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INTERIM PROCEDURES FOR INACTIVATION OF PETROLEUM-IMPACTED SITES

New York State Department of
Environmental Conservation

Division of Environmental Remediation

George E. Pataki, Governor

January 2, 1997

PREFACE

Each year over 10,000 petroleum spills or releases are reported to the Department of Environmental Conservation (DEC). These incidents vary from small home heating oil spills to large oil spills from vessels. Each spill, however, must be timely and appropriately investigated and the contamination addressed. Investigation and cleanup may take one day for small surface spills to several years for a spill that has contaminated groundwater. Currently, DEC has over 15,000 ongoing cleanup projects.

DEC has recognized the need for improving corrective action decision processes to minimize delays in the closure of these sites as well as maximizing the effective use of limited resources, both public and private. In response to this need, DEC has developed this document, which clarifies and expands current guidelines for site closure to include a risk-based corrective action decision process for petroleum impacted sites. This process provides a streamlined, cost effective approach that is also protective of the public health and safety and the environment.

This draft document was developed to be utilized for two purposes. First, in the context of reaching a site closure decision, this document is still incomplete. DEC has established an Advisory Group, consisting of interested parties from the private, governmental and public sectors, to review and comment on this document. More importantly, however, this advisory group must develop recommendations to DEC on several unresolved issues critical to the successful implementation of this process.

Secondly, DEC recognizes the remaining development and approval of this document will take from a minimum of six months to possibly one year or more. To bridge this time period, DEC believes the technical portions of this document can still be implemented, under certain constraints (see Appendix S), for making interim risk-based corrective action decisions without jeopardizing the public's health and safety and the environment. Once this document has completed the approval process and is available for implementation, those decisions will be re-evaluated under the new guidelines for a site closure/no further action decision. Those responsible parties that need or want a site closure decision now must meet current guidelines (which includes current procedures now described in Section 5.3) for unrestrictive use of the property and the groundwater.

ERRATA SHEET

Please make the following changes to this document:

1. Section 3.2 Source Removal Criteria Paragraph 3.A Page 3-1 change "4.3(B) below" to "B below".

2. Section 3.2 Source Removal Criteria Page 3-2 third paragraph change "paragraph 3" to "criteria 3"

3. Appendix E Paragraph E.2.1 Page E-2 change "From Table 5.2" to "From Table 5.1"

4. Appendix E Table E.1 change the Benzene concentration for the On-site Commercial Worker and Tier 1 Levels from "0.0158" to "0.158"

5. Appendix E Table E.1 Footnote ** Page E-3 change "(from Table 5-4) to (from Appendix Q-Table Q.5).

6. Appendix E Tables E.2 and E.5 Footnote * Pages E-4 and E-5 change "Table 5-5" to "Table 5-1".

7. Appendix G Page G-2 change NYS Default Value of 15 cm (5.9 inches) for the capillary fringe thickness to 5 cm (1.97 inches)

#345

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THE COMMONWEALTH OF MASSACHUSETTS

Office of the Secretary of the Commonwealth

Regulation Filing *To be completed by filing agency*

CHAPTER NUMBER: 310 CMR 40.0000

CHAPTER TITLE: Massachusetts Contingency Plan

AGENCY: Department of Environmental Protection

SUMMARY OF REGULATION
State the general requirements and purposes of this regulation:

See Attachment 1

REGULATORY AUTHORITY: See Attachment 1
AGENCY CONTACT: James C. Colman PHONE: 617-292-5648
ADDRESS: 1 Winter Street, Boston, MA 02108

Compliance with M.G.L. c. 30A

EMERGENCY ADOPTION
If this regulation is adopted as an emergency regulation, state the nature of the emergency.

PRIOR NOTIFICATION AND/OR APPROVAL
If prior notification to and/or approval of the Governor, legislature or others was required, list each notification, approval and date, including notice to the Local Government Advisory Commission:

See Attachment 1

PUBLIC REVIEW
Was notice of the hearing or comment period filed with the Secretary of State published in appropriate newspapers and sent to persons to whom specific notice must be given at least 21 days prior to such hearing or comment period?
Yes ☒ Date of public hearing or comment period: See Attachment 1

FISCAL EFFECT

Estimate the fiscal effect on the public and private sectors:

For the first and second years:
For the first five years: See Attachment 1
No fiscal effect:

SMALL BUSINESS IMPACT

State the impact of this regulation on small business. Include a description of reporting, record keeping and other compliance requirements as well as the appropriateness of performance versus design standards and whether this regulation duplicates or conflicts with any other regulation. If the purpose of this regulation is to set rates for the state this section does not apply.

See Attachment 1

CODE OF MASSACHUSETTS REGULATIONS INDEX

List key subjects entries that are relevant to this regulation:

environmental regulation, notification, assessment, remediation, oil, hazardous material, response actions, superfund

PROMULGATION

State the action taken by this regulation and its effect on existing provisions of the Code of Massachusetts Regulations (CMR) to repeal, replace or amend. List by CMR number:

This regulation amends 310 CMR 40.0000

ATTESTATION

The regulation described herein and attached hereto is a true copy of the regulation adopted by this agency. ATTEST:

Signature: David B Struhs Date: March 22, 1996

Publication *To be completed by the Regulations Division*

MASSACHUSETTS REGISTER NUMBER: 788 DATE: 4/5/96

EFFECTIVE DATE: 4/5/96

CODE OF MASSACHUSETTS REGULATIONS

Remove these pages:	*Insert these pages:*
1487 - 1488	1487 - 1488
1535 - 1536	1535 - 1536
1549 - 1550	1549 - 1550
1647 - 1658	1647 - 1658
1663 - 1666	1663 - 1666
1673 - 1678	1673-1678
1807 - 1808	1807 - 1808
1833 - 1836	1833 - 1836
1845 - 1846	1845 - 1846
1865 - 1866	1865 - 1866
1877 - 1878	1877 - 1878
1899 - 1900	1899 - 1900
1905 - 1906	1905 - 1906
1993 - 1994	1993 - 1994
1999 - 2000	1999 - 2000
2005 - 2006	2005 - 2006

A TRUE COPY ATTEST
William Francis Galvin
WILLIAM FRANCIS GALVIN
SECRETARY OF THE COMMONWEALTH
ATE 3/22/96 CLERK KM

ATTACHMENT 1

SUMMARY OF REGULATION

The regulations being promulgated on April 5, 1996 include the following changes:

- Changes to the Reportable Concentrations and Numeric Cleanup Standards contained in the MCP. The changes are the result of updated toxicity information (e.g., US EPA Reference Doses, Cancer Slope Factors). The substitution of the new toxicity information in the approach used to develop the original standards has resulted in changes to both the Reportable Concentrations and cleanup standards.

- Revision to the 120 Day notification rule (310 CMR 40.0360) specifying that reporting is based on the reporting criteria in effect on the date of the sample analysis (i.e., criteria changes are not retroactive).

- "Remedial Additives" definition correction (the previous definition precluded application of common additives to enhance groundwater remediation, e.g., hydrogen peroxide).

- Correction of a reporting provision [310 CMR 40.0315(2)]. Revision adds "waste oil" to a reporting exclusion meant to keep small automotive-related releases (of oil and/or waste oil) out of the MCP process.

REGULATORY AUTHORITY

M.G.L. c. 21E, §§ 3(c), 3(d), 3(e), 3A(d), 3A(f), 3A(g), 3A(m), 3B, 5A, 6, 7 and 14, and M.G.L. c. 21A, § 2(28), M.G.L. c. 21C and M.G.L. c. 111, § 160.

PRIOR NOTIFICATION AND/OR APPROVAL

On December 5, 1996, the Department provided notice of its intent to amend 310 CMR 40.0000 to the following:

- Local Government Advisory Committee
- Department of Community Affairs
- Department of Public Utilities
- Energy Facilities Siting Council
- Massachusetts Board of Toxics Use Reduction
- Toxics Use Reduction Council
- Executive Office of Environmental Affairs
- MEPA Unit of the Executive Office of Environmental Affairs
- Executive Office of Economic Affairs
- Massachusetts Historical Commission
- Department of Public Health

PUBLIC REVIEW

DEP began identifying proposals for this regulation package in early summer of 1995. Proposals were discussed at monthly meetings of the Waste Site Cleanup Program Advisory Committee. The Advisory Committee reviewed early drafts of the proposed regulations.

DEP held public hearings on the proposed regulations on January 9, 1996, in Springfield, and on January 10, 1996, in Boston. Written comments were accepted through February 13, 1996.

The Department also filed an Environmental Notification Form ("ENF") with the MEPA Unit of the Executive Office of Environmental Affairs on December 15, 1995. The ENF was published in the Environmental Monitor on December 22, 1995, and comments were accepted on the ENF through February 13, 1996. On February 23, 1996, the Secretary of Environmental Affairs issued a Certificate on the ENF stating that the MCP amendment project does not require the preparation of an Environmental Impact Report.

FISCAL EFFECT AND SMALL BUSINESS IMPACT

The Department believes that, for the most part, these regulations have a positive fiscal effect on both the private and public sectors, including small businesses, in both the first two years of implementation and over the next five years. Some of the changes in cleanup standards may increase costs for parties conducting cleanups; however, these changes are based on updated scientific information and are therefore more protective of public health and therefore should reduce potential health effects and related costs.

The effects of these regulations are more specifically described below.

Changes to Reportable Concentrations and Numeric Cleanup Standards: These changes are the result of updated toxicity information (e.g., U.S. Environmental Protection Agency Reference Doses, Cancer Slope Factors). The changes expected to have the greatest impacts at Chapter 21E disposal sites are:

> **Dichloroethylenes**: The *cis*- and *trans*- isomers of 1,2-Dichloroethylene are relatively common groundwater contaminants. The absence of GW-2 standards (which protect against volatilization of contaminants into indoor air) in the past has resulted in some uncertainty (and frequent inquiries to DEP) as to the potential indoor air impacts which may be occurring. The proposed GW-2 standards are at levels which are unlikely to significantly change the assessment or remediation requirements for most disposal sites.
>
> **Methyl t-Butyl Ether (MTBE)**: MTBE is a fuel additive commonly reported at disposal sites where petroleum releases have occurred. Sites with MTBE contamination are likely to be contaminated with other volatile organic compounds, such as

benzene, toluene, xylenes and ethylbenzene. Cleanups may be more difficult (and therefore more costly) to achieve at gasoline sites with the ten-fold decrease (i.e., more stringent) in the MTBE soil and groundwater standards, although the actual impact will depend upon the extent to which the MTBE standards (and not those of the other contaminants present) drive the remediation. The changes in the Reportable Concentrations for MTBE may result in more (or earlier) reporting of releases, depending upon the importance of MTBE relative to the other gasoline constituents. Reporting of groundwater contamination while a plume is still relatively localized should reduce cleanup costs since the problem could then be addressed before contamination has time to spread (increasing the costs and complexity of cleanup actions).

Tetrachloroethylene: Tetrachloroethylene is a relatively common contaminant, often associated with dry cleaning facilities. At disposal sites, tetrachloroethylene is mostly a concern in groundwater and residual soil levels are typically low or non-detect. The proposed decrease in soil standards is expected to impact only a small number of sites, and those are likely to have significant groundwater problems.

Revision to the 120 Day notification rule: this change will eliminate the burden (and any associated costs) on parties who discover contamination below reporting criteria from having to keep abreast of future changes to reporting criteria (i.e., criteria changes will not be retroactive).

"Remedial Additives" definition correction: this change should lead to more efficient (and therefore cost-effective) cleanup by allowing application of common additives used to enhance groundwater remediation (e.g., hydrogen peroxide).

Correction of a reporting provision: this change will exclude small automotive-related releases (of oil and/or waste oil) from the requirement to follow the MCP process, which will reduce the costs associated with addressing these small releases.

40.0006: continued

Professional Services means the rendering of LSP Opinions, and services associated with the rendering of LSP Opinions, by a Licensed Site Professional who has either

- (a) in the case of an LSP Opinion related to an assessment:
  - 1. managed, supervised or actually performed such assessment, or
  - 2. periodically observed the performance by others of such assessment; or
- (b) in the case of an LSP Opinion related to a containment or removal:
  - 1. managed, supervised or actually performed such action, or
  - 2. periodically reviewed and evaluated the performance by others of such action.

Property Interest means, for purposes of 310 CMR 40.1250, an interest in property held by an owner, mortgagee or holder of a leasehold interest, holder of rights under an easement or other recorded instrument affecting title to property, or holder of a security interest or lien.

