Table 12.1

Category	Acceptable Uses	Limitations
<u>Category 4 Soils:</u> Soils with high levels of petroleum contamination that should not be re-used except in very limited circumstances.	• Use in the manufacture of asphalt. • Use as daily cover in a lined municipal solid waste or limited purpose landfill provided this is allowed under the landfill operating permit.	**<u>Landfill Limitations:</u>** The soil should be tested for and pass the following tests: ➢ Free liquids test. Soils that contain free liquids cannot be landfilled without treatment. ➢ TCLP for lead and benzene. Unless exempt under WAC 173-303-071(3)(t), soils that fail a TCLP for lead or benzene must be disposed of as hazardous waste. ➢ Flammability test. Soils that fail this test must be disposed of as hazardous waste. ➢ Bioassay test under WAC 173-303-100(5). Soils that fail this test must be disposed of as hazardous waste. ➢ PCBs. Soils with a total PCB content of 2 ppm or more must be disposed of as hazardous waste. Soil used for daily cover should be stockpiled within the landfill lined fill area. Soil containing more than 10,000 mg/kg TPH should be buried immediately with other wastes or daily covered to limit potential worker exposure. Any additional limitations specified in the landfill permit or in other state or local regulations. **<u>Asphalt Manufacturing Limitations:</u>** Soil storage areas should be contained in a bermed area to minimize contact with surface water runoff from adjacent areas. Runoff from storage areas should be considered contaminated until tested to prove otherwise. Soil storage areas should also be lined and covered with a roof or secured tarp to minimize contact with precipitation and potential groundwater contamination. Leachate from storage areas should be considered contaminated until tested to prove otherwise. The soil should be tested for and pass the following tests: ➢ TCLP for lead and benzene. Unless exempt under WAC 173-303-071(3)(t), soils that fail a TCLP for lead or benzene must be disposed of as hazardous waste. ➢ Flammability test. Soils that fail this test must be disposed of as hazardous waste. ➢ Bioassay test under WAC 173-303-100(5). Soils that fail this test must be disposed of as hazardous waste. ➢ No detectable levels of PCBs in soil (<0.04 mg/kg). Precautions should be taken to minimize worker exposure to soil storage piles and any dust or vapors from these piles prior to feeding into the asphalt batch plant.

IMPORTANT: See the following page for additional information!

Notes to Table 12.1:

Contaminated soils can be treated to achieve these concentrations but dilution with clean soil to achieve these concentrations is a violation of Washington State solid and hazardous waste laws.

(1) See Table 7.1 for a description of what products fall within these general categories. If the product released is unknown, use the limitations for gasoline range organics. If the soil is contaminated from releases from more than one product, use the limitations for both products. For example, if the release is a mixture of gasoline and diesel, the soil should be tested for components of both gas and diesel and the limitations for both fuels and their components used.

(2) The concentrations for diesel, heavy oil and mineral oil are not additive. Use the TPH product category most closely representing the TPH mixture and apply the limitations for that product to the mixture. ***The reuse of waste oil contaminated soil is not allowed due to the wide variety of contaminants likely to be present.***

(3) Value is total of m, o, & p xylenes.

(4) Value is the total of all PCBs. Only heavy oil and mineral oil contaminated soils need to be tested for PCBs. Soil contaminated with a spill from a regulated PCB containing device must be disposed of in a TSCA permitted landfill, regardless of the PCB concentration. Other PCB contaminated soils may be disposed of in a municipal solid waste landfill permitted to receive such materials, provided the concentration does not exceed 2 ppm PCBs (WAC 173-303-9904).

(5) Value is total of naphthalene, 1-methyl naphthalene and 2-methyl naphthalene. Only diesel and heavy oil contaminated soils need to be tested for naphthalenes.

(6) The value is the benzo(a)pyrene equivalent concentration of the following seven cPAHs. See Appendix C for how to calculate a toxic equivalent concentration. The seven cPAHs are as follows: benz(a)anthracene; benzo(b)fluoranthene; benzo(k)fluoranthene; benzo(a)pyrene; chrysene; dibenz(a,h)anthracene; and, indeno(1,2,3-cd)pyrene. Only diesel and heavy oil contaminated soils need to be tested for cPAHs. Soils contaminated with more than 1% polycyclic aromatic hydrocarbons, as that term is defined in WAC 173-303-040 (which is more expansive than the above list), must be disposed of as hazardous waste.

(7) No visible sheen observed on water when approximately one tablespoon of soil placed in approximately ½ liter of water held in a shallow pan (like a gold pan or similar container).

(8) A soil in a lower category can be used for uses specified in any higher category. This means that:

- A category 1 soil can be used for any use specified in categories 1, 2, 3 and 4.
- A category 2 soil can be used for any use specified in categories 2, 3 and 4.
- A categories 3 soil can be used for any use specified in categories 3 and 4.

(9) ***If an environmental site assessment or soil or groundwater analyses indicate contaminants other than common petroleum constituents and naturally occurring levels of metals are likely to be present in the soil of interest at the site (for example, solvents or pesticides), do not reuse the soil.*** The soil should instead be treated using appropriate technology to address all contaminants or landfilled at a solid waste or hazardous waste facility permitted to receive these materials.

(10) Soils in categories 2, 3 and 4 should be stockpiled consistent with the soil storage recommendations in Subsection 11.3 of this guidance.

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(See also Subsection 1.7 in this guidance, "Other Publications and Resources.")

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Appendix A:

Site Characterization Report Contents

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Appendix A: Site Characterization Report Contents

The following information should typically be included in a report on a petroleum-contaminated site remedial investigation. The information does not need to be provided in this exact order. The scope of this information will vary from site to site. This list should not be read as an exclusive list of requirements. Where the information is not relevant to the site, there is no need to include it. At the time of publication of this guidance (June 2016), Ecology was in the process of creating a checklist for remedial investigation reports. In addition to the information presented here, consult that checklist for guidance on the expected contents of a remedial investigation report. Visit Toxics Cleanup Program's web page, "Checklists and Template for Plans and Report" at: http://www.ecy.wa.gov/programs/tcp/policies/checklists.html

1. **Cover letter.** Include a letter describing the document and requested action, if any, by Ecology.

2. **Number of copies.** Provide three copies of the plan or report to the department's office responsible for the facility. The department may require additional copies to meet public participation and interagency coordination needs.

3. **Visuals.** Maps, figures, photographs, and tables to clarify information or conclusions must be legible. All maps, plan sheets, drawings, and cross-sections must meet the following requirements: (from WAC 173-340-840)

   (a) To facilitate filing and handling, be on paper no larger than 24 x 36 inches and no smaller than 8-1/2 x 11 inches. Photo-reduced copies of plan sheets may be submitted provided at least one full-sized copy of the photo-reduced sheets are included in the submittal.

   (b) Identify and use appropriate and consistent scales to show all required details in sufficient clarity.

   (c) Be numbered, titled, have a legend of all symbols used, and specify drafting or origination dates.

   (d) Contain a north arrow.

   (e) Use United States Geological Survey datum (NGVD88) as a basis for all elevations.

   (f) For planimetric views, show a survey grid based on monuments established in the field and referenced to state plane coordinates. This requirement does not apply to conceptual diagrams or sketches when the exact location of items shown is not needed to convey the necessary information.

   (g) For excavation and grading plans, show original topography in the background, in addition to showing the changed site topography.

(h) For cross-sections, identify the location and be cross-referenced to the appropriate planimetric view. A reduced diagram of a cross-section location map shall be included on the sheets with the cross-sections.