Protected Open Space means

- (a) any federal, state or local government-protected open space, including, but not limited to, parks, forests and watershed lands;
- (b) any land used for conservation purposes by a non-profit corporation, such as the Massachusetts Audubon Society, the Trustees of Reservation (excluding land held for its historic value only) and the Nature Conservancy; and
- (c) excluding any privately held land associated with a conservation restriction or easement or controlled by a person other than a non-profit corporation or Agency.

Public Involvement Activities means those activities which a person undertaking one or more response actions is required to perform by M.G.L. c. 21E and 310 CMR 40.1400 to inform the public of, and/or involve the public in, decisions regarding response actions at disposal sites, including, without limitation, the designation of a disposal site as a PIP Site, the provision of notice of response actions to local officials, the publication of notices of public meetings and/or of response actions in newspapers of general circulation in a community, the development of a Public Involvement Plan and the provision of relevant information to the public.

Public Involvement Plan Site and PIP Site each means a disposal site for which additional public involvement activities are required beyond those required for every disposal site and which has been designated as a PIP site pursuant to 310 CMR 40.1404.

Public water supply means a source of water supply, including, but not limited to, primary, backup and emergency sources, utilized by a public water system. For purposes of 310 CMR 40.0000, the terms "public water system," "primary source," "backup source," and "emergency source" shall have the meaning ascribed to such terms by 310 CMR 22.02.

Public water supply distribution pipeline means any piping used for the conveyance of potable water in a public water system.

Public Way means land in use as a public street or highway.

Rail Right-of-Way means lands or interests in lands which are in use as rights-of-way for rail purposes. This definition includes rights-of-way which are in use for rail transportation as regulated by M.G.L. c. 161C, and rail rights-of-way which are in use by the Massachusetts Bay Transportation Authority. This definition does not include related facilities, such as rail yards and rail maintenance facilities.

Random audit means an audit where the subject of the audit was selected using a methodology in which each member of a class has an equal probability of being selected for audit.

RCRA means the Federal Solid Waste Disposal Act as revised by the Resource Conservation and Recovery Act of 1976, P.L. 94 - 580, 42 U.S.C. §§ 6901 *et seq.*, as amended.

40.0006: continued

Receptor means a Human Receptor or Environmental Receptor.

Record of Decision and ROD each mean the document prepared pursuant to 40 CFR 300.430(f) for a final remedy selection decision under CERCLA.

Recreation area (*See* Park, playground and recreation area)

Reference Concentration means the daily concentration in air of an oil and/or hazardous material which would not be expected to result in any adverse non-cancer health effects, as published by EPA.

Reference Dose means the daily dose of an oil or hazardous material which would not be expected to result in any adverse non-cancer health effects, as published by EPA.

Release means any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping or disposing into the environment, but excludes:

(a) emissions from the exhaust of an engine;
(b) release of source, byproduct, or special nuclear material from a nuclear incident, as those terms are defined in 42 U.S.C. § 2014, if such release is subject to requirements with respect to financial protection established by the Nuclear Regulatory Commission under 42 U.S.C. § 2210;
(c) the normal application of fertilizer;
(d) the application of pesticides in a manner consistent with their labelling; and
(e) the application of residuals in accordance with 310 CMR 32.00.

Release Abatement Measure and RAM each means any response actions undertaken in accordance with 310 CMR 40.0440.

Release Notification Form means the form required by 310 CMR 40.0333(1)(b) and 310 CMR 40.0371 for purposes of providing written notification of a release or threat of release to the Department.

Release Tracking Number means the file number assigned by the Department to a release or threat of release reported in accordance with 310 CMR 40.0300.

Remedial Additives - means any aqueous, gaseous, or solid phase agent that is designed to treat or enhance the treatment of, or assessment of, soil and/or groundwater. The term shall include oxidizing agents, encapsulants, sequestering agents, non-pathogenic microbes, enzymes, nutrients, surfactants, and anti-fouling agents used to inhibit microbial growth in remedial treatment systems and monitoring wells.

Remedial Additive By-product - means any physical, chemical, or biological reaction by-product that results from the application or discharge of Remedial Additives to soil and/or groundwater.

Remedial action means any containment or removal.

Remedial alternative means a measure or combination of measures identified and evaluated in accordance with 310 CMR 40.0850 for its effectiveness in reducing, mitigating or eliminating risks posed by a disposal site.

Remedial Action Plan each means the document that is prepared in accordance with 310 CMR 40.0861 to justify the selection of a remedial action.

Remedial Site means a site at which remedial actions have been completed and for which no further remedial actions are planned.

Remedial technology means a design, measure or engineering practice which comprises, in whole or on part, a remedial action.

40.0311: continued

(6) a release to the environment indicated by the measurement of oil and/or hazardous material in a private drinking water supply well at concentrations equal to or greater than a Category RCGW-1 Reportable Concentration, as described in 310 CMR 40.0360 through 40.0369 and listed at 40.1600;

(7) any release of any oil and/or hazardous material, in any quantity or concentration, that poses or could pose an Imminent Hazard, as described in 310 CMR 40.0321 and 40.0950;

(8) any release of oil and/or hazardous material described in 310 CMR 40.0311(1) through (4) or 310 CMR 40.0311(7) that is indirectly discharged to the environment by means of discharge to a stormwater drainage system;

(9) any release of oil and/or hazardous material described in 310 CMR 40.0311(7) that is indirectly discharged into the environment by means of discharge to a sanitary sewerage system.

40.0312: Threats of Release Which Require Notification Within Two Hours

Except as provided in 310 CMR 40.0317 or 310 CMR 40.0332(1) or (7), persons required to notify under 310 CMR 40.0331 shall notify the Department as soon as possible but not more than two hours after obtaining knowledge that a threat of release meets one or more of the following sets of criteria:

(1) a threat of release to the environment of oil and/or hazardous material that is listed at 310 CMR 40.1600 or that exhibits one or more of the characteristics described in 310 CMR 40.0347, when:
(a) it is likely that the release threatened is about to occur; and
(b) it is likely that the quantity of the release, if it occurred, would be equal to or greater than the applicable Reportable Quantity specified at 310 CMR 40.0351, 40.0352 or 40.1600; or

(2) a threat of release to the environment of oil and/or hazardous material that is listed at 310 CMR 40.1600 or that exhibits one or more of the characteristics described in 310 CMR 40.0347, which poses or could pose an Imminent Hazard, as described in 310 CMR 40.0321, irrespective of the quantity likely to be released.

40.0313: Releases Which Require Notification Within 72 Hours

Except as provided in 310 CMR 40.0317 or 40.0332(7), persons required to notify under 310 CMR 40.0331 shall notify the Department not more than 72 hours after obtaining knowledge that a release meets one or more of the following sets of criteria:

(1) a release to the environment indicated by the presence of a subsurface Non-Aqueous Phase Liquid (NAPL) having a measured thickness equal to or greater than ½ inch;

(2) a release to the environment indicated by the presence of oil and/or hazardous material within ten feet of the exterior wall of an underground storage tank, as established by measurement of equal to or greater than 100 parts-per-million (ppm) by volume of total organic vapors "as benzene" in the headspace of a soil or groundwater sample using a headspace screening method, and where such sample was obtained:
(a) greater than two feet below the ground surface; and
(b) as part of a closure assessment required pursuant to 527 CMR 9.00 and 40 CFR Parts 280 and 281, or in connection with the removal or closure of an underground storage tank otherwise regulated by M.G.L. c. 148 or 527 CMR 9.00;

40.0313: continued

(3) a release to the environment indicated by the measurement of oil and/or hazardous material in the groundwater at concentrations equal to or greater than a Category RCGW-1 Reportable Concentration, as described in 310 CMR 40.0360 through 40.0369 and listed at 40.1600, within:
  (a) the Zone I of a public water supply well; or
  (b) 500 feet of a private water supply well; or

(4) a release to the environment indicated by measurement within the groundwater of equal to or greater than five milligrams per liter of total volatile organic compounds at any point located within 30 feet of a school or occupied residential structure, where the groundwater table is less than 15 feet below the surface of the ground.

40.0314: Threats of Release Which Require Notification Within 72 Hours

Except as provided in 310 CMR 40.0317, persons required to notify under 310 CMR 40.0331 shall notify the Department not more than 72 hours after obtaining knowledge of a threat of release of oil and/or hazardous material to the environment from an underground storage tank, as established by a tank test conducted in conformance with the methodology prescribed for that test which indicates:

(1) there is a substantial likelihood of a leak equal to or greater than 0.05 gallons per hour in a single walled tank;

(2) there is a substantial likelihood of a leak equal to or greater than 0.05 gallons per hour in the inner wall of a double-walled tank; or

(3) there is a substantial likelihood of a leak in the outer wall of a double-walled tank as established by the relevant parameters of that test.

40.0315: Releases Which Require Notification Within 120 Days

Except as provided in 310 CMR 40.0317 or 40.0318, persons required to notify under 310 CMR 40.0331 shall notify the Department not more than 120 days after obtaining knowledge that a release meets one or more of the following sets of criteria:

(1) a release to the environment indicated by the measurement of one or more hazardous materials in soil or groundwater in an amount equal to or greater than the applicable Reportable Concentration described in 310 CMR 40.0360 through 40.0369 and listed at 40.1600;

(2) a release to the environment indicated by the measurement of oil and/or waste oil in soil in an amount equal to or greater than the applicable Reportable Concentration described in 310 CMR 40.0360 through 40.0369 and listed at 40.1600, where the total contiguous volume of the oil and/or waste oil contaminated soil is equal to or greater than two cubic yards;

(3) a release to the environment indicated by the measurement of oil in groundwater in an amount equal to or greater than the applicable Reportable Concentration described in 310 CMR 40.0360 through 40.0369 and listed at 40.01600; or

(4) a release to the environment indicated by the presence of a subsurface Non-Aqueous Phase Liquid (NAPL) having a measured thickness equal to or greater than ⅛ inch and less than ½ inch.

40.0317: Releases and Threats of Release Which Do Not Require Notification

Notwithstanding the provisions of 310 CMR 40.0311 through 40.0315, the following releases and threats of release of oil and/or hazardous material are exempt from the notification requirements set forth in 310 CMR 40.0300:

40.0352: continued

(4) Mixtures or solutions:

(a) When a mixture or solution contains one or more component materials that are hazardous materials which appear at 310 CMR 40.1600 or that exhibit one or more of the characteristics of ignitability, corrosivity, or reactivity described at 310 40.0347(1) through (3), releases or threats of release to the environment of the mixture shall be reported to the Department under 310 CMR 40.0311 through 40.0312, when any of the following conditions exist:

1. the concentrations of the component hazardous materials are known and the quantity of any of the component hazardous materials released or threatening to be released is equal to or greater than the Reportable Quantities for those component hazardous materials;

2. the mixture or solution contains at least two component hazardous materials, the concentrations of the component hazardous materials are known and the quantity of any of the component hazardous materials released or threatened to be released does not exceed their respective Reportable Quantity but the total quantity of the hazardous material in the mixture or solution released or threatened to be released is equal to or greater than 50 pounds; or

3. the concentrations of the component hazardous materials are not known, and the total quantity of the mixture or solution released or threatened to be released is equal to or greater than the Reportable Quantity for that component hazardous material which has the lowest Reportable Quantity in 310 CMR 40.1600.

(b) The Reportable Quantity for mixtures which are hazardous material because they exhibit the characteristic of toxicity, as described in 310 CMR 30.125B, shall be determined according to 310 CMR 40.0352(3).

(c) The Reportable Quantity provisions of 310 CMR 40.0352(4) do not apply to soils, sediments, residuals, surface waters and groundwaters that are being managed otherwise in compliance with all federal, state and local laws, regulations, and ordinances.

(5) Materials Containing Polychlorinated Biphenyls:

(a) Releases or threats of release to the environment of materials th t contain polychlorinated biphenyls shall be reported to the Department pursuant to 310 CMR 40.0300, if:

1. the concentration of polychlorinated biphenyls in a material is either unknown or known to be less than 500 ppm, and the release or threat of release of such material is equal to or greater than ten gallons; or

2. the concentration of polychlorinated biphenyls in a material is known or likely to be equal to or greater than 500 ppm, and the release or threat of release of such material is equal to or greater than one gallon.

(b) The Reportable Quantity provisions of 310 CMR 40.0352(5) do not apply to soils, sediments, residuals, surface waters and groundwaters that are being managed otherwise in compliance with all federal, state and local laws, regulations, and ordinances.