4. **Sampling Data.** All sampling data must be submitted in both printed form and entered into Ecology's Environmental Information Management (EIM) system. For more information on Ecology's data submittal requirements, see Ecology Policy 840 http://www.ecy.wa.gov/programs/tcp/policies/tcppoly.html

5. **General Facility Information**

(a) Site address. For rural areas--location by township & range, section, quarter.

(b) Current owner and operator of the facility and contact information (address & phone number).

(c) Chronological listing of previous owners and operators of the facility, the timeframe of their involvement with the facility and contact information, to the extent known.

(d) Environmental consultants, legal counsel and other contacts for the facility.

(e) Tax parcel number.

(f) Facility industrial classification number.

(g) Federal, state and local permits pertaining to the facility.

(h) For sites with underground or above ground storage tanks (both current and previously removed tanks):

(i) Location, capacity, dimensions and material.

(ii) Date of installation, name of installer (if known).

(iii) Products stored (both current and historical)

(iv) Leak detection system(s), results of any leak testing, records of previous leaks and description of any repairs completed.

(v) Corrosion protection systems.

(vi) Anchoring system.

(vii) For underground storage tanks--regulatory status (active, closed, temporarily closed). If the tank was closed, method of closure and closure date (removed, filled with sand).

(iv) Description of connecting piping and dispensing systems including, location, diameter, materials, valves and flex connectors.

6. **Regional Site Conditions Maps**.

(a) A zoning map for the facility and the area within ¼ mile.

(b) A 7.5-minute USGS map of the facility and the area within ¼ mile.

(c) Public and private wells within a 1-mile radius.

(d) A recent available air photo of the facility and the area within ¼ mile.

(e) If the facility has significantly changed configuration over the years of operation, available historic air photos and maps or sketches illustrating these changes.

7. **Existing Site Conditions Map.** This should encompass all areas where contamination has come to be located and sufficient adjacent areas to provide context. The scale of this map should be sufficient to show site features with clarity. Use multiple maps with different scales, if necessary. It should illustrate the following features:

   (a) Property boundaries.

   (b) Surface topography.

   (c) Paved and vegetated areas.

   (d) Buildings and other surface structures.

   (e) Subsurface structures such as USTs.

   (f) For all above ground and below ground tanks show tanks and connecting piping, anchor systems, corrosion protection system, leak detection system and other relevant features.

   (g) Underground utilities including water, sewer, storm sewers, power and cable.

   (h) Surface water infiltration facilities—ponds, drywells, galleries.

   (i) Wells, borings and other sampling locations.

   (j) Surface water bodies, wetlands, drainage ditches and other surface drainage features.

8. **Land Use.** Summarize existing land uses for the site and surrounding area and uses allowed under the current zoning and comprehensive plan for the nearby area. Include extracts of text from local land use codes in the report appendix. Discuss any proposed zoning changes and development proposals for the site and nearby area. Use maps as appropriate.

9. **Site Geology and Soils.** Provide a description of the site geologic conditions as inferred from soil borings, test pits or other information. Discuss this information in the context of available information on regional geologic and soil conditions. Use maps and cross-sections as appropriate.

10. **Hydrology.** Describe topography and surface water, wetland and drainage features of the site and nearby areas. Discuss this information in the context of available regional information on surface drainage basins and patterns. Use maps as appropriate.

11. **Hydrogeology.** Describe site groundwater conditions, including depth to groundwater, groundwater gradients (vertical and horizontal) and direction of flow. Describe groundwater aquifers and water supplies. Discuss this information in the context of available information on regional hydrogeologic conditions. Use maps and cross-sections as appropriate.

12. **Sampling Plan.** Provide a summary of sampling events. Include rational for sampling locations, sampling methods, preservation and transport procedures, analytical methods and quality assurance/quality control data.

13. **Contamination Description.**

    (a) Summary table(s) of analytical data

    (b) Provide maps showing the horizontal extent of soil and groundwater contamination. Highlight areas of NAPL. It is often helpful to present multiple views illustrating the data different ways (multiple contaminants on the same map and/or changes in contaminant concentrations over time). Isoconcentration lines superimposed over concentration data can help visualize impacted areas.

    (c) Provide a series of geologic cross-sections passing through selected borings and wells. These cross sections should illustrate existing topography, boring and well locations, soil layers, water levels, areas with NAPL, free-product thickness and contaminant concentration data. Again, multiple views may be helpful in visualizing impacted areas.

    (d) Where multiple readings have been taken over time, plot contaminant concentrations versus water level elevation. Significant differences with water elevation may indicate the presence of a smear zone that has not be adequately characterized.

    (e) Provide an estimate of the volume of contaminated soil and groundwater and an estimate of the mass of contaminant present.

    (f) Discuss any natural or man-made features that may affect the spread of contamination.

14. **Natural Resources and Ecological Receptors.** Present information describing the natural resources and ecological receptors of the site and nearby areas. Include documentation supporting the terrestrial ecological evaluation.

15. **Exposure Pathways Description.** Describe current, actual exposure pathways. Describe potential future exposure pathways using the reasonable maximum exposure routes required by MTCA.

16. **Cleanup Levels.** Determine the concentrations necessary to be protective of human health and the environment for actual and potential future exposure pathways and media of concern. (see Section 8 for additional guidance on establishing cleanup levels).

17. **Investigative Waste Management.** Describe how wastes generated by site investigations were managed, including description of any on-site and off-site storage, treatment and disposal arrangements.

18. **Interim Actions Conducted.** If any interim cleanup actions were conducted during the course of the investigation, provide a description of these actions, who conducted these actions and the fate of contaminated materials generated by these actions. For example, UST tanks and piping systems removed, stockpiled soil, vapor extraction systems, free-

product removal systems, and treatment or disposal methods used for contaminated materials.

19. **Conclusions/Recommendations.** Provide a summary of the extent of contamination defined by site investigations, recommendations for additional assessment and recommendations for potential future remedial actions.

20. **Appendices.** Include information relied upon in preparation of the submittal and that will facilitate the review. This should include, for example:

    (a) References with complete citation

    (b) Well and boring logs

    (c) Field test results and observations

    (d) Laboratory data sheets

    (e) Chain of custody forms

    (f) Quality assurance/quality control reports

    (g) Sampling plan (if not previously submitted)

    (h) Copies of relevant permits

    (i) Calculations such as slug test calculations, volume and mass of contamination estimates

    (j) Photographs of site

    (k) Tank tightness testing records

    (l) Treatment or disposal receipts

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Appendix B:

Remedy Selection under the Model Toxics Control Act

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Appendix B: Remedy Selection under the Model Toxics Control Act

The following is a description of the recommended process for identifying, screening and evaluating alternatives for cleaning up a site. See Figure 350-1 for a visual depiction of this process.

Step 1. **Remedial Action Goals.** Identify the goals expected to be achieved by the cleanup, in addition to compliance with MTCA.

Step 2. **Identify Alternatives.** Identify alternatives that address all areas of the site where cleanup levels have been exceeded and for all relevant exposure pathways. The alternatives must provide for protection of human health and the environment (including, as appropriate, aquatic and terrestrial ecological receptors) by eliminating, reducing or otherwise controlling risks posed through each exposure pathway and migration route.

(A) Evaluate a reasonable number and type of alternatives, taking into account the characteristics and complexity of the site, including current site conditions and physical constraints.

(B) Include at least one permanent cleanup action alternative. This will serve as the baseline against which other alternatives shall be evaluated against for the purpose of determining whether an alternative is permanent to the maximum extent practicable. The most practicable permanent cleanup action alternative shall be included.

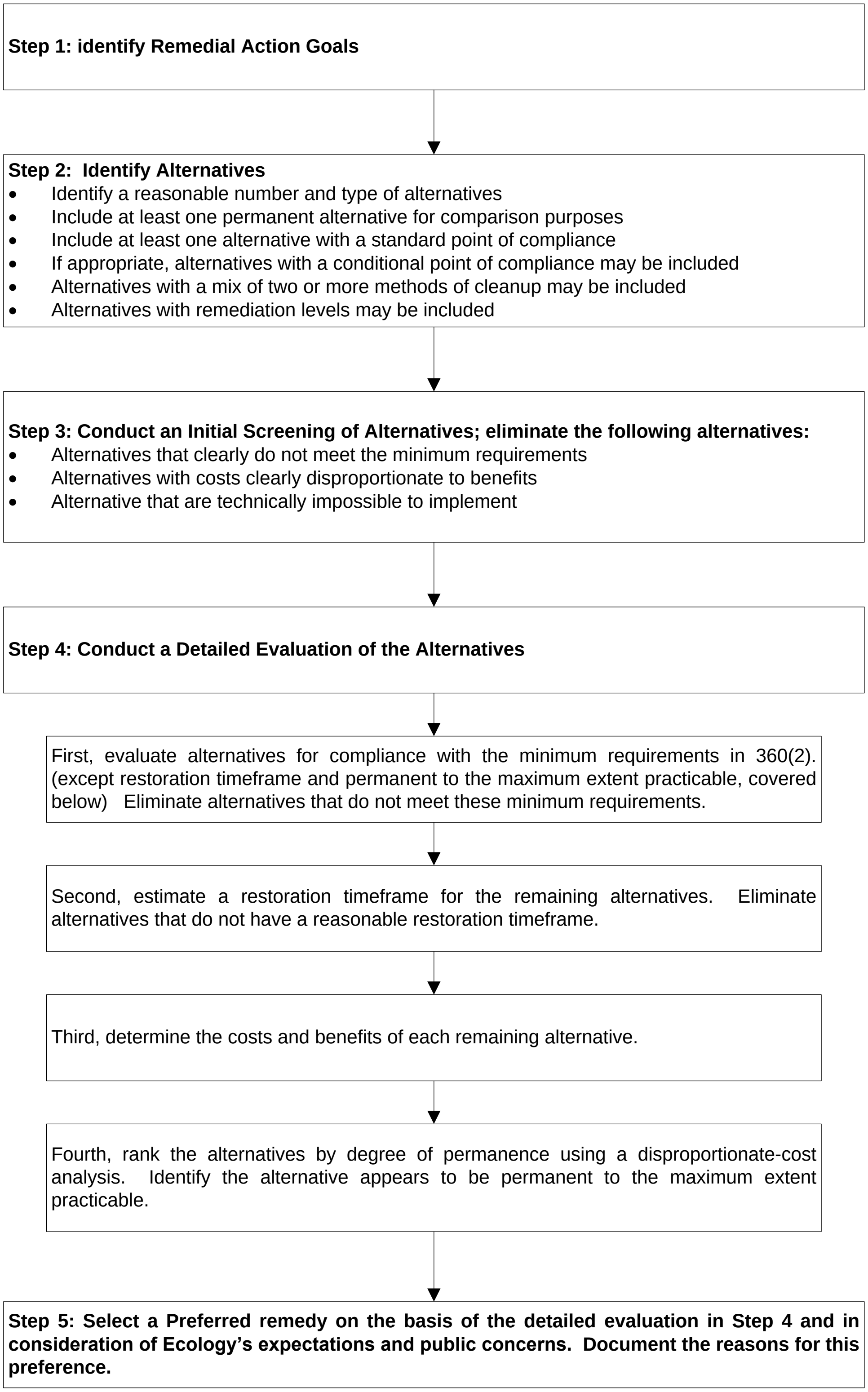
(C) Sites requiring an environmental impact statement and federal cleanup law sites must include a no action alternative.

(D) Include alternatives that use a standard point of compliance for each environmental medium. Where appropriate, alternatives with conditional points of compliance can also be included.

(E) Alternatives can be included that consist of a mix of cleanup action components. For example, an alternative that consists of treating the areas of highest soil concentration and off-site disposal of the remaining contaminated soil.

(F) Alternatives can also include remediation levels to define when particular cleanup action components will be used. For example, in the preceding example in (E), the concentration determining which soils are treated versus which are disposed of would be considered a remediation level. The basis for this concentration, such as technology limits or human health risk, would need to be explained in the feasibility report. See WAC 173-340-355 for additional discussion of remediation levels.

Appendix B. Figure 350-1 Remedy selection process under WAC 173-340-350.



Step 1: identify Remedial Action Goals

Step 2: Identify Alternatives

- Identify a reasonable number and type of alternatives
- Include at least one permanent alternative for comparison purposes
- Include at least one alternative with a standard point of compliance
- If appropriate, alternatives with a conditional point of compliance may be included
- Alternatives with a mix of two or more methods of cleanup may be included
- Alternatives with remediation levels may be included

Step 3: Conduct an Initial Screening of Alternatives; eliminate the following alternatives:

- Alternatives that clearly do not meet the minimum requirements
- Alternatives with costs clearly disproportionate to benefits
- Alternative that are technically impossible to implement

Step 4: Conduct a Detailed Evaluation of the Alternatives

First, evaluate alternatives for compliance with the minimum requirements in 360(2). (except restoration timeframe and permanent to the maximum extent practicable, covered below) Eliminate alternatives that do not meet these minimum requirements.

Second, estimate a restoration timeframe for the remaining alternatives. Eliminate alternatives that do not have a reasonable restoration timeframe.

Third, determine the costs and benefits of each remaining alternative.

Fourth, rank the alternatives by degree of permanence using a disproportionate-cost analysis. Identify the alternative appears to be permanent to the maximum extent practicable.

Step 5: Select a Preferred remedy on the basis of the detailed evaluation in Step 4 and in consideration of Ecology's expectations and public concerns. Document the reasons for this preference.

Step 3. **Initial Screening of Alternatives.** Where appropriate, screen alternatives to reduce the number of alternatives for the final detailed evaluation. For sites conducting a feasibility study under an order or decree, the department makes the final determination of which alternatives must be evaluated in detail in the feasibility study. The following cleanup action alternatives or components may be eliminated from the feasibility study:

(A) Alternatives that, based on a preliminary analysis, so clearly do not meet the minimum requirements specified in WAC 173-340-360 that a more detailed analysis is unnecessary.

(B) Alternatives for which costs are clearly disproportionate under WAC 173-340-360(4); and

(C) Alternatives or components that are not technically possible at the site.

Step 4. **Detailed Evaluation of Alternatives.** Next, conduct a detailed evaluation of each alternative not eliminated under step 3. Use the criteria specified in WAC 173-340-360 and the following procedure:

(A) First, evaluate whether each alternative meets all of the minimum requirements in WAC 173-340-360(2), except the restoration time frame and the permanent to the maximum extent practicable requirements (which are evaluated later). Drop out alternatives that do not meet the minimum requirements.

(B) Second, estimate a restoration time frame for each alternative and describe the basis for this estimate. Then evaluate the reasonableness of this time frame using the criteria in WAC 173-340-360(4). When sufficient information exists, eliminate alternatives that do not provide for a reasonable restoration time frame. [43]

(C) Third, determine the costs and benefits of each alternative using the evaluation criteria in WAC 173-340-360(3).

(D) Fourth, conduct the disproportionate-cost analysis specified in WAC 176-340-360(3). Rank the alternatives by the degree to which they are permanent to the maximum extent practicable using the criteria in WAC 176-340-360.

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[43] In some cases it will not be possible to determine what a reasonable restoration timeframe is until the disproportionate-cost analysis has been completed. In these cases, the alternatives should be carried through the full evaluation process and the restoration timeframe and permanence evaluation conducted concurrently.