40.0360: Reportable Concentrations for Oil and Hazardous Material

(1) A release indicated by the measurement of oil and/or hazardous material in soil and/or groundwater requires notification to the Department under the provisions of 310 CMR 40.0315 if the measured concentration of one or more listed substance in 310 CMR 40.1600 in any soil or groundwater sample is equal to or greater than the media and category-specific Reportable Concentration value listed at 310 CMR 40.1600 in effect on the date of the sample analysis.

(2) The Reportable Concentration for the oils listed at 310 CMR 40.1600 shall be the Reportable Concentration established in 310 CMR 40.1600 for Total Petroleum Hydrocarbons (TPH). For the purpose of determining whether a notification obligation exists under 310 CMR 40.0315, the applicable TPH Reportable Concentration shall be compared to concentrations of TPH measured in soil or groundwater samples by standard analytical techniques or by analytical procedures recommended by the Department.

40.0360: continued

(3) The Reportable Concentration values for the hazardous materials listed at 310 CMR 40.1600, including hazardous materials that may be components of oil or waste oil, shall be compared to concentrations of hazardous material in soil or groundwater that have been measured by the analytical procedures detailed in EPA Publication SW-846, "Test Methods for Evaluating Solid Waste", or any other appropriate analytical procedure, as described in 310 CMR 40.0018, and where there is greater than a 95% probability that the reported analyte is present at or above the Reportable Concentration.

(4) The techniques utilized for obtaining soil and groundwater samples for comparison to the Reportable Concentration values listed at 310 CMR 40.1600 shall be in conformance with generally accepted practices and procedures, consistent with the Response Action Performance Standard described in 310 CMR 40.0191, and shall not involve measures or steps that are undertaken to cause or promote the dilution of analyte values for the sole purpose of avoiding reporting obligations imposed in 310 CMR 40.0315.

(5) Persons notifying the Department of a release under the provisions of 310 CMR 40.0315 and 40.0360 through 40.0369 shall specify whether the measured concentration of one or more of the listed substances in 310 CMR 40.1600 constitutes a release of oil, hazardous material, or both oil and hazardous material. Such a determination shall be based upon:

(a) factual evidence relating to the source and mechanism of the release;
(b) factual evidence relating to the storage, use and disposal of oil and hazardous material at the site of the release; and/or
(c) analytical characterization of the release.

<u>40.0361: Reportable Concentrations of Oil and Hazardous Material in Soil</u>

(1) For the purpose of determining whether a notification obligation exists under 310 CMR 40.0315, measured concentrations of any oil or hazardous material listed at 310 CMR 40.1600 shall be compared to the Reportable Concentration value in the reporting category that best characterizes the current use of the site under evaluation, as described below:

(a) <u>Reporting Category RCS-1</u>. Reporting category RCS-1 shall be applied to all soil samples obtained:
  1. at or within 500 feet of a residential dwelling, a residentially-zoned property, school, playground, recreational area or park; or
  2. within the geographic boundaries of a groundwater resource area categorized as RCGW-1 in 310 CMR 40.0362(1)(a).

(b) <u>Reporting Category RCS-2</u>. Reporting category RCS-2 shall be applied to all soil samples that are not obtained from category RCS-1 areas.

(2) Reporting category RCS-1 shall be selected whenever and wherever reasonable doubts exist over the selection of the appropriate soil Reportable Concentration category.

<u>40.0362: Reportable Concentrations of Oil and Hazardous Material in Groundwater</u>

(1) For the purpose of determining whether a notification obligation exists under 310 CMR 40.0315, measured dissolved concentrations of any oil or hazardous material listed at 310 CMR 40.1600 shall be compared to the Reportable Concentration value in the reporting category that best characterizes the site under evaluation, as described below:

(a) <u>Reporting Category RCGW-1</u>. Reporting category RCGW-1 shall be applied to all groundwater samples obtained:
  1. within the Zone II for a public water supply;
  2. within the Interim Wellhead Protection Area for a public water supply;
  3. within all Potentially Productive Aquifers;
  4. within the Zone A of a Class A surface water body used as a public water supply;
  5. at any point located 500 or more feet from a public water supply distribution pipeline, except for sampling points that are located on a parcel or land or at a facility where any portion of that parcel of land or facility is located within 500 feet of a public water supply distribution pipeline; or

40.0973: continued

(b) For soil, the Exposure Point(s) shall be defined by the horizontal and vertical distribution of the material in soil in combination with the soil category(ies) determined to be applicable. For a contiguous volume of contaminated soil comprised of one or more soil categories as defined in 310 CMR 40.0933, a separate and distinct Exposure Point shall be represented by the soil in each soil category.

(4) The MCP Method 1 Standards assume exposure to the concentrations of oil and/or hazardous material in the soil and groundwater under current or foreseeable future conditions. For the Exposure Point Concentrations to be directly comparable to the MCP Method 1 Standards, they shall:

(a) be determined for each oil and/or hazardous material at each Exposure Point as described in 310 CMR 40.0926; and

(b) be representative of the actual concentration of oil and/or hazardous material at that Exposure Point, unmodified by other exposure assumptions.

(5) The applicable MCP Method 1 Groundwater and Soil Standards shall be identified as described in 310 CMR 40.0974 and 40.0975, and listed in the documentation of the Risk Characterization.

(6) The Exposure Point Concentrations identified in 310 CMR 40.0973(4) shall be compared to all applicable MCP Method 1 Standards identified in 310 CMR 40.0973(5).

(7) A condition of no significant risk of harm to health, public welfare and the environment exists if no Exposure Point Concentration is greater than the applicable MCP Method 1 Soil or Groundwater Standard.

(8) The documentation of the Method 1 Risk Characterization shall clearly state whether or not a condition of no significant risk of harm to health, public welfare and the environment exists or has been achieved at the disposal site.

40.0974: Identification of Applicable Groundwater Standards in Method 1.

(1) The groundwater categories (GW-1, GW-2 and/or GW-3) identified for the disposal site per 310 CMR 40.0932 shall determine which column(s) of numerical standards listed in Table 1 are applicable to the groundwater. If multiple categories apply to the groundwater at the disposal site, the lowest of the applicable MCP Method 1 Groundwater Standards shall be used to characterize the risk of harm posed by the oil and/or hazardous material at the disposal site. The applicability of groundwater standards is independent of the classification of the soil at the disposal site.

40.0974: continued

(2) Table 1 lists the potentially applicable MCP Method 1 Groundwater Standards.

310 CMR 40.0974(2)

TABLE 1

MCP Method 1 GROUNDWATER STANDARDS APPLICABLE IN AREAS WHERE THE GROUNDWATER IS CONSIDERED TO BE ONE OR MORE OF THE FOLLOWING CATEGORIES PER 310 CMR 40.0932

Oil and/or Hazardous Material	**CAS Number**	**GW-1 Standard µg/liter (ppb)**	**GW-2 Standard µg/liter (ppb)**	**GW-3 Standard µg/liter (ppb)**
ACENAPHTHENE	83329	20	NA	2,000
ACENAPHTHYLENE	208968	300	NA	2,000
ACETONE	67641	3,000	50,000	50,000
ALDRIN	309002	0.5	0.5	9
ANTHRACENE	120127	600	NA	600
ANTIMONY	7440360	6	NA	300
ARSENIC	7440382	50	NA	400
BARIUM	7440393	2,000	NA	30,000
BENZENE	71432	5	2,000	7,000
BENZO(a)ANTHRACENE	56553	1	NA	5
BENZO(a)PYRENE	50328	0.2	NA	2
BENZO(b)FLUORANTHENE	205992	1	NA	7
BENZO(g,h,i)PERYLENE	191242	0.5	NA	0.5
BENZO(k)FLUORANTHENE	207089	1	NA	1
BERYLLIUM	7440417	4	NA	50
BIPHENYL, 1,1-	92524	400	NA	4,000
BIS(2-CHLOROETHYL)ETHER	111444	30	100	50,000
BIS(2-CHLOROISOPROPYL)ETHER	39638329	30	400	50,000
BIS(2-ETHYLHEXYL)PHTHALATE	117817	6	700	30
BROMODICHLOROMETHANE	75274	5	NA	50,000
BROMOFORM	75252	5	800	50,000
BROMOMETHANE	74839	10	2	50,000
CADMIUM	7440439	5	NA	10
CARBON TETRACHLORIDE	56235	5	20	50,000
CHLORDANE	57749	2	NA	2
CHLOROANILINE, p-	106478	30	NA	50,000
CHLOROBENZENE	108907	100	1,000	500
CHLOROFORM	67663	5	400	10,000
CHLOROPHENOL, 2-	95578	10	NA	40,000
CHROMIUM (TOTAL)	7440473	100	NA	2,000
CHROMIUM (III)	16065831	100	NA	2,000
CHROMIUM (VI)	18540299	50	NA	100
CHRYSENE	218019	2	NA	3
CYANIDE *	57125	200	NA	10
DIBENZO(a,h)ANTHRACENE	53703	0.5	NA	0.5
DIBROMOCHLOROMETHANE	124481	5	NA	50,000
DICHLOROBENZENE, 1,2- (o-DCB)	95501	600	10,000	8,000
DICHLOROBENZENE, 1,3- (m-DCB)	541731	600	10,000	8,000
DICHLOROBENZENE, 1,4- (p-DCB)	106467	5	30,000	8,000
DICHLOROBENZIDINE, 3,3'-	91941	80	NA	2,000
DDD	72548	0.1	NA	6
DDE	72559	0.1	NA	20
DDT	50293	0.3	NA	0.3
DICHLOROETHANE, 1,1-	75343	70	9,000	50,000
DICHLOROETHANE, 1,2-	107062	5	20	50,000
DICHLOROETHYLENE, 1,1-	75354	7	1	50,000
DICHLOROETHYLENE, CIS-1,2-	156592	70	30,000	50,000
DICHLOROETHYLENE, TRANS-1,2-	156605	100	20,000	50,000
DICHLOROPHENOL, 2,4-	120832	10	NA	4,000
DICHLOROPROPANE, 1,2-	78875	5	9	30,000
DICHLOROPROPENE, 1,3-	542756	0.5	5	2,000
DIELDRIN	60571	0.1	NA	0.1
DIETHYL PHTHALATE	84662	6,000	NA	30
DIMETHYL PHTHALATE	131113	50,000	NA	30

40.0974: continued

310 CMR 40.0974(2)

TABLE 1

MCP Method 1 GROUNDWATER STANDARDS APPLICABLE IN AREAS WHERE THE GROUNDWATER IS CONSIDERED TO BE ONE OR MORE OF THE FOLLOWING CATEGORIES PER 310 CMR 40.0932

Oil and/or Hazardous Material	**CAS Number**	**GW-1 Standard µg/liter (ppb)**	**GW-2 Standard µg/liter (ppb)**	**GW-3 Standard µg/liter (ppb)**
DIMETHYLPHENOL, 2,4-	105679	100	NA	20,000
DINITROPHENOL, 2,4-	51285	200	NA	2,000
DINITROTOLUENE, 2,4-	121142	30	NA	2,000
DIOXIN **	1746016	3E-05	NA	1E-04
ENDOSULFAN	115297	40	NA	0.1
ENDRIN	72208	2	NA	5
ETHYLBENZENE	100414	700	30,000	4,000
ETHYLENE DIBROMIDE	106934	0.02	3	50,000
FLUORANTHENE	206440	100	NA	100
FLUORENE	86737	300	NA	1,000
HEPTACHLOR	76448	0.4	NA	1
HEPTACHLOR EPOXIDE	1024573	0.2	NA	2
HEXACHLOROBENZENE	118741	1	NA	40
HEXACHLOROBUTADIENE	87683	0.6	1	90
HEXACHLOROCYCLOHEXANE, GAMMA	58899	0.2	NA	0.8
HEXACHLOROETHANE	67721	8	10	5,000
INDENO(1,2,3-cd)PYRENE	193395	0.5	NA	0.5
LEAD	7439921	15	NA	30
MERCURY	7439976	2	NA	1
METHOXYCHLOR	72435	40	NA	2
METHYL ETHYL KETONE	78933	350	50,000	50,000
METHYL ISOBUTYL KETONE	108101	350	50,000	50,000
METHYL MERCURY	22967926	0.7	NA	0.1
METHYL t-BUTYL ETHER	1634044	70	50,000	50,000
METHYLENE CHLORIDE	75092	5	50,000	50,000
METHYLNAPHTHALENE, 2-	91576	10	10,000	3,000
NAPHTHALENE	91203	20	6,000	6,000
NICKEL	7440020	100	NA	80
PENTACHLOROPHENOL	87865	1	NA	80
PHENANTHRENE	85018	300	NA	50
PHENOL	108952	4,000	50,000	30,000
POLYCHLORINATED BIPHENYLS	1336363	0.5	NA	0.3
PYRENE	129000	80	NA	80
SELENIUM	7782492	50	NA	80
SILVER	7440224	40	NA	7
STYRENE	100425	100	900	50,000
TETRACHLOROETHANE, 1,1,1,2-	630206	5	6	50,000
TETRACHLOROETHANE, 1,1,2,2-	79345	2	20	20,000
TETRACHLOROETHYLENE	127184	5	3,000	5,000
THALLIUM	7440280	2	NA	400
TOLUENE	108883	1,000	6,000	50,000
TOTAL PETROLEUM HYDROCARBON †	NA	1,000	NA	50,000
TRICHLOROBENZENE, 1,2,4-	120821	70	10,000	500
TRICHLOROETHANE, 1,1,1-	71556	200	4,000	50,000
TRICHLOROETHANE, 1,1,2-	79005	5	20,000	50,000
TRICHLOROETHYLENE	79016	5	300	20,000
TRICHLOROPHENOL, 2,4,5-	95954	200	NA	100
TRICHLOROPHENOL, 2,4,6-	88062	10	40,000	10,000
VANADIUM	7440622	50	NA	2,000
VINYL CHLORIDE	75014	2	2	600
XYLENES (Mixed Isomers)	1330207	10,000	6,000	50,000
ZINC	7440666	2,000	NA	900