Step 5. Select a Remedy. On the basis of the detailed evaluation in step 4, and in consideration of the expectations in WAC 173-340-370 and known public concerns, propose a preferred remedy.

Feasibility Study Content. The following information should typically be included in a feasibility study for a petroleum-contaminated site. The information does not need to be provided in this exact order. The scope of this information will vary from site to site. This list should not be read as an exclusive list of requirements. Where the information is not relevant to the site, there is no need to include it. At the time of publication of this guidance (June 2016), Ecology was in the process of creating a checklist for feasibility study reports. In addition to the information presented here, consult that checklist for guidance on the expected contents of a feasibility study report. Visit Toxics Cleanup Program's web page, "Checklists and Template for Plans and Report" at: http://www.ecy.wa.gov/programs/tcp/policies/checklists.html

1. A summary of the findings from the remedial investigation, updated with the latest information including:
    - Conceptual site model;
    - Applicable local, state and federal laws;
    - Preliminary cleanup levels for indicator hazardous substances in each affected medium;
    - The proposed point of compliance for each affected medium; and,
    - Maps, cross-sections, and appropriate calculations illustrating the location, estimated amount and concentration distribution of hazardous substances above proposed cleanup levels for each affected medium.
2. Results of any additional investigations conducted since completion of the remedial investigation;
3. The results of any treatability studies conducted to refine proposed alternatives;
4. Remedial action goals identified in step 1 of the feasibility study;
5. Alternatives identified in step 2 of the feasibility study;
6. Alternatives eliminated in the step 3 initial screening process and the basis for elimination;
7. Documentation of the detailed evaluation process in step 4 of the feasibility study. For each alternative evaluated in detail include:
    - The location and estimated amount of each contaminant to be removed or treated by the alternative and the estimated time frame in which removal or treatment will occur;

    - The location, estimated amount and projected concentration distribution of each contaminant remaining on site above proposed cleanup levels after implementation of the alternative;
8. The proposed preferred remedy (step 5) and the basis for this selection;

9. Applicable local, state and federal laws specific to the proposed preferred remedy, including a description of permit/approval conditions identified in consultation with the permitting agencies;
10. A completed environmental checklist for the proposed preferred remedy and other information needed to make a threshold determination; and
11. Other relevant information, such as:
    - Information necessary to integrate the remedial investigation/feasibility study with an environmental impact statement (see WAC 197-11-262).
    - Treatability and pilot studies needed to develop and evaluate cleanup action alternatives for a site.

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Appendix C: Evaluating the Human Health Toxicity of Carcinogenic PAHs (cPAHs) Using Toxicity Equivalency Factors (TEFs)

The attached memo (Implementation Memorandum #10) was published separately as Ecology Publication No. 15-09-049 on April 20, 2015.

The memo can also be found on Ecology's Publications website at: https://fortress.wa.gov/ecy/publications/SummaryPages/1509049.html

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DEPARTMENT OF
ECOLOGY
State of Washington

Evaluating the Human Health Toxicity of Carcinogenic PAHs (cPAHs) Using Toxicity Equivalency Factors (TEFs)

Implementation Memorandum #10

To: Interested Persons

From: Jeff Johnston, Manager
Information and Policy Section
Toxics Cleanup Program

Date: April 20, 2015

Purpose of this Memorandum

This implementation memorandum describes the procedures for evaluating compliance of environmental samples containing carcinogenic polycyclic aromatic hydrocarbon (cPAH) mixtures using toxicity equivalency factors (TEFs) to estimate human health toxicity, as required by WAC 173-340-708(8)(e) in the Model Toxics Control Act (MTCA) rule.

Introduction

WAC 173-340-200 defines cPAHs as the polycyclic aromatic hydrocarbons identified as Group A (known human) or B (probable human) carcinogens by the U.S. Environmental Protection Agency (EPA). For petroleum-contaminated sites, these include at a minimum: benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene. [1]

The Washington State Department of Ecology (Ecology) uses TEFs to evaluate the toxicity and assess the risks for environmental mixtures of dioxins and furans, dioxin-like polychlorinated biphenyls, and cPAHs. The TEF method used in MTCA is based on a concept developed by the

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[1] Ecology may also require inclusion of the additional cPAHs in Table 708-3 in WAC 173-340-900 if site testing data or information from other comparable sites or waste types indicates the additional compounds are potentially present at the site. As of the date of this guidance, Ecology has not required inclusion of these additional cPAHs at contaminated sites.

EPA. The method evaluates the toxicity and assesses the risks of a mixture of structurally-related chemicals that cause the same human health effect through the same biological process or "mechanism of action" (in this case, cancer triggered by the cPAH binding to the same molecular receptor in the cell). [2]

A TEF is an estimate of the toxicity of a chemical relative to that of a **reference chemical.** For mixtures of cPAHs, the reference chemical is **benzo(a)pyrene.** Benzo(a)pyrene was chosen as the reference chemical because its toxicity is well characterized. Thus, the TEF for each cPAH is an estimate of that cPAH's toxicity relative to that of benzo(a)pyrene.

The policies and procedures described in this memo for applying TEFs to cPAHs are intended to provide guidance for implementing WAC 173-340-708(8)(e) in the Model Toxics Control Act (MTCA) rule which requires that:

- Mixtures of cPAHs be considered a single hazardous substance when establishing and determining compliance with cleanup levels. This means that a target cancer risk level of one in one million (1 X 10^{-6}) is used for the whole mixture when calculating cleanup levels under Method B, and one in one hundred thousand (1 X 10^{-5}) under Method C.
- The TEFs in Table 708-2 (and Table 708-3, if applicable) be used to evaluate the toxicity of these mixtures.
- The physical-chemical properties of individual cPAHs be used when evaluating cross-media impacts such as leaching of cPAHs from soil to groundwater.

Although there are toxicity values available in EPA's IRIS database for some cPAHs, the MTCA rule requires that TEFs be used when determining compliance with cleanup levels for cPAH mixtures. The cPAHs at a minimum that must be analyzed for and included in the calculations, and their respective TEFs, are listed in Table 1.

Table 1. Toxicity equivalency factors (TEFs) for the minimum required carcinogenic polycyclic aromatic hydrocarbons under WAC 173- 340-708(e) (from Table 708-2 in WAC 173-340-900)

CAS Number	cPAH	TEF (Unitless)
50-32-8	Benzo(a)pyrene	1
56-55-3	Benzo(a)anthracene	0.1
205-99-2	Benzo(b)fluoranthene	0.1
207-08-9	Benzo(k)fluoranthene	0.1
218-01-9	Chrysene	0.01
53-70-3	Dibenz(a,h)anthracene	0.1
193-39-5	Indeno(1,2,3-cd)pyrene	0.1

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[2] EPA uses the term "Relative Potency Factor" for cPAHs. See: *Development of a Relative Potency Factor (RPF) Approach for Polycyclic Aromatic Hydrocarbon (PAH) Mixtures*, EPA/635/R-08/012A, February, 2010 Review Draft.