NA - Not Applicable
* - Cyanide expressed as free, or physiologically available cyanide.
** - Dioxins expressed as 2,3,7,8-TCDD equivalents.
† - Total Petroleum Hydrocarbon as measured using standard analytical methods or the MADEP TPH approach. This standard does not address and is not sufficient to evaluate specific chemicals which may be present in some petroleum products and which have promulgated MCP standards (such as benzene, toluene, ethylbenzene, xylenes and polycyclic aromatic hydrocarbons (PAHs)).

40.0975: Identification of Applicable Soil Standards in Method 1

The MCP Method 1 Soil Standards consider both the potential risk of harm resulting from direct exposure to the oil and/or hazardous material in the soil and the potential impacts on the groundwater at the disposal site. The applicability of a specific numerical Standard is thus a function of both the soil and the groundwater category identified:

(1) The category of soil (S-1, S-2, or S-3) at each Exposure Point determines which one of the three tables of MCP Method 1 Soil Standards is applicable.

(2) The category of groundwater (GW-1, GW-2, and/or GW-3) at or near each Exposure Point determines which column of the applicable MCP Method 1 Soil Standards table are relevant to the soil at the Exposure Point. If more than one groundwater category is applicable at the disposal site, then multiple MCP Method 1 Soil Standards may be applicable to the soil of interest, and the lowest of those identified standards shall be selected to characterize the risk of harm.

(3) The MCP Method 1 Soil Standards listed in Table 2 in 310 CMR 40.0975(6)(a) are applicable to soil determined to be category S-1.

(4) The MCP Method 1 Soil Standards listed in Table 3 in 310 CMR 40.0975(6)(b) are applicable to soil determined to be category S-2.

(5) The MCP Method 1 Soil Standards listed in Table 4 in 310 CMR 40.0975(6)(c) are applicable to soil determined to be category S-3.

(6) Tables 2, 3 and 4 list the potentially applicable MCP Method 1 Soil Standards.

310 CMR 40.0975(6)(a)

TABLE 2

MCP Method 1: SOIL CATEGORY S-1 STANDARDS

APPLICABLE TO SOIL WHERE THE COMBINATION OF SOIL & GROUNDWATER CATEGORIES ARE:

Oil and/or Hazardous Material	CAS Number	S-1 SOIL & GW-1 µg/g (ppm)	S-1 SOIL & GW-2 µg/g (ppm)	S-1 SOIL & GW-3 µg/g (ppm)
ACENAPHTHENE	83329	20	1,000	1,000
ACENAPHTHYLENE	208968	100	100	100
ACETONE	67641	3	60	60
ALDRIN	309002	0.03	0.03	0.03
ANTHRACENE	120127	1,000	1,000	1,000
ANTIMONY	7440360	10	10	10
ARSENIC	7440382	30	30	30
BARIUM	7440393	1,000	1,000	1,000
BENZENE	71432	10	40	40
BENZO(a)ANTHRACENE	56553	0.7	0.7	0.7
BENZO(a)PYRENE	50328	0.7	0.7	0.7
BENZO(b)FLUORANTHENE	205992	0.7	0.7	0.7
BENZO(g,h,i)PERYLENE	191242	100	1,000	100
BENZO(k)FLUORANTHENE	207089	7	7	7
BERYLLIUM	7440417	0.7	0.7	0.7
BIPHENYL, 1,1-	92524	1	1,000	10
BIS(2-CHLOROETHYL)ETHER	111444	0.7	0.7	0.7
BIS(2-CHLOROISOPROPYL)ETHER	39638329	0.7	2	2
BIS(2-ETHYLHEXYL)PHTHALATE	117817	100	200	200
BROMODICHLOROMETHANE	75274	0.1	20	20
BROMOFORM	75252	0.1	20	100
BROMOMETHANE	74839	10	3	50
CADMIUM	7440439	30	30	30
CARBON TETRACHLORIDE	56235	1	4	7
CHLORDANE	57749	1	1	1
CHLOROANILINE, p-	106478	1	100	30
CHLOROBENZENE	108907	8	80	40
CHLOROFORM	67663	0.1	10	200
CHLOROPHENOL, 2-	95578	0.7	100	20
CHROMIUM (TOTAL)	7440473	1,000	1,000	1,000
CHROMIUM (III)	16065831	1,000	1,000	1,000
CHROMIUM (VI)	18540299	200	200	200
CHRYSENE	218019	7	7	7
CYANIDE •	57125	100	100	100

310 CMR 40.0975(6)(a)

TABLE 2

MCP Method 1: SOIL CATEGORY S-1 STANDARDS

APPLICABLE TO SOIL WHERE THE COMBINATION OF SOIL & GROUNDWATER CATEGORIES ARE:

Oil and/or Hazardous Material	CAS Number	S-1 SOIL & GW-1 µg/g (ppm)	S-1 SOIL & GW-2 µg/g (ppm)	S-1 SOIL & GW-3 µg/g (ppm)
DIBENZO(a,h)ANTHRACENE	53703	0.7	0.7	0.7
DIBROMOCHLOROMETHANE	124481	0.09	10	10
DICHLOROBENZENE, 1,2- (o-DCB)	95501	100	100	100
DICHLOROBENZENE, 1,3- (m-DCB)	541731	100	100	100
DICHLOROBENZENE, 1,4- (p-DCB)	106467	2	40	40
DICHLOROBENZIDINE, 3,3'-	91941	1	1	1
DDD	72548	2	2	2
DDE	72559	2	2	2
DDT	50293	2	2	2
DICHLOROETHANE, 1,1-	75343	3	100	100
DICHLOROETHANE, 1,2-	107062	0.05	0.2	10
DICHLOROETHYLENE, 1,1-	75354	0.7	0.1	2
DICHLOROETHYLENE, CIS-1,2-	156592	2	100	100
DICHLOROETHYLENE, TRANS-1,2-	156605	4	500	500
DICHLOROPHENOL, 2,4-	120832	10	40	40
DICHLOROPROPANE, 1,2-	78875	0.1	0.2	8
DICHLOROPROPENE, 1,3-	542756	0.01	0.1	3
DIELDRIN	60571	0.03	0.03	0.03
DIETHYL PHTHALATE	84662	100	1,000	0.7
DIMETHYL PHTHALATE	131113	30	1,000	0.7
DIMETHYLPHENOL, 2,4-	105679	0.7	400	10
DINITROPHENOL, 2,4-	51285	3	40	6
DINITROTOLUENE, 2,4-	121142	0.7	1	1
DIOXIN **	1746016	4E-06	4E-06	4E-06
ENDOSULFAN	115297	20	100	0.05
ENDRIN	72208	0.6	6	1
ETHYLBENZENE	100414	80	500	500
ETHYLENE DIBROMIDE	106934	0.005	0.01	0.01
FLUORANTHENE	206440	600	1,000	600
FLUORENE	86737	400	1,000	1,000
HEPTACHLOR	76448	0.1	0.1	0.1
HEPTACHLOR EPOXIDE	1024573	0.06	0.06	0.06
HEXACHLOROBENZENE	118741	0.7	0.7	0.7
HEXACHLOROBUTADIENE	87683	3	3	5
HEXACHLOROCYCLOHEXANE, GAMMA	58899	0.1	0.4	0.4
HEXACHLOROETHANE	67721	6	6	6
INDENO(1,2,3-cd)PYRENE	193395	0.7	0.7	0.7
LEAD	7439921	300	300	300
MERCURY	7439976	20	20	20
METHOXYCHLOR	72435	100	100	30
METHYL ETHYL KETONE	78933	0.3	40	40
METHYL ISOBUTYL KETONE	108101	0.5	70	70
METHYL MERCURY	22967926	2	2	2
METHYL t-BUTYL ETHER	1634044	0.3	100	100
METHYLENE CHLORIDE	75092	0.1	100	100
METHYLNAPHTHALENE, 2-	91576	0.7	20	7
NAPHTHALENE	91203	4	100	100
NICKEL	7440020	300	300	300
PENTACHLOROPHENOL	87865	5	7	7
PHENANTHRENE	85018	700	1,000	100
PHENOL	108952	60	500	500
POLYCHLORINATED BIPHENYLS (PCBs)	1336363	2	2	2
PYRENE	129000	500	700	500
SELENIUM	7782492	400	400	400
SILVER	7440224	100	100	100
STYRENE	100425	2	20	20
TETRACHLOROETHANE, 1,1,1,2-	630206	0.4	0.5	4
TETRACHLOROETHANE, 1,1,2,2-	79345	0.02	0.2	0.5

40.0975: continued

310 CMR 40.0975(6)(a)

TABLE 2

MCP Method 1: SOIL CATEGORY S-1 STANDARDS

APPLICABLE TO SOIL WHERE THE COMBINATION OF SOIL & GROUNDWATER CATEGORIES ARE:

Oil and/or Hazardous Material	CAS Number	S-1 SOIL & GW-1 µg/g (ppm)	S-1 SOIL & GW-2 µg/g (ppm)	S-1 SOIL & GW-3 µg/g (ppm)
TETRACHLOROETHYLENE	127184	0.5	20	20
THALLIUM	7440280	8	8	8
TOLUENE	108883	90	500	500
TOTAL PETROLEUM HYDROCARBON †	NA	500	500	500
TRICHLOROBENZENE, 1,2,4-	120821	100	400	400
TRICHLOROETHANE, 1,1,1-	71556	30	100	100
TRICHLOROETHANE, 1,1,2-	79005	0.3	2	2
TRICHLOROETHYLENE	79016	0.4	20	70
TRICHLOROPHENOL, 2,4,5-	95954	3	1,000	2
TRICHLOROPHENOL 2,4,6-	88062	3	40	40
VANADIUM	7440622	400	400	400
VINYL CHLORIDE	75014	0.3	0.3	0.3
XYLENES (mixed isomers)	1330207	500	500	500
ZINC	7440666	2,500	2,500	2,500

NOTE:	All concentrations of oil and/or hazardous material in soil are calculated and presented on a dry weight/dry weight basis.
NA -	Not Applicable
* -	Cyanide expressed as free, or physiologically available cyanide.
** -	Dioxins expressed as 2,3,7,8-TCDD equivalents.
† -	Total Petroleum Hydrocarbon as measured using standard analytical methods or the MADEP TPH approach. This standard does not address and is not sufficient to evaluate specific chemicals which may be present in some petroleum products and which have promulgated MCP standards (such as benzene, toluene, ethylbenzene, xylenes and polycyclic aromatic hydrocarbons (PAHs)).

310 CMR 40.0975(6)(b)

TABLE 3

MCP Method 1: SOIL CATEGORY S-2 STANDARDS

APPLICABLE TO SOIL WHERE THE COMBINATION OF SOIL & GROUNDWATER CATEGORIES ARE:

Oil and/or Hazardous Material	CAS Number	S-2 SOIL & GW-1 µg/g (ppm)	S-2 SOIL & GW-2 µg/g (ppm)	S-2 SOIL & GW-3 µg/g (ppm)
ACENAPHTHENE	83329	20	2,500	2,000
ACENAPHTHYLENE	208968	100	2,500	800
ACETONE	67641	3	60	60
ALDRIN	309002	0.04	0.04	0.04
ANTHRACENE	120127	1,000	2,500	1,000
ANTIMONY	7440360	40	40	40
ARSENIC	7440382	30	30	30
BARIUM	7440393	2,500	2,500	2,500
BENZENE	71432	10	60	60
BENZO(a)ANTHRACENE	56553	1	1	1
BENZO(a)PYRENE	50328	0.7	0.7	0.7
BENZO(b)FLUORANTHENE	205992	1	1	1
BENZO(g,h,i)PERYLENE	191242	100	2,500	100
BENZO(k)FLUORANTHENE	207089	10	10	10
BERYLLIUM	7440417	0.8	0.8	0.8

40.0975: continued

310 CMR 40.0975(6)(b)

TABLE 3

MCP Method 1: SOIL CATEGORY S-2 STANDARDS

APPLICABLE TO SOIL WHERE THE COMBINATION OF SOIL & GROUNDWATER CATEGORIES ARE:

Oil and/or Hazardous Material	CAS Number	S-2 SOIL & GW-1 µg/g (ppm)	S-2 SOIL & GW-2 µg/g (ppm)	S-2 SOIL & GW-3 µg/g (ppm)
BIPHENYL, 1,1-	92524	1	2,500	10
BIS(2-CHLOROETHYL)ETHER	111444	0.7	0.7	0.7
BIS(2-CHLOROISOPROPYL)ETHER	39638329	0.7	3	3
BIS(2-ETHYLHEXYL)PHTHALATE	117817	100	300	300
BROMODICHLOROMETHANE	75274	0.1	20	20
BROMOFORM	75252	0.1	20	200
BROMOMETHANE	74839	10	3	200
CADMIUM	7440439	80	80	80
CARBON TETRACHLORIDE	56235	1	4	10
CHLORDANE	57749	2	2	2
CHLOROANILINE, p-	106478	1	400	30
CHLOROBENZENE	108907	8	80	40
CHLOROFORM	67663	0.1	10	200
CHLOROPHENOL, 2-	95578	0.7	200	20
CHROMIUM (TOTAL)	7440473	2,500	2,500	2,500
CHROMIUM (III)	16065831	2,500	2,500	2,500
CHROMIUM (VI)	18540299	600	600	600
CHRYSENE	218019	10	10	10
CYANIDE *	57125	100	100	100
DIBENZO(a,h)ANTHRACENE	53703	0.7	0.7	0.7
DIBROMOCHLOROMETHANE	124481	0.09	20	20
DICHLOROBENZENE, 1,2- (o-DCB)	95501	200	500	500
DICHLOROBENZENE, 1,3- (m-DCB)	541731	200	500	500
DICHLOROBENZENE, 1,4- (p-DCB)	106467	2	60	60
DICHLOROBENZIDINE, 3,3'-	91941	1	1	1
DDD	72548	3	3	3
DDE	72559	2	2	2
DDT	50293	2	2	2
DICHLOROETHANE, 1,1-	75343	3	400	500
DICHLOROETHANE, 1,2-	107062	0.05	0.2	20
DICHLOROETHYLENE, 1,1-	75354	0.7	0.1	2
DICHLOROETHYLENE, CIS-1,2-	156592	2	500	500
DICHLOROETHYLENE, TRANS-1,2-	156605	4	800	1,000
DICHLOROPHENOL, 2,4-	120832	10	90	90
DICHLOROPROPANE, 1,2-	78875	0.1	0.2	10
DICHLOROPROPENE, 1,3-	542756	0.01	0.1	5
DIELDRIN	60571	0.04	0.04	0.04
DIETHYL PHTHALATE	84662	100	2,500	0.7
DIMETHYL PHTHALATE	131113	30	2,500	0.7
DIMETHYLPHENOL, 2,4-	105679	0.7	900	10
DINITROPHENOL, 2,4-	51285	3	90	6
DINITROTOLUENE, 2,4-	121142	0.7	2	2
DIOXIN **	1746016	6E-06	6E-06	6E-06
ENDOSULFAN	115297	20	400	0.05
ENDRIN	72208	0.6	10	1
ETHYLBENZENE	100414	80	1,000	500
ETHYLENE DIBROMIDE	106934	0.005	0.02	0.02
FLUORANTHENE	206440	600	2,000	600
FLUORENE	86737	400	2,000	1,000
HEPTACHLOR	76448	0.2	0.2	0.2
HEPTACHLOR EPOXIDE	1024573	0.09	0.09	0.09
HEXACHLOROBENZENE	118741	0.8	0.8	0.8
HEXACHLOROBUTADIENE	87683	3	3	10
HEXACHLOROCYCLOHEXANE, GAMMA	58899	0.1	0.6	0.5

40.0975: continued

310 CMR 40.0975(6)(b)

TABLE 3

MCP Method 1: SOIL CATEGORY S-2 STANDARDS

APPLICABLE TO SOIL WHERE THE COMBINATION OF SOIL & GROUNDWATER CATEGORIES ARE:

Oil and/or Hazardous Material	CAS Number	S-2 SOIL & GW-1 µg/g (ppm)	S-2 SOIL & GW-2 µg/g (ppm)	S-2 SOIL & GW-3 µg/g (ppm)
HEXACHLOROETHANE	67721	10	10	10
INDENO(1,2,3-cd)PYRENE	193395	1	1	1
LEAD	7439921	600	600	600
MERCURY	7439976	60	60	60
METHOXYCHLOR	72435	300	300	30
METHYL ETHYL KETONE	78933	0.3	40	40
METHYL ISOBUTYL KETONE	108101	0.5	70	70
METHYL MERCURY	22967926	6	6	6
METHYL t-BUTYL ETHER	1634044	0.3	200	200
METHYLENE CHLORIDE	75092	0.1	200	200
METHYLNAPHTHALENE, 2-	91576	0.7	20	7
NAPHTHALENE	91203	4	1,000	1,000
NICKEL	7440020	700	700	700
PENTACHLOROPHENOL	87865	5	10	10
PHENANTHRENE	85018	700	2,500	100
PHENOL	108952	60	800	500
POLYCHLORINATED BIPHENYLS (PCBs)	1336363	2	2	2
PYRENE	129000	500	2,000	500
SELENIUM	7782492	2,500	2,500	2,500
SILVER	7440224	200	200	200
STYRENE	100425	2	20	30
TETRACHLOROETHANE, 1,1,1,2-	630206	0.4	0.5	5
TETRACHLOROETHANE, 1,1,2,2-	79345	0.02	0.2	0.6
TETRACHLOROETHYLENE	127184	0.5	30	30
THALLIUM	7440280	30	30	30
TOLUENE	108883	90	500	1,000
TOTAL PETROLEUM HYDROCARBON †	NA	2,500	2,500	2,500
TRICHLOROBENZENE, 1,2,4-	120821	100	2,000	800
TRICHLOROETHANE, 1,1,1-	71556	30	500	500
TRICHLOROETHANE, 1,1,2-	79005	0.3	3	3
TRICHLOROETHYLENE	79016	0.4	20	100
TRICHLOROPHENOL, 2,4,5-	95954	3	2,500	2
TRICHLOROPHENOL 2,4,6-	88062	3	60	60
VANADIUM	7440622	2,000	2,000	2,000
VINYL CHLORIDE	75014	0.4	0.3	0.5
XYLENES (mixed isomers)	1330207	800	500	1,000
ZINC	7440666	2,500	2,500	2,500

NOTE:	All concentrations of oil and/or hazardous material in soil are calculated and presented on a dry weight/dry weight basis.
NA -	Not Applicable
* -	Cyanide expressed as free, or physiologically available cyanide.
** -	Dioxins expressed as 2,3,7,8-TCDD equivalents.
† -	Total Petroleum Hydrocarbon as measured using standard analytical methods or the MADEP TPH approach. This standard does not address and is not sufficient to evaluate specific chemicals which may be present in some petroleum products and which have promulgated MCP standards (such as benzene, toluene, ethylbenzene, xylenes and polycyclic aromatic hydrocarbons (PAHs)).

40.0975: continued

310 CMR 40.0975(6)(c)

TABLE 4

MCP Method 1: SOIL CATEGORY S-3 STANDARDS

APPLICABLE TO SOIL WHERE THE COMBINATION OF SOIL & GROUNDWATER CATEGORIES ARE:

Oil and/or Hazardous Material	CAS Number	S-3 SOIL & GW-1 µg/g (ppm)	S-3 SOIL & GW-2 µg/g (ppm)	S-3 SOIL & GW-3 µg/g (ppm)
ACENAPHTHENE	83329	20	5,000	2,000
ACENAPHTHYLENE	208968	100	2,500	800
ACETONE	67641	3	60	60
ALDRIN	309002	0.1	0.1	0.1
ANTHRACENE	120127	1,000	5,000	1,000
ANTIMONY	7440360	40	40	40
ARSENIC	7440382	30	30	30
BARIUM	7440393	5,000	5,000	5,000
BENZENE	71432	10	100	200
BENZO(a)ANTHRACENE	56553	4	4	4
BENZO(a)PYRENE	50328	0.7	0.7	0.7
BENZO(b)FLUORANTHENE	205992	4	4	4
BENZO(g,h,i)PERYLENE	191242	100	2,500	100
BENZO(k)FLUORANTHENE	207089	40	40	40
BERYLLIUM	7440417	3	3	3
BIPHENYL, 1,1-	92524	1	3,000	10
BIS(2-CHLOROETHYL)ETHER	111444	0.7	0.7	0.7
BIS(2-CHLOROISOPROPYL)ETHER	39638329	0.7	4	9
BIS(2-ETHYLHEXYL)PHTHALATE	117817	100	1,000	500
BROMODICHLOROMETHANE	75274	0.1	90	90
BROMOFORM	75252	0.1	20	700
BROMOMETHANE	74839	10	3	700
CADMIUM	7440439	80	80	80
CARBON TETRACHLORIDE	56235	1	4	40
CHLORDANE	57749	5	5	5
CHLOROANILINE, p-	106478	1	400	30
CHLOROBENZENE	108907	8	80	40
CHLOROFORM	67663	0.1	10	300
CHLOROPHENOL, 2-	95578	0.7	1,000	20
CHROMIUM (TOTAL)	7440473	5,000	5,000	5,000
CHROMIUM (III)	16065831	5,000	5,000	5,000
CHROMIUM (VI)	18540299	1,000	1,000	1,000
CHRYSENE	218019	40	40	40
CYANIDE *	57125	400	400	400
DIBENZO(a,h)ANTHRACENE	53703	0.8	0.8	0.8
DIBROMOCHLOROMETHANE	124481	0.09	70	70
DICHLOROBENZENE, 1,2- (o-DCB)	95501	200	500	500
DICHLOROBENZENE, 1,3- (m-DCB)	541731	200	500	500
DICHLOROBENZENE, 1,4- (p-DCB)	106467	2	200	200
DICHLOROBENZIDINE, 3,3'-	91941	3	3	3
DDD	72548	10	10	10
DDE	72559	9	9	9
DDT	50293	9	9	9
DICHLOROETHANE, 1,1-	75343	3	400	500
DICHLOROETHANE, 1,2-	107062	0.05	0.2	60
DICHLOROETHYLENE, 1,1-	75354	0.7	0.1	9
DICHLOROETHYLENE, CIS-1,2-	156592	2	500	500
DICHLOROETHYLENE, TRANS-1,2-	156605	4	2,500	2,000
DICHLOROPHENOL, 2,4-	120832	10	90	90
DICHLOROPROPANE, 1,2-	78875	0.1	0.2	40
DICHLOROPROPENE, 1,3-	542756	0.01	0.1	20
DIELDRIN	60571	0.1	0.2	0.1
DIETHYL PHTHALATE	84662	100	5,000	0.7
DIMETHYL PHTHALATE	131113	30	5,000	0.7

40.0975: continued

310 CMR 40.0975(6)(c)

TABLE 4

MCP Method 1: SOIL CATEGORY S-3 STANDARDS

APPLICABLE TO SOIL WHERE THE COMBINATION OF SOIL & GROUNDWATER CATEGORIES ARE:

Oil and/or Hazardous Material	CAS Number	S-3 SOIL & GW-1 µg/g (ppm)	S-3 SOIL & GW-2 µg/g (ppm)	S-3 SOIL & GW-3 µg/g (ppm)
DIMETHYLPHENOL, 2,4-	105679	0.7	4,000	10
DINITROPHENOL, 2,4-	51285	3	90	6
DINITROTOLUENE, 2,4-	121142	0.7	7	7
DIOXIN **	1746016	2E-05	2E-05	2E-05
ENDOSULFAN	115297	20	400	0.05
ENDRIN	72208	0.6	10	1
ETHYLBENZENE	100414	80	2,500	500
ETHYLENE DIBROMIDE	106934	0.005	0.04	0.07
FLUORANTHENE	206440	600	5,000	600
FLUORENE	86737	400	5,000	1,000
HEPTACHLOR	76448	0.7	0.7	0.7
HEPTACHLOR EPOXIDE	1024573	0.3	0.3	0.3
HEXACHLOROBENZENE	118741	3	3	3
HEXACHLOROBUTADIENE	87683	3	3	40
HEXACHLOROCYCLOHEXANE, GAMMA	58899	0.1	2	0.5
HEXACHLOROETHANE	67721	30	30	50
INDENO(1,2,3-cd)PYRENE	193395	4	4	4
LEAD	7439921	600	600	600
MERCURY	7439976	60	60	60
METHOXYCHLOR	72435	300	300	30
METHYL ETHYL KETONE	78933	0.3	40	40
METHYL ISOBUTYL KETONE	108101	0.5	70	70
METHYL MERCURY	22967926	8	8	8
METHYL t-BUTYL ETHER	1634044	0.3	200	200
METHYLENE CHLORIDE	75092	0.1	700	700
METHYLNAPHTHALENE, 2-	91576	0.7	20	7
NAPHTHALENE	91203	4	1,000	1,000
NICKEL	7440020	700	700	700
PENTACHLOROPHENOL	87865	5	40	40
PHENANTHRENE	85018	700	2,500	100
PHENOL	108952	60	800	500
POLYCHLORINATED BIPHENYLS (PCBs)	1336363	2	2	2
PYRENE	129000	500	5,000	500
SELENIUM	7782492	2,500	2,500	2,500
SILVER	7440224	200	200	200
STYRENE	100425	2	20	100
TETRACHLOROETHANE, 1,1,1,2-	630206	0.4	0.5	20
TETRACHLOROETHANE, 1,1,2,2-	79345	0.02	0.2	2
TETRACHLOROETHYLENE	127184	0.5	100	100
THALLIUM	7440280	100	100	100
TOLUENE	108883	90	500	2,500
TOTAL PETROLEUM HYDROCARBON †	NA	5,000	5,000	5,000

40.0975: continued

310 CMR 40.0975(6)(c)

TABLE 4

MCP Method 1: SOIL CATEGORY S-3 STANDARDS

APPLICABLE TO SOIL WHERE THE COMBINATION OF SOIL & GROUNDWATER CATEGORIES ARE:

Oil and/or Hazardous Material	CAS Number	S-3 SOIL & GW-1 µg/g (ppm)	S-3 SOIL & GW-2 µg/g (ppm)	S-3 SOIL & GW-3 µg/g (ppm)
TRICHLOROBENZENE, 1,2,4-	120821	100	2,000	800
TRICHLOROETHANE, 1,1,1-	71556	30	500	500
TRICHLOROETHANE, 1,1,2-	79005	0.3	10	10
TRICHLOROETHYLENE	79016	0.4	20	500
TRICHLOROPHENOL, 2,4,5-	95954	3	5,000	2
TRICHLOROPHENOL 2,4,6-	88062	3	200	200
VANADIUM	7440622	2,000	2,000	2,000
VINYL CHLORIDE	75014	0.4	0.3	2
XYLENES (mixed isomers)	1330207	800	500	2,500
ZINC	7440666	5,000	5,000	5,000

NOTE:	All concentrations of oil and/or hazardous material in soil are calculated and presented on a dry weight/dry weight basis.
NA -	Not Applicable
* -	Cyanide expressed as free, or physiologically available cyanide.
** -	Dioxins expressed as 2,3,7,8-TCDD equivalents.
† -	Total Petroleum Hydrocarbon as measured using standard analytical methods or the MADEP TPH approach. This standard does not address and is not sufficient to evaluate specific chemicals which may be present in some petroleum products and which have promulgated MCP standards (such as benzene, toluene, ethylbenzene, xylenes and polycyclic aromatic hydrocarbons (PAHs)).

40.0980: Method 2 Risk Characterization

40.0981 Applicability of Method 2

Method 2 may be used to characterize the risk of harm to health, public welfare and the environment at disposal sites where site investigations conducted in accordance with 310 CMR 40.0000 have determined that the release of oil and/or hazardous material is limited to soil and/or groundwater. If contamination is present in one or more environmental media other than soil or groundwater, Method 2 shall not be used, except as described in 310 CMR 40.0942(2). A Method 2 Risk Characterization shall be conducted in combination with a separate characterization of the risk of harm to safety, as described in 310 CMR 40.0960.

40.0982 General Approach to Method 2

A Method 2 Risk Characterization supplements and modifies the MCP Method 1 Standards with site-and chemical-specific information. For the purposes of 310 cmr 40.0000, "MCP Method 2 Standards" shall refer to the MCP Method 1 Standards which have been modified to address site-specific conditions as described in 310 cmr 40.0982. Site conditions are then compared to such MCP Method 2 Standards, in the same manner that MCP Method 1 Standards are used under 310 CMR 40.0973, to characterize the risk of harm to health, public welfare and the environment.

(1) MCP Method 1 GW-1 Standards shall not be modified in Method 2. These standards are listed in 310 CMR 40.0974(2).

(2) The component of the MCP Method 1 Soil Standards which is protective of direct contact exposures to the soil shall not be modified in Method 2. These standards are listed in 310 CMR 40.0985(6).

40.0982: continued

(3) The following information may be used under Method 2 to modify the Method 1 Standards:

(a) MCP Method 2 Groundwater and Soil Standards may be developed for chemicals for which MCP Method 1 Standards have not been promulgated by the Department. This process is described in 310 CMR 40.0983 and 40.0984.

(b) Site-specific information may be used to either modify the leaching component of the MCP Method 1 Soil Standards or to demonstrate that a contaminant will not leach to groundwater. The incorporation of such site-specific information will result in MCP Method 2 Soil Standards or a determination that the leaching component of one or more Method 1 soil standard is not applicable. These site-specific modifications are described in 310 CMR 40.0985.

(c) Site-specific information may be used to either modify the MCP Method 1 GW-2 Standards, which model potential volatilization of oil and/or hazardous material to indoor air, or to demonstrate that such vapor infiltration will not occur. The incorporation of such site-specific information will result in MCP Method 2 GW-2 Standards or a determination that one or more Method 1 GW-2 standard is not applicable at this site. These site-specific modifications are described in 310 CMR 40.0986.

(d) Site-specific information may be used to either modify the MCP Method 1 GW-3 Standards, which are set to be protective of potential discharges of oil and/or hazardous material to surface water, or to demonstrate that such discharges will not occur. The incorporation of such site-specific information will result in MCP Method 2 GW-3 Standards or a determination that one or more Method 1 GW-3 standard is not applicable. These site-specific modifications are described in 310 CMR 40.0987.

(4) If the modification of a MCP Method 1 GW-2 or GW-3 Standard results in a concentration of an oil and/or hazardous material greater than the Upper Concentration Limit in Groundwater listed in 310 CMR 40.0996(5), then the Upper Concentration Limit for that chemical shall be used to characterize the risk of harm to health, public welfare and the environment in Method 2.

(5) MCP Method 1 Standards may be used in combination with one or more MCP Method 2 Standards. A Risk Characterization which uses a combination of MCP Method 1 and 2 Standards shall be considered a Method 2 Risk Characterization.

(6) The MCP Method 2 Standards developed and used or relied upon by the LSP shall be listed and suitably documented.

(7) The Department may develop and publish sets of chemical-specific concentrations which, for specific types of disposal sites, will demonstrably meet the Risk Characterization requirements described at 40.0990. Such concentrations may be used at the RP's, PRP's or Other Person's option to characterize risk at a disposal site, and the use of these sets of concentrations shall be considered a Method 2 Risk Characterization.

40.0983: Derivation of Additional Method 1 Groundwater Standards for Use in Method 2.

If an MCP Method 1 Groundwater Standard has not been promulgated by the Department, the LSP may develop an MCP Method 2 Standard for that oil and/or hazardous material on the basis of the following assumptions and procedures:

(1) A site-specific background concentration in groundwater shall be identified for the oil and/or hazardous material.

(2) GW-1 Standards shall be calculated as follows:

(a) Based on non-cancer health risk, a concentration in drinking water of the oil and/or hazardous associated with 20% of a Reference Dose shall be identified using the following equation:

40.0985: Determination of Method 2 Soil Standards Considering Leaching Potential

MCP Method 1 Soil Standards consider both the risks associated with direct contact with the contaminated soil and the potential for the oil and/or hazardous material to leach to groundwater. The leaching component of the MCP Method 1 Soil Standards can be modified or eliminated in Method 2 considering site-specific information. The direct contact-exposure component of the standard shall not be adjusted in this Method.

(1) The development of alternative leaching-based soil concentrations or the determination that leaching-based concentrations are not applicable shall be based upon information which is scientifically justified and completely documented.

(2) When developing alternative leaching-based concentrations in soil, alternative values shall be developed for each oil and hazardous material and for each applicable groundwater category. Demonstrations that the leaching-based component of the Method 1 soil standards is not applicable may be made on a chemical-by-chemical basis or for the site as a whole, depending upon the information relevant to that determination.

(3) The following methods may be used to demonstrate that the concentrations of oil and/or hazardous material in soil at the disposal site now and in the foreseeable future will result in compliance with all applicable MCP Method 1 or 2 Groundwater Standards:
(a) transport and fate modeling that incorporates site-specific information on source mass and subsurface hydrogeological conditions; and/or
(b) laboratory tests that demonstrate, under site conditions, the oil and/or hazardous material in the soil will not leach to groundwater at levels which exceed the applicable MCP Method 1 or 2 Groundwater Standards.

(4) For each combination of soil category (S-1, S-2, and S-3) and groundwater category (GW-1, GW-2, and GW-3), the lower of the following is the applicable MCP Method 2 Soil Standard for the oil and/or hazardous material:
(a) The leaching-based soil concentration identified in 310 CMR 40.0985(2) specific to the groundwater category, and
(b) The direct contact exposure-based concentration specific to the soil category, listed in Table 5 in 310 CMR 40.0985(6). The direct contact standard is applicable when it is determined that the leaching-based component of the Method 1 standard is not applicable per 310 CMR 40.0985(2).

(5) Groundwater monitoring shall demonstrate that residual soil contamination is not and will not result in groundwater concentrations greater than the applicable MCP Method 1 or 2 Groundwater Standards. The duration of required monitoring shall depend on the source mass, the mobility of the oil and/or hazardous material, and subsurface conditions.

(6) Table 5 lists the Direct Contact Exposure-Based Soil Concentrations.

40.0985: continued

310 CMR 40.0985(6)

TABLE 5

MCP Method 2: DIRECT CONTACT EXPOSURE-BASED SOIL CONCENTRATIONS APPLICABLE TO THE SPECIFIED SOIL CATEGORY.