Using TEFs to Evaluate the Human Health Toxicity of cPAH Mixtures

To evaluate the human health toxicity of a cPAH mixture, the chemical concentrations of the cPAHs in the mixture are converted to an equivalent concentration of benzo(a)pyrene. This calculation can be expressed mathematically, below. This formula applies to any medium, but is used most commonly for soil and groundwater samples. For notation purposes, the result is referred here as the "total toxic equivalent concentration" or "Total TEQ."

$$\text{Total TEQ} = \sum C_n * TEF_n$$

Where:

Total TEQ = Total Toxic Equivalent Concentration of a cPAH mixture [3]
C_n = Concentration of the individual cPAH in the mixture
TEF_n = Toxicity equivalency factor for the individual cPAH in the mixture

The following steps describe how to determine the Total TEQ for a mixture of cPAHs in a sample, and how to use this value to evaluate compliance (see Examples 1 and 2):

1. Analyze the sample to determine the concentration of each cPAH.
2. Multiply each cPAH concentration in the sample by its corresponding TEF from Table 1, above. This provides a toxic equivalent concentration (TEQ) for each cPAH.
3. Add the products in step 2 to obtain the Total TEQ for the sample.
4. Either look up or calculate a cleanup level for benzo(a)pyrene for the medium of concern (e.g. groundwater or soil). [4]
5. To evaluate compliance, compare the Total TEQ for the sample with the applicable cleanup level for benzo(a)pyrene for the medium being sampled (e.g. soil or groundwater).

Evaluating the Potential for cPAH Mixtures in Soil to Impact Groundwater

When evaluating the potential for cPAH mixtures in soil to impact groundwater, the MTCA rule requires that the physical and chemical properties of individual carcinogenic cPAHs be considered (WAC 173-340-708(8)(e)(iv)). This adds complexity to the above calculation

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[3] EPA calls this the "Total Toxicity Equivalence".

[4] Either use a) the Method A cleanup level in Table 720-1 for groundwater, and Tables 740-1 or 745-1 for soil (as appropriate); or b) determine cleanup levels using the equations in MTCA sections 720, 740, or 745. See Ecology's CLARC tables for pre-calculated Method B and C concentrations for groundwater. Because MTCA requires that the soil ingestion AND dermal pathways be evaluated for petroleum mixtures, the soil direct contact value for cPAHs must be calculated using Equations 740-5 (for unrestricted land use) or 745-5 (for industrial land use). These values are not in CLARC and must be calculated using the equations. See Tables 6 and 7 for the results of these calculations using default assumptions.

because both the toxicity and mobility of the individual cPAHs must be considered when determining compliance. There are three ways this can be done:

1. Use the MTCATPH spreadsheet to derive a soil concentration protective of groundwater.
2. Calculate a simplified total "toxic mobility equivalent concentration" that considers both the TEF (for toxicity) and the organic carbon-water partitioning coefficient (Koc) (for mobility) of each cPAH.
3. Use other methods authorized by WAC 173-340-747, such as using a different leaching model or conducting an empirical demonstration. [5]

This approach is typically needed for soil samples at sites with cleanup levels based on industrial land use *because concentrations derived that are protective for the direct contact exposure pathway for industrial land use may not be low enough to be protective of groundwater.*

Method 1: Using the MTCATPH Spreadsheet

To evaluate the potential for cPAH mixtures in soil to cause unacceptable risks in groundwater using the MTCATPH spreadsheet, enter the cPAH data into the spreadsheet and a value of zero for the petroleum fractions and other petroleum compounds. Use the spreadsheet to evaluate if the sample will cause the groundwater to exceed the level of risk acceptable under MTCA. The spreadsheet already factors in the TEFs and relative mobility of the individual cPAHs.

The output from the spreadsheet will be a statement as to whether the sample "passes" (is protective of groundwater) or "fails" (is not protective). Another function on the spreadsheet can be used to back-calculate a soil concentration for the cPAH mixture that would be protective of groundwater.

This spreadsheet and instructions for its use can be found at:
http://www.ecy.wa.gov/programs/tcp/tools/toolmain.html

Method 2: Calculating a Total Toxic Mobility Equivalent Concentration

Another method that can be used to evaluate the potential for cPAH mixtures in soil to impact groundwater is to convert the cPAH mixture to an equivalent concentration of benzo(a)pyrene that accounts for both the toxicity and mobility of the individual cPAH compounds relative to benzo(a)pyrene.

Under this method, the mobility of a cPAH relative to benzo(a)pyrene can be approximated by dividing the Koc for benzo(a)pyrene by the Koc for the cPAH of interest. This "relative mobility factor" can then be used to assess the mobility of individual cPAHs and cPAH mixtures. Relative mobility factors for the cPAHs that must be analyzed for and included in the calculation

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[5] These methods are beyond the scope of this memo. Ecology is currently preparing separate guidance on empirical demonstrations.

are presented in Table 3.

The calculation to convert the chemical concentrations in a cPAH mixture to an equivalent concentration of benzo(a)pyrene that factors in both the toxicity and leaching mobility of the individual cPAHs can be expressed mathematically as follows. For notation purposes, the result is referred here as the "total toxic mobility equivalent concentration" or "Total TMEQ."

Total TMEQ = $\sum C_n * TEF_n * RMF_n$

Where:

Total TMEQ = Total Toxic Mobility Equivalent Concentration
C_n = Concentration of the individual cPAH in the mixture
TEF_n = Toxic equivalency factor for the individual cPAH in the mixture (from Table 1)
RMF_n = Relative mobility factor for the individual cPAH in the mixture (from Table 2)

Table 2. Relative mobility factors for the minimum required carcinogenic polycyclic aromatic hydrocarbons under WAC 173- 340-708(e)

CAS #	cPAH	Koc [6]	Relative Mobility Factor
50-32-8	Benzo(a)pyrene	968,774	1.00
56-55-3	Benzo(a)anthracene	357,537	2.71
205-99-2	Benzo(b) fluoranthene	1,230,000	0.79
207-08-9	Benzo(k) fluoranthene	1,230,000	0.79
218-01-9	Chrysene	398,000	2.43
53-70-3	Dibenz(a,h)anthracene	1,789,101	0.54
207-08-9	Indeno(1,2,3-cd)pyrene	3,470,000	0.28

Koc = Organic carbon – water partitioning coefficient
Relative mobility factor = Benzo(a)pyrene Koc / cPAH Koc

The following steps describe how to determine the Total TMEQ for mixtures of cPAHs, and how to use this value to evaluate compliance (see Examples 3, 4, and 5):

1. Analyze the sample to determine the concentration of each cPAH.
2. Multiply each cPAH concentration in the sample by its corresponding TEF from Table 1 (above) and its corresponding relative mobility factor from Table 2 (above). This calculates a toxic mobility equivalent concentration (TMEQ) for each cPAH.
3. Add the products in Step 2 to obtain the Total TMEQ for the cPAH mixture.
4. Either look up or calculate a cleanup level for benzo(a)pyrene that is protective of

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[6] Source: Koc's for benzo(a)pyrene, benzo(a)anthracene and dibenzo(a,h)anthracene are from Table 747-1 in WAC 173-340-920; the remainder are from the MTCATPH 11 workbook.

groundwater through the leaching pathway.[7]

5. To evaluate compliance for the sample, compare the Total TMEQ for the cPAH mixture with the soil concentration protective of groundwater for benzo(a)pyrene.

How to Handle Non-Detected Values in Total TEQ and Total TMEQ Calculations

The cleanup levels for cPAHs are quite low. This may require using sensitive analytical methods such as EPA Method 8270 SIM to minimize the number of non-detected values. However, even with this method, there may be several non-detected values in samples at a site. If so, use the following as guidance for handling these non-detected values in these calculations.

If an analytical method with detection limits acceptable to Ecology has been used, and one or more of the cPAHs has never been detected in any sample at the site, then a value of zero may be assigned to the concentration of that cPAH for these calculations.

If a cPAH is not detected in a sample but has been detected at the site, there are a variety of methods that can be used to enable these calculations. The easiest method is to assign a value of one-half the detection limit (or one-half the reporting limit, if the detection limit is not provided) to that cPAH when conducting these calculations. However, for data sets with a large number of nondetects (e.g., greater than 50 percent), this may skew the calculations. In this case, consider consulting with a statistician on alternative methods for handling nondetects.[8]

Examples Illustrating These Calculations

The following examples illustrate these calculations.