Oil and/or Hazardous Material	CAS Number	Soil Category S-1 µg/g (ppm)	Soil Category S-2 µg/g (ppm)	Soil Category S-3 µg/g (ppm)
ACENAPHTHENE	83329	1,000	2,500	5,000
ACENAPHTHYLENE	208968	100	2,500	2,500
ACETONE	67641	500	1,000	2,500
ALDRIN	309002	0.03	0.04	0.1
ANTHRACENE	120127	1,000	2,500	5,000
ANTIMONY	7440360	10	40	40
ARSENIC	7440382	30	30	30
BARIUM	7440393	1,000	2,500	5,000
BENZENE	71432	40	60	200
BENZO(a)ANTHRACENE	56553	0.7	1	4
BENZO(a)PYRENE	50328	0.7	0.7	0.7
BENZO(b)FLUORANTHENE	205992	0.7	1	4
BENZO(g,h,i)PERYLENE	191242	1,000	2,500	2,500
BENZO(k)FLUORANTHENE	207089	7	10	40
BERYLLIUM	7440417	0.7	0.8	3
BIPHENYL, 1,1-	92524	1,000	2,500	3,000
BIS(2-CHLOROETHYL)ETHER	111444	0.7	0.7	0.7
BIS(2-CHLOROISOPROPYL)ETHER	39638329	2	3	9
BIS(2-ETHYLHEXYL)PHTHALATE	117817	200	300	1,000
BROMODICHLOROMETHANE	75274	20	20	90
BROMOFORM	75252	100	200	700
BROMOMETHANE	74839	50	200	700
CADMIUM	7440439	30	80	80
CARBON TETRACHLORIDE	56235	7	10	40
CHLORDANE	57749	1	2	5
CHLOROANILINE, p-	106478	100	400	400
CHLOROBENZENE	108907	500	1,000	2,500
CHLOROFORM	67663	200	200	500
CHLOROPHENOL, 2-	95578	100	200	1,000
CHROMIUM (TOTAL)	7440473	1,000	2,500	5,000
CHROMIUM (III)	16065831	1,000	2,500	5,000
CHROMIUM (VI)	18540299	200	600	1,000
CHRYSENE	218019	7	10	40
CYANIDE *	57125	100	100	400
DIBENZO(a,h)ANTHRACENE	53703	0.7	0.7	0.8
DIBROMOCHLOROMETHANE	124481	10	20	70
DICHLOROBENZENE, 1,2- (o-DCB)	95501	100	500	500
DICHLOROBENZENE, 1,3- (m-DCB)	541731	100	500	500
DICHLOROBENZENE, 1,4- (p-DCB)	106467	40	60	200
DICHLOROBENZIDINE, 3,3'-	91941	1	1	3
DDD	72548	2	3	10
DDE	72559	2	2	9
DDT	50293	2	2	9
DICHLOROETHANE, 1,1-	75343	100	500	500
DICHLOROETHANE, 1,2-	107062	10	20	60
DICHLOROETHYLENE, 1,1-	75354	2	2	9
DICHLOROETHYLENE, CIS-1,2-	156592	100	500	500
DICHLOROETHYLENE, TRANS-1,2-	156605	500	1,000	2,500
DICHLOROPHENOL, 2,4-	120832	40	90	90
DICHLOROPROPANE, 1,2-	78875	8	10	40
DICHLOROPROPENE, 1,3-	542756	3	5	20
DIELDRIN	60571	0.03	0.04	0.2
DIETHYL PHTHALATE	84662	1,000	2,500	5,000
DIMETHYL PHTHALATE	131113	1,000	2,500	5,000
DIMETHYLPHENOL, 2,4-	105679	400	900	4,000
DINITROPHENOL, 2,4-	51285	40	90	90
DINITROTOLUENE, 2,4-	121142	1	2	7
DIOXIN **	1746016	4E-06	6E-06	2E-05
ENDOSULFAN	115297	100	400	400

40.0985: continued

310 CMR 40.0985(6)

TABLE 5

MCP Method 2: DIRECT CONTACT EXPOSURE-BASED SOIL CONCENTRATIONS APPLICABLE TO THE SPECIFIED SOIL CATEGORY.

Oil and/or Hazardous Material	**CAS Number**	**Soil Category S-1 µg/g (ppm)**	**Soil Category S-2 µg/g (ppm)**	**Soil Category S-3 µg/g (ppm)**
ENDRIN	72208	6	10	10
ETHYLBENZENE	100414	500	1,000	2,500
ETHYLENE DIBROMIDE	106934	0.01	0.02	0.07
FLUORANTHENE	206440	1,000	2,000	5,000
FLUORENE	86737	1,000	2.000	5,000
HEPTACHLOR	76448	0.1	0.2	0.7
HEPTACHLOR EPOXIDE	1024573	0.06	0.09	0.3
HEXACHLOROBENZENE	118741	0.7	0.8	3
HEXACHLOROBUTADIENE	87683	5	10	40
HEXACHLOROCYCLOHEXANE, GAMMA	58899	0.4	0.6	2
HEXACHLOROETHANE	67721	6	10	50
INDENO(1,2,3-cd)PYRENE	193395	0.7	1	4
LEAD	7439921	300	600	600
MERCURY	7439976	20	60	60
METHOXYCHLOR	72435	100	300	300
METHYL ETHYL KETONE	78933	500	1,000	2,500
METHYL ISOBUTYL KETONE	108101	100	500	1,000
METHYL MERCURY	22967926	2	6	8
METHYL t-BUTYL ETHER	1634044	100	500	500
METHYLENE CHLORIDE	75092	100	200	700
METHYLNAPHTHALENE, 2-	91576	1,000	2,500	2,500
NAPHTHALENE	91203	100	2,500	2.500
NICKEL	7440020	300	700	700
PENTACHLOROPHENOL	87865	7	10	40
PHENANTHRENE	85018	1,000	2,500	2,500
PHENOL	108952	500	1,000	2,500
POLYCHLORINATED BIPHENYLS (PCBs)	1336363	2	2	2
PYRENE	129000	700	2,000	5,000
SELENIUM	7782492	400	2,500	2,500
SILVER	7440224	100	200	200
STYRENE	100425	20	30	100
TETRACHLOROETHANE, 1,1,1,2-	630206	4	5	20
TETRACHLOROETHANE, 1,1,2,2-	79345	0.5	0.6	2
TETRACHLOROETHYLENE	127184	20	30	100
THALLIUM	7440280	8	30	100
TOLUENE	108883	500	1,000	2,500
TOTAL PETROLEUM HYDROCARBON †	NA	500	2,500	5,000

40.0985: continued

310 CMR 40.0985(6)

TABLE 5

MCP Method 2: DIRECT CONTACT EXPOSURE-BASED SOIL CONCENTRATIONS APPLICABLE TO THE SPECIFIED SOIL CATEGORY.

Oil and/or Hazardous Material	CAS Number	Soil Category S-1 µg/g (ppm)	Soil Category S-2 µg/g (ppm)	Soil Category S-3 µg/g (ppm)
TRICHLOROBENZENE, 1,2,4-	120821	400	1,000	1,000
TRICHLOROETHANE, 1,1,1-	71556	100	500	500
TRICHLOROETHANE, 1,1,2-	79005	2	3	10
TRICHLOROETHYLENE	79016	70	100	500
TRICHLOROPHENOL, 2,4,5-	95954	1,000	2,500	5,000
TRICHLOROPHENOL 2,4,6-	88062	40	60	200
VANADIUM	7440622	400	2,000	2,000
VINYL CHLORIDE	75014	0.3	0.5	2
XYLENES (mixed isomers)	1330207	500	1,000	2,500
ZINC	7440666	2,500	2,500	5,000

NOTE: All concentrations of oil and/or hazardous material in soil are calculated and presented on a dry weight/dry weight basis.
NA - Not Applicable
* - Cyanide expressed as free, or physiologically available cyanide.
** - Dioxins expressed as 2,3,7,8-TCDD equivalents.
† - Total Petroleum Hydrocarbon as measured using standard analytical methods or methods which provide toxicity-weighted concentrations, such as the MADEP TPH approach. This standard does <u>not</u> address and is <u>not</u> sufficient to evaluate specific chemicals which may be present in some petroleum products and which have promulgated MCP standards (such as benzene, toluene, ethylbenzene, xylenes and polycyclic aromatic hydrocarbons (PAHs)).

40.0986: Determination of Method 2 GW-2 Standards.

(1) MCP Method 1 GW-2 Standards consider the potential for oil and/or hazardous material to volatilize from the groundwater and migrate to indoor air. These standards may be modified under Method 2, or a determination may be made that one or more GW-2 standards are not applicable, based upon site-specific conditions. Modifications of a standard will result in a proposed MCP Method 2 GW-2 Standard. Proposed Method 2 standards or the determination that one or more GW-2 standards are not applicable shall be scientifically justified and sufficiently documented to demonstrate that the Response Action Performance Standard, described in 310 CMR 40.0193 has been met.

(2) An MCP Method 2 GW-2 Standard shall be protective of migration of oil and/or hazardous material into indoor air. The presence of oil and/or hazardous material in the groundwater at the proposed MCP Method 2 GW-2 Standard below or near a building shall not result in indoor air concentrations which pose a significant risk of harm to health, public welfare or the environment. The MCP Method 2 GW-2 Standard may be greater or less than the corresponding MCP Method 1 GW-2 Standard, or it may be determined that the Method 1 Standard is not applicable, based upon site-specific conditions. The development of such standards shall be documented by:

(a) transport and fate modeling that incorporates site-specific information on source, hydrogeological, and building conditions, and which demonstrates that the oil and/or hazardous material in the soil will not infiltrate to indoor air and result in significant risk of harm to health, public welfare or the environment; and/or

(b) soil gas characterization data, indoor air characterization data, and other information and data resulting from field investigation conducted at and proximate to the disposal site.

40.0995: continued

3. Risk Characterization. In the final phase of the risk assessment, the results of the environmental exposure and effects analysis shall be used to evaluate the likelihood of adverse ecological effects. The documentation of the Risk Characterization shall include a summary of assumptions, scientific uncertainties, strengths and weaknesses of the analyses, and justification of conclusions reached concerning the ecological significance of the risks.

(c) The Stage II Environmental Risk Characterization may also include the development of an environmental risk-based guideline for oil and/or hazardous material for which no environmental standards exists, and to the extent sufficient information concerning the environmental risks posed by the oil and/or hazardous material is available. Such guidelines shall be developed in a manner consistent with scientifically acceptable practices, taking into account guidance published by the Department or the U.S. Environmental Protection Agency, and information from the scientific literature, laboratory studies or field studies.

(d) Conclusions. A level of no significant risk of harm to the environment exists, or has been achieved, if:

1. there is no physical evidence of a continuing release of oil and/or hazardous material at or from the disposal site to surface waters and wetlands which significantly affects Environmental Receptors; and

2. there is no evidence of biologically significant harm (at the subpopulation, community, or system-wide level) known or believed to be associated with current or foreseeable future exposure of wildlife, fish, shellfish or other aquatic biota to oil and/or hazardous material at or from the disposal site; and

3. concentrations of oil and/or hazardous material at or from the disposal site do not and are not likely to exceed any applicable or suitably analogous environmental standards which have been formally promulgated, including Massachusetts Surface Water Quality Standards promulgated at 314 CMR 4.00 at current and reasonably foreseeable Exposure Points; and

4. there is no indication of the potential for biologically significant harm (at the subpopulation, community, or system-wide level), either currently or for any foreseeable period of time, to Environmental Receptors considering their potential exposures to oil and/or hazardous material and the toxicity of the OHM.

(5) The risk of harm to the environment shall also be characterized by comparing the concentration of each oil or hazardous material to the Upper Concentration Limits in Soil and Groundwater, as described in 310 CMR 40.0996.

(6) The documentation of the Method 3 environmental Risk Characterization shall clearly state whether or not a condition of no significant risk of harm to environmental resources, biota and habitats exists or has been achieved at the disposal site.

40.0996: Method 3 Upper Concentration Limits

(1) Upper Concentration Limits in soil and groundwater are concentrations of oil and/or hazardous material which, if exceeded, indicate the potential for significant risk of harm to public welfare and the environment under future conditions. If a condition of No Significant Risk has not been achieved for future conditions but all substantial hazards have been eliminated, then the site may be eligible for a Class C RAO described in 310 CMR 40.1050.

(2) The risk of harm to public welfare and the environment shall also be characterized by comparing the arithmetic mean of the concentration of the chemical in soil and groundwater to the Upper Concentration Limits in Soil and Groundwater listed in 310 CMR 40.0996(5). If one or more hot spots have been identified at the site pursuant to 310 CMR 40.0924(2), then the concentrations within each hot spot shall also be compared to the Upper Concentration Limits.

(a) A level of No Significant Risk of harm to public welfare and to the environment exists or has been achieved for both current and future conditions if no concentration of oil and/or hazardous material exceeds an applicable Upper Concentration Limit.

40.0996: continued

(b) A level of No Significant Risk of harm to public welfare and to the environment exists or has been achieved for current conditions, but does not yet exist for future conditions if the concentration of one or more oil and/or hazardous materials exceeds an applicable Upper Concentration Limit. The disposal site may, however, meet the conditions of a Class C Response Action Outcome if all other requirements for a Class C Response Action Outcome are satisfied.

(3) Upper Concentration Limits are not applicable to soil which has been permanently immobilized or fixated as part of a remedial response action.

(4) The presence of non-aqueous phase liquids (NAPL) having a thickness equal to or greater than ½ inch in any environmental medium shall be considered a level which exceeds Upper Concentration Limits.

(5) Table 6 lists the Upper Concentration Limits in Groundwater and Soil.