Example 1: Evaluating Compliance with Method A Unrestricted Land Use Soil Cleanup Levels

Consider a residential site where the soil is contaminated with a mixture of cPAHs and the soil cleanup level is based on Method A for unrestricted land use. Based on this scenario, use the following steps to evaluate whether the cPAH concentrations in a soil sample exceed the Method A soil cleanup level for cPAH mixtures. Measured soil concentrations and calculations referred to in the following steps are presented in Table 3, below.

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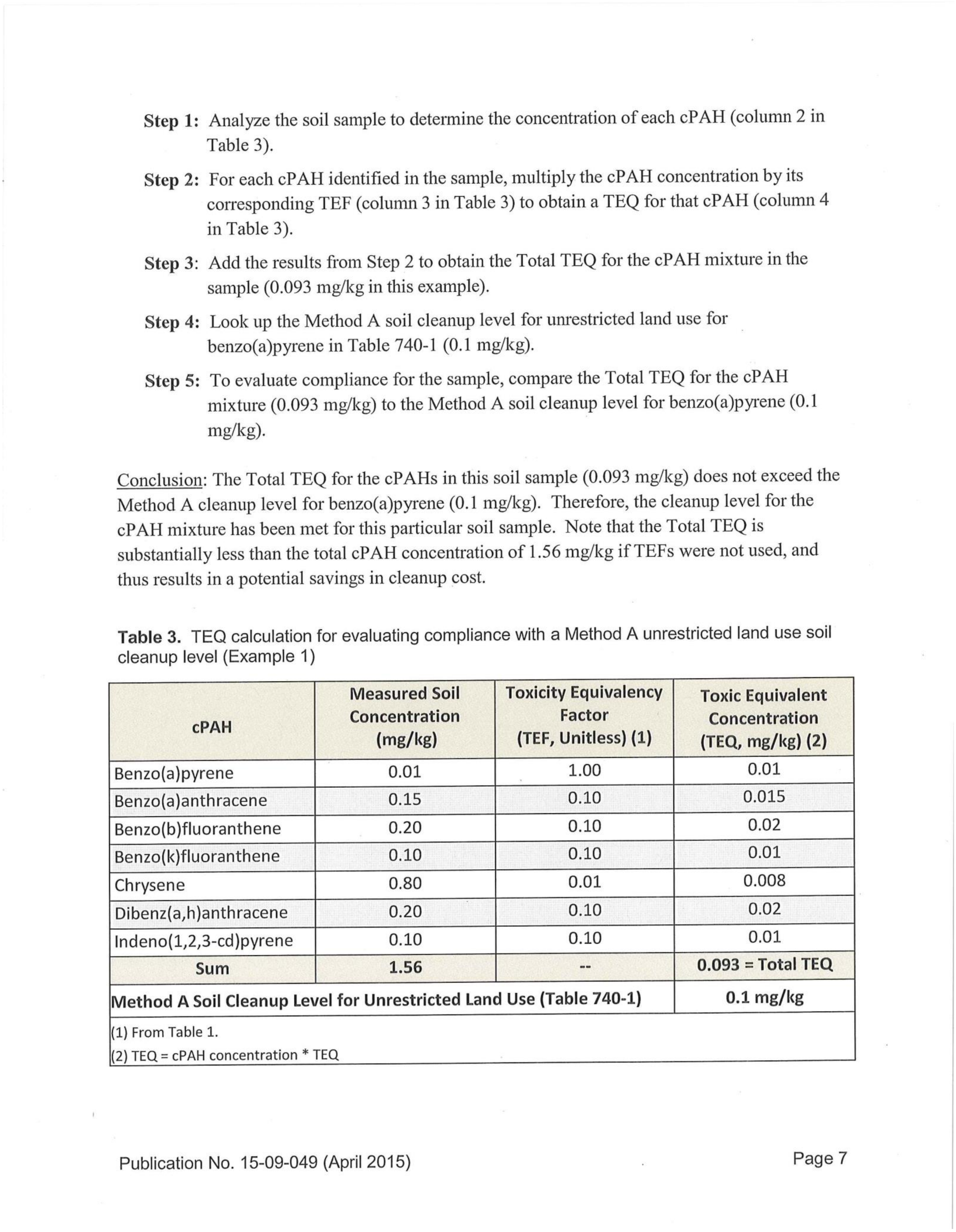
[7] Lookup value in Ecology's CLARC tables for a soil concentration of benzo(a)pyrene that is protective of groundwater, or calculate a site-specific concentration using equation 747-1 or the MTCASGL spreadsheet (3 phase model).

[8] See also EPA's statistical guidance for handling non-detects. For example, see EPA's statistical guidance (Pro UCL) http://www.epa.gov/osp/hstl/tsc/software.htm and EPA Region 3 *Guidance on Handling Chemical Concentration Data near the Detection Limit in Risk Assessments.* http://www.epa.gov/reg3hwmd/risk/human/info/guide3.htm



Step 1: Analyze the soil sample to determine the concentration of each cPAH (column 2 in Table 3).

Step 2: For each cPAH identified in the sample, multiply the cPAH concentration by its corresponding TEF (column 3 in Table 3) to obtain a TEQ for that cPAH (column 4 in Table 3).

Step 3: Add the results from Step 2 to obtain the Total TEQ for the cPAH mixture in the sample (0.093 mg/kg in this example).

Step 4: Look up the Method A soil cleanup level for unrestricted land use for benzo(a)pyrene in Table 740-1 (0.1 mg/kg).

Step 5: To evaluate compliance for the sample, compare the Total TEQ for the cPAH mixture (0.093 mg/kg) to the Method A soil cleanup level for benzo(a)pyrene (0.1 mg/kg).

Conclusion: The Total TEQ for the cPAHs in this soil sample (0.093 mg/kg) does not exceed the Method A cleanup level for benzo(a)pyrene (0.1 mg/kg). Therefore, the cleanup level for the cPAH mixture has been met for this particular soil sample. Note that the Total TEQ is substantially less than the total cPAH concentration of 1.56 mg/kg if TEFs were not used, and thus results in a potential savings in cleanup cost.

Table 3. TEQ calculation for evaluating compliance with a Method A unrestricted land use soil cleanup level (Example 1)

cPAH	**Measured Soil Concentration (mg/kg)**	**Toxicity Equivalency Factor (TEF, Unitless) (1)**	**Toxic Equivalent Concentration (TEQ, mg/kg) (2)**
Benzo(a)pyrene	0.01	1.00	0.01
Benzo(a)anthracene	0.15	0.10	0.015
Benzo(b)fluoranthene	0.20	0.10	0.02
Benzo(k)fluoranthene	0.10	0.10	0.01
Chrysene	0.80	0.01	0.008
Dibenz(a,h)anthracene	0.20	0.10	0.02
Indeno(1,2,3-cd)pyrene	0.10	0.10	0.01
Sum	**1.56**	**--**	**0.093 = Total TEQ**
Method A Soil Cleanup Level for Unrestricted Land Use (Table 740-1)			**0.1 mg/kg**

(1) From Table 1.
(2) TEQ = cPAH concentration * TEQ

Example 2: Evaluating Compliance with Method A Groundwater Cleanup Levels

Consider a cleanup site where the groundwater is contaminated with a mixture of cPAHs and the groundwater cleanup level is based on Method A. Based on this scenario, use the following steps to evaluate whether the cPAH concentrations in a groundwater sample exceed the Method A soil cleanup level for cPAH mixtures. Measured groundwater concentrations and calculations referred to in the following steps are presented in Table 4, below.

Step 1: Analyze the groundwater sample to determine the concentration of each cPAH (column 2 in Table 4)

Step 2: For each cPAH identified in the sample, multiply the cPAH concentration by its corresponding TEF (column 3 in Table 4) to obtain a TEQ for that cPAH (column 4 in Table 4).

Step 3: Add the results from Step 2 to obtain the Total TEQ for the cPAH mixture in the sample (0.044 ug/liter in this example).

Step 4: Look up the Method A groundwater cleanup level for for benzo(a)pyrene in Table 720-1 (0.1 ug/liter).

Step 5: To evaluate compliance for the sample, compare the Total TEQ for the cPAH mixture (0.044 ug/liter) to the Method A groundwater cleanup level for benzo(a)pyrene (0.1 ug/liter).

Conclusion: The Total TEQ for the cPAHs in this groundwater sample (0.044 ug/liter) does not exceed the Method A groundwater cleanup level for benzo(a)pyrene (0.1 ug/liter). Therefore, the cleanup level for the cPAH mixture has been met for this particular groundwater sample. Note that the Total TEQ is substantially less than the total cPAH concentration of 0.2 ug/liter if TEFs were not used, and thus results in a potential savings in cleanup cost.

Table 4. TEQ calculation for evaluating compliance with a Method A groundwater cleanup level (Example 2)

cPAH	Measured Groundwater Concentration (ug/liter)	Toxicity Equivalency Factor (TEF, Unitless) (1)	Toxic Equivalent Concentration (TEQ, ug/liter) (2)
Benzo(a)pyrene	0.03	1.00	0.03
Benzo(a)anthracene	0.04	0.10	0.004
Benzo(b)fluoranthene	0.03	0.10	0.003
Benzo(k)fluoranthene	0.03	0.10	0.003
Chrysene	0.05	0.01	0.0005
Dibenz(a,h)anthracene	0.01	0.10	0.001
Indeno(1,2,3-cd)pyrene	0.02	0.10	0.002
Sum	**0.2**	**--**	**0.044 = Total TEQ**
Method A Groundwater Cleanup Level (Table 720-1)			**0.1 ug/liter**

(1) From Table 1.

(2) TEQ = cPAH concentration * TEQ

Example 3: Evaluating Compliance with Method A Industrial Land Use Soil Cleanup Levels

Consider an industrial site where the soil is contaminated with a mixture of cPAHs and that soil cleanup level is based on the Method A industrial soil cleanup level. The footnote to the benzo(a)pyrene cleanup level in Table 745-1 indicates this cleanup level is based on protection of groundwater. So, both the toxicity and the mobility of the cPAH mixture must be considered when evaluating compliance with this cleanup level.

Based on this scenario, use the following steps to evaluate whether the cPAH concentrations in a soil sample exceed the Method A industrial soil cleanup level for cPAH mixtures. Measured soil concentrations and calculations referred in the following steps are presented in Table 5, below.

Step 1: Analyze the soil sample to determine the concentration of each cPAH (column 2 in Table 5).

Step 2: For each cPAH identified in the sample, multiply its soil concentration by its corresponding TEF (column 3 in Table 5) and relative mobility factor (column 4 in Table 5) to obtain a TMEQ for that cPAH (column 5 in Table 5).

Step 3: Add the results from Step 2 to obtain the Total TMEQ for the cPAH mixture (0.57 mg/kg in this example).

Step 4: Look up the Method A industrial soil cleanup level for benzo(a)pyrene in Table 745-1 (2.0 mg/kg).

Step 5: To evaluate compliance for the sample, compare the Total TMEQ for the cPAH mixture (0.57 mg/kg) with the Method A industrial soil cleanup level for benzo(a)pyrene (2.0 mg/kg).

Table 5. TMEQ Calculation for evaluating compliance with a Method A industrial land use soil cleanup level (Example 3)

cPAH	Measured Soil Concentration (mg/kg)	Toxicity Equivalency Factor (TEF) (Unitless) (1)	Relative Mobility Factor (RMF) (Unitless) (2)	Toxic Mobility Equivalent Concentration (mg/kg) (3)
Benzo(a)pyrene	0.2	1.0	1.00	0.2
Benzo(a)anthracene	0.5	0.1	2.71	0.14
Benzo(b)fluoranthene	0.7	0.1	0.79	0.06
Benzo(k)fluoranthene	0.6	0.1	0.79	0.05
Chrysene	2.2	0.01	2.43	0.05
Dibenz(a,h)anthracene	1.0	0.1	0.54	0.05
Indeno(1,2,3-cd)pyrene	0.8	0.1	0.28	0.02
Sum	**6.0**	--	--	**0.57 = Total TMEQ**
Method A Industrial Land Use Soil Cleanup Level for Benzo(a)pyrene (Table 745-1)				**2.0**

(1) From Table 1.
(2) From Table 2.
(3) TMEQ = cPAH concentration * TEF * RMF

Conclusion: The Total TMEQ for the cPAHs in this soil sample (0.57 mg/kg) does not exceed the Method A industrial soil cleanup level for benzo(a)pyrene (2.0 mg/kg). Therefore, the cleanup level for benzo(a)pyrene has been met for this particular soil sample. Note that the Total TMEQ is substantially less than the total cPAH concentration of 6.0 mg/kg, if TEFs and the relative mobility of the cPAHs were not considered, and thus results in a potential savings in cleanup cost.

Example 4: Evaluating Compliance with Method B Soil Cleanup Levels

When Method B is used to establish a soil cleanup level, it may not always be evident which exposure pathway—direct contact or soil leaching to groundwater—is the controlling exposure pathway for a soil sample (that is, whether a cPAH mixture concentration will be protective for direct contact while not protective for leaching because of differences in mobility among the cPAHs). This example is intended to illustrate one way to conduct this evaluation.

Consider a residential site where the soil is contaminated with a mixture of cPAHs and the soil cleanup level is based on Method B for unrestricted land use. In this example, the soil sample will be checked for compliance with the Method B soil concentrations protective of both the direct contact and soil leaching to groundwater exposure pathways.

Based on this scenario, use the following steps to evaluate compliance for a soil sample. Measured soil concentrations and calculations referred in the following steps are presented in Table 6, below.

Step 1: Analyze the soil sample to determine the concentration of each cPAH (column 2 in Table 6).

Step 2: For each cPAH identified in the sample, multiply the soil concentration by the applicable TEF (column 3 in Table 6) to obtain a TEQ for that cPAH (column 5 in Table 6).

Step 3: Add the results from step 2 to obtain the Total TEQ for the cPAH mixture (1.22 mg/kg in this example).

Step 4: For each cPAH identified in the sample, multiply the soil concentration by the applicable toxicity equivalency factor (column 3 in Table 6) and relative mobility factor (column 4 in Table 6) to obtain a toxic mobility equivalent concentration for that cPAH (column 6 in Table 6).

Step 5: Add the results from Step 4 to obtain the Total TMEQ for the cPAH mixture (1.45 mg/kg in this example).

Step 6: Calculate a Method B direct contact soil concentration for benzo(a)pyrene using equation 740-5 (0.1 mg/kg).[9]

Step 7: Calculate a Method B soil concentration protective of groundwater for benzo(a)pyrene using equation 747-1 (3-phase model). For this example, the Method B benzo(a)pyrene groundwater cleanup level of 0.12 ug/L was used as the target groundwater concentration for the calculation (which results in a soil concentration of 2.3 mg/kg in this example).

Step 8: To evaluate whether the sample is in compliance, compare the Total TEQ (Step 3) with the soil cleanup level for direct contact (Step 6), and the Total TMEQ for the cPAH mixture (Step 5) with the soil concentration for the protection of groundwater derived in Step 7.

Conclusion: The total TMEQ for the cPAHs in this soil sample (1.45 mg/kg) does not exceed the Method B soil leaching concentration for benzo(a)pyrene (2.3 mg/kg). Therefore, the cPAH mixture does not pose a threat to groundwater. However, the Total TEQ for the cPAHs in this soil sample (1.22 mg/kg) exceeds the Method B direct contact value (0.1 mg/kg). As a result, the cleanup level for the cPAH mixture should be based on the direct contact exposure pathway, and this soil cleanup level for the cPAH mixture has not been met for this particular soil sample.

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[9] Equation 740-5 is required to be used for petroleum mixtures.

Table 6. TEQ and TMEQ Calculations for evaluating compliance with a Method B unrestricted land use soil cleanup level (Example 4)

cPAH	Measured Soil Concentration (mg/kg)	Toxicity Equivalency Factor (TEF) Unitless (1)	Relative Mobility Factor (RMF) Unitless (2)	Toxic Equivalent Concentration (TEQ) mg/kg (3)	Toxic Mobility Equivalent Concentration (TMEQ) mg/kg (4)
Benzo(a)pyrene	0.95	1.0	1.00	0.9500	0.9500
Benzo(a)anthracene	1.45	0.1	2.71	0.1450	0.3930
Benzo(b)fluoranthene	0.66	0.1	0.79	0.0660	0.0521
Benzo(k)fluoranthene	0.08	0.1	0.79	0.0080	0.0063
Chrysene	1.39	0.01	2.43	0.0139	0.0338
Dibenz(a,h)anthracene	0.08	0.1	0.54	0.0080	0.0043
Indeno(1,2,3-cd)pyrene	0.27	0.1	0.28	0.0270	0.0076
Sum	**4.88**	--	--	**1.22**	**1.45**
Method B Benzo(a)pyrene Direct Contact (5)				**0.1** [10]	--
Method B Benzo(a)pyrene Leaching (6)				--	**2.3**

(1) From Table 1.
(2) From Table 2.
(3) TEQ = cPAH concentration * TEF
(4) TMEQ = cPAH concentration * TEF * RMF
(5) From equation 740-5 with equation defaults
(6) From equation 747-1 with equation defaults and using the Method B cleanup level of 0.12 ug/liter as the target groundwater concentration. The Method B cleanup level of 0.12 ug/liter is the drinking water standard for benzo(a)pyrene (0.2 ug/liter) adjusted to a $1X10^{-5}$ risk per WAC 1473-340-720(7)(b).

Example 5: Evaluating Compliance with Method C Soil Cleanup Levels

As with Method B (Example 4), when Method C is used to establish a soil cleanup level, it may not always be evident which exposure pathway—direct contact or soil leaching to groundwater—is the controlling exposure pathway for a soil sample. This example is intended to illustrate one way to conduct this evaluation.

Consider an industrial site where the soil is contaminated with a mixture of cPAHs and the soil cleanup level is based on Method C for industrial land use. In this example, the soil sample will be checked for compliance with the Method C soil concentrations protective of both the direct contact and soil leaching to groundwater exposure pathways.

Based on this scenario, use the following steps to evaluate compliance for a soil sample. Measured soil concentrations and calculations referred in the following steps are presented in Table 7, below.

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[10] Note that this value does not address the concern that EPA has determined that cPAHs are more toxic to young children and that a more stringent cancer slope factor should be used for this life stage ("early life exposure"). Ecology is currently evaluating whether to include this consideration under MTCA.

Step 1: Analyze the soil sample to determine the concentration of each cPAH (column 2 in Table 7).

Step 2: For each cPAH identified in the sample, multiply the soil concentration by the applicable TEF (column 3 in Table 7) to obtain a TEQ for that cPAH (column 5 in Table 7).

Step 3: Add the results from Step 2 to obtain the Total TEQ for the cPAH mixture (2.0 mg/kg in this example).

Step 4: For each cPAH identified in the sample, multiply the soil concentration by the applicable toxicity equivalency factor (column 3 in Table 7) and relative mobility factor (column 4 in Table 7) to obtain a TMEQ for that cPAH (column 6 in Table 7).

Step 5: Add the results from Step 4 to obtain the Total TMEQ for the cPAH mixture (2.22 mg/kg in this example).

Step 6: Calculate a Method C direct contact soil concentration for benzo(a)pyrene using equation 745-5 (4.27 mg/kg in this example).

Step 7: Calculate a Method C soil concentration protective of groundwater for benzo(a)pyrene using equation 747-1 (3-phase model). For this example, the Method B benzo(a)pyrene groundwater cleanup level of 0.12 ug/L was used as the target groundwater concentration for the calculation (which results in a soil concentration of 2.3 mg/kg in this example).

Step 8: To evaluate whether the sample is in compliance, compare the Total TEQ (Step 3) with the soil cleanup level for direct contact (Step 6), and the Total TMEQ for the cPAH mixture (Step 5) with the soil concentration protective of groundwater derived in Step 7.

Conclusion: The Total TEQ for the cPAH mixture in this soil sample (2.18 mg/kg) does not exceed the Method C direct contact value (4.3 mg/kg). Therefore, the soil sample is in compliance for the direct contact exposure pathway. However, the Total TMEQ for the cPAH mixture in this soil sample (2.79 mg/kg) exceeds the Method C soil concentration protective of groundwater for benzo(a)pyrene (2.3 mg/kg) and the cPAH mixture poses a threat to groundwater. As a result, the cleanup level for the cPAH mixture should be based on the leaching exposure pathway, and this soil cleanup level for the cPAH mixture has not been met for this particular soil sample.

Note that the Total TMEQ for the cPAH mixture (2.79 mg/kg) exceeds the 3-phase model concentration of 2.3 mg/kg by a small amount. Assuming this sample is representative of the site, this site may be a good candidate for an empirical demonstration to show that the soil is not impacting groundwater.

Table 7. TEQ and TMEQ calculations for evaluating compliance with a Method C industrial land use soil cleanup level (Example 5)

cPAH	Measured Soil Concentration (mg/kg)	Toxicity Equivalency Factor (TEF) Unitless) (1)	Relative Mobility Factor (RMF) Unitless (2)	Toxicity Equivalent Concentration (TEQ) mg/kg (3)	Toxic Mobility Equivalent Concentration (TMEQ) mg/kg (4)
Benzo(a)pyrene	1.59	1.0	1.00	1.5900	1.5900
Benzo(a)anthracene	3.87	0.1	2.71	0.3870	1.0488
Benzo(b)fluoranthene	1.18	0.1	0.79	0.1180	0.0932
Benzo(k)fluoranthene	0.25	0.1	0.79	0. 2500	0.0198
Chrysene	0.71	0.01	2.43	0.0071	0.0173
Dibenz(a,h)anthracene	0.25	0.1	0.54	0.0250	0.0135
Indeno(1,2,3-cd)pyrene	0.25	0.1	0.28	0.0250	
Sum	**8.10**	--	--	**2.18**	**2.79**
Method C Benzo(a)pyrene Direct Contact (5)				**4.3**	--
Method C Benzo(a)pyrene Leaching (6)				--	**2.3**

(1) From Table 1.
(2) From Table 2.
(3) TEQ = cPAH concentration * TEF
(4) TMEQ = cPAH concentration * TEF * RMF
(5) From equation 745-5 with equation defaults
(6) From equation 747-1 with equation defaults and using the Method B cleanup level of 0.12 ug/liter as the target groundwater concentration. The Method B cleanup level of 0.12 ug/liter is the drinking water standard for benzo(a)pyrene (0.2 ug/liter) adjusted to a $1X10^{-5}$ risk per WAC 1473-340-720(7)(b).