310 CMR 40.0996(5)

TABLE 6

MCP Method 3:

UPPER CONCENTRATION LIMITS (UCLs) IN GROUNDWATER AND SOIL

Oil and/or Hazardous Material	CAS Number	UCLs IN GROUNDWATER µg/L (ppb)	UCLs IN SOIL µg/g (ppm)
ACENAPHTHENE	83329	2,000	10,000
ACENAPHTHYLENE	208968	2,000	10,000
ACETONE	67641	100,000	10,000
ALDRIN	309002	9	1
ANTHRACENE	120127	600	10,000
ANTIMONY	7440360	3,000	400
ARSENIC	7440382	4,000	300
BARIUM	7440393	100,000	10,000
BENZENE	71432	70,000	2,000
BENZO(a)ANTHRACENE	56553	5	100
BENZO(a)PYRENE	50328	2	100
BENZO(b)FLUORANTHENE	205992	7	100
BENZO(g,h,i)PERYLENE	191242	0.5	10,000
BENZO(k)FLUORANTHENE	207089	1	400
BERYLLIUM	7440417	500	30
BIPHENYL, 1,1-	92524	4,000	10,000
BIS(2-CHLOROETHYL)ETHER	111444	100,000	7
BIS(2-CHLOROISOPROPYL)ETHER	39638329	100,000	90
BIS(2-ETHYLHEXYL)PHTHALATE	117817	700	10,000
BROMODICHLOROMETHANE	75274	100,000	900
BROMOFORM	75252	100,000	7,000
BROMOMETHANE	74839	100,000	7,000
CADMIUM	7440439	100	800
CARBON TETRACHLORIDE	56235	100,000	400
CHLORDANE	57749	20	50
CHLOROANILINE, p-	106478	100,000	4,000
CHLOROBENZENE	108907	10,000	10,000
CHLOROFORM	67663	100,000	5,000
CHLOROPHENOL, 2-	95578	100,000	10,000
CHROMIUM (TOTAL)	7440473	20,000	10,000
CHROMIUM (III)	16065831	20,000	10,000
CHROMIUM (VI)	18540299	1,000	10,000
CHRYSENE	218019	3	400
CYANIDE *	57125	2,000	4,000

40.0996: continued

310 CMR 40.0996(5)

TABLE 6

MCP Method 3:

UPPER CONCENTRATION LIMITS (UCLs) IN GROUNDWATER AND SOIL

Oil and/or Hazardous Material	CAS Number	UCLs IN GROUNDWATER µg/L (ppb)	UCLs IN SOIL µg/g (ppm)
DIBENZO(a,h)ANTHRACENE	53703	0.5	100
DIBROMOCHLOROMETHANE	124481	100,000	700
DICHLOROBENZENE, 1,2- (o-DCB)	95501	100,000	5,000
DICHLOROBENZENE, 1,3- (m-DCB)	541731	100,000	5,000
DICHLOROBENZENE, 1,4- (p-DCB)	106467	40,000	2,000
DICHLOROBENZIDINE, 3,3'-	91941	2,000	30
DDD	72548	60	100
DDE	72559	20	90
DDT	50293	3	90
DICHLOROETHANE, 1,1-	75343	100,000	5,000
DICHLOROETHANE, 1,2-	107062	100,000	600
DICHLOROETHYLENE, 1,1-	75354	100,000	90
DICHLOROETHYLENE, CIS-1,2-	156592	100,000	5,000
DICHLOROETHYLENE, TRANS-1,2-	156605	100,000	10,000
DICHLOROPHENOL, 2,4-	120832	40,000	900
DICHLOROPROPANE, 1,2-	78875	100,000	400
DICHLOROPROPENE, 1,3-	542756	20,000	200
DIELDRIN	60571	1	2
DIETHYL PHTHALATE	84662	60,000	10,000
DIMETHYL PHTHALATE	131113	100,000	10,000
DIMETHYLPHENOL, 2,4-	105679	100,000	10,000
DINITROPHENOL, 2,4-	51285	20,000	900
DINITROTOLUENE, 2,4-	121142	20,000	70
DIOXIN **	1746016	1E-03	2E-04
ENDOSULFAN	115297	150	4,000
ENDRIN	72208	50	100
ETHYLBENZENE	100414	100,000	10,000
ETHYLENE DIBROMIDE	106934	100,000	0.7
FLUORANTHENE	206440	100	10,000
FLUORENE	86737	1,000	10,000
HEPTACHLOR	76448	10	7
HEPTACHLOR EPOXIDE	1024573	20	3
HEXACHLOROBENZENE	118741	60	30
HEXACHLOROBUTADIENE	87683	900	400
HEXACHLOROCYCLOHEXANE, GAMMA	58899	8	20
HEXACHLOROETHANE	67721	50,000	500
INDENO(1,2,3-cd)PYRENE	193395	0.5	100
LEAD	7439921	300	6,000
MERCURY	7439976	20	600
METHOXYCHLOR	72435	40	3,000
METHYL ETHYL KETONE	78933	100,000	10,000
METHYL ISOBUTYL KETONE	108101	100,000	10,000
METHYL MERCURY	22967926	7	80
METHYL t-BUTYL ETHER	1634044	100,000	5,000
METHYLENE CHLORIDE	75092	100,000	7,000
METHYLNAPHTHALENE, 2-	91576	10,000	10,000
NAPHTHALENE	91203	20,000	10,000
NICKEL	7440020	1,000	7,000
PENTACHLOROPHENOL	87865	800	400
PHENANTHRENE	85018	400	10,000
PHENOL	108952	100,000	10,000
POLYCHLORINATED BIPHENYLS (PCBs) ***	1336363	5	100
PYRENE	129000	80	10,000
SELENIUM	7782492	800	10,000

40.0996: continued

310 CMR 40.0996(5)

TABLE 6

MCP Method 3:

**UPPER CONCENTRATION LIMITS (UCLs)
IN GROUNDWATER AND SOIL**

Oil and/or Hazardous Material	CAS Number	UCLs IN GROUNDWATER µg/L (ppb)	UCLs IN SOIL µg/g (ppm)
SILVER	7440224	400	2,000
STYRENE	100425	100,000	1,000
TETRACHLOROETHANE, 1,1,1,2-	630206	100,000	200
TETRACHLOROETHANE, 1,1,2,2-	79345	100,000	20
TETRACHLOROETHYLENE	127184	50,000	1,000
THALLIUM	7440280	4,000	1,000
TOLUENE	108883	100,000	10,000
TOTAL PETROLEUM HYDROCARBON †	NA	100,000	10,000
TRICHLOROBENZENE, 1,2,4-	120821	50,000	10,000
TRICHLOROETHANE, 1,1,1-	71556	100,000	5,000
TRICHLOROETHANE, 1,1,2-	79005	100,000	100
TRICHLOROETHYLENE	79016	100,000	5,000
TRICHLOROPHENOL, 2,4,5-	95954	2,000	10,000
TRICHLOROPHENOL 2,4,6-	88062	100,000	2,000
VANADIUM	7440622	20,000	10,000
VINYL CHLORIDE	75014	600	20
XYLENES (mixed isomers)	1330207	100,000	10,000
ZINC	7440666	20,000	10,000

NOTE: All concentrations of oil and/or hazardous material in soil are calculated and presented on a dry weight/dry weight basis.
NA - Not Applicable
* - Cyanide expressed as free, or physiologically available cyanide.
** - Dioxins expressed as 2,3,7,8-TCDD equivalents.
*** - Federal requirements under the Toxic Substances Control Act (TSCA) and/or Federal regulatory provisions/policies may vary from the Upper Concentration Limit in soils for Polychlorinated Biphenyls.
† - Total Petroleum Hydrocarbon as measured using standard analytical methods or the MADEP TPH approach. This standard does not address and is not sufficient to evaluate specific chemicals which may be present in some petroleum products and which have promulgated MCP standards (such as benzene, toluene, ethylbenzene, xylenes and polycyclic aromatic hydrocarbons (PAHs)).

SUBPART J: RESPONSE ACTION OUTCOMES

40.1000: Response Action Outcomes

310 CMR 40.1001 through 40.1099 shall be cited collectively as 310 CMR 40.1000.

40.1001: Purpose

(1) 310 CMR 40.1000 establishes requirements and procedures for:
(a) determining when the response actions taken at a site where there has been a release or threat of release of oil and/or hazardous material to the environment are sufficient to meet the requirements of a Response Action Outcome (RAO);
(b) implementing Activity and Use Limitations;
(c) determining the class of RAO achieved as the result of response actions taken at a site or disposal site; and
(d) documenting and supporting the RAO in a Response Action Outcome Statement.

40.1002: Applicability

The requirements contained in 310 CMR 40.1000 are applicable to all releases and threats of release of oil and/or hazardous material which require notification to the Department under the provisions of 310 CMR 40.0300 or are required to comply with these regulations pursuant to 310 CMR 40.0600, except where a site or disposal site is adequately regulated pursuant to 310 CMR 40.0110.

40.1003: General Provisions for Response Action Outcomes

(1) All necessary and required response actions under 310 CMR 40.0000 shall not have been conducted at a site or disposal site unless and until a level of No Significant Risk exists or has been achieved and a Class A or Class B Response Action Outcome has been achieved in accordance with 310 CMR 40.1000.

(2) RPs, PRPs and Other Persons conducting response actions at any site for which a release or threat of release of oil and/or hazardous material has been reported pursuant to 310 CMR 40.0300 shall achieve a Response Action Outcome and submit a Response Action Outcome Statement to the Department in accordance with the requirements of 310 CMR 40.1000 within the deadlines established in 310 CMR 40.0500, or any other deadline established under 310 CMR 40.0000 or any determination or order issued by the Department.

(3) A Response Action Outcome may be achieved and a Response Action Outcome Statement may be submitted for an entire site, disposal site, or a portion of a disposal site.

(4) The location of a site for which a Response Action Outcome applies shall be clearly and accurately identified in the Response Action Outcome Statement. The boundaries of a disposal site or portion of a disposal site for which a Response Action Outcome applies shall be clearly and accurately delineated and provided in documentation submitted with the Response Action Outcome Statement.

(5) A Class A or Class B Response Action Outcome shall not be achieved unless and until each source of oil and/or hazardous material which is resulting or is likely to result in an increase in concentrations of oil and/or hazardous material in an environmental medium, either as a consequence of a direct discharge or through intermedia transfer of oil and/or hazardous material, is eliminated or controlled.

(a) Such sources may include, without limitation:

1. leaking storage tanks, vessels, drums and other containers;
2. dry wells or wastewater disposal systems which are not in compliance with regulations governing discharges from those systems;
3. contaminated fill, soil, sediment and waste deposits; and
4. non-aqueous phase liquids.

(b) For the purposes of 310 CMR 40.1003(5), the downgradient leading edge of a plume of oil and/or hazardous material dissolved in and migrating with groundwater shall not, in and of itself, be considered a source of oil and/or hazardous material.

40.1004: Performance Standards for Response Action Outcomes

(1) A Response Action Outcome shall be supported by assessments and evaluations conducted pursuant to 310 CMR 40.0000 which:

(a) are of sufficient scope, detail, and level of effort to characterize the risk of harm to health, safety, public welfare and the environment posed by the site or disposal site pursuant to 310 CMR 40.0900;

(b) are consistent with the Response Action Performance Standard described in 310 CMR 40.0191;

(c) are commensurate with the nature and extent of the release or threat of release and complexity of site conditions;

(d) demonstrate that all requirements of the applicable class of Response Action Outcome pursuant to 310 CMR 40.1000 have been met; and

(e) conform with applicable requirements and procedures for conducting response actions specified in 310 CMR 40.0000.

40.1005: Defining "Foreseeable Period of Time" for Purposes of a Response Action Outcome

(1) Each Class A and Class B Response Action Outcome shall ensure a level of control of each identified substance of concern at a site or in the surrounding environment such that no such substance of concern shall present a significant risk of harm to health, safety, public welfare or the environment during any foreseeable period of time.

40.1005: continued

(2) "Any foreseeable period of time" shall mean the period of time during which the conditions for achieving and maintaining a level of No Significant Risk upon which a Class A or Class B RAO is based will remain in effect. Any foreseeable period of time:

(a) for Class A-1, A-2 or B-1 RAOs shall be an unlimited period of time;

(b) for Class B-2 RAOs shall be that period of time that Activity and Use Limitations will remain in effect; and

(c) for Class A-3 RAOs shall be that period of time that Activity and Use Limitations will remain in effect or the design life of any remedial systems necessary to maintain a condition of No Significant Risk, whichever is shorter.

40.1012: Application of Activity and Use Limitations

(1) The purpose of an Activity and Use Limitation is to narrow the scope of exposure assumptions used to characterize risks to human health from a release pursuant to 310 CMR 40.0900, by specifying activities and uses that will be prohibited and allowed at the disposal site in the future. This section establishes rules for determining when an Activity and Use Limitation must be used, when one cannot be used, and when one may be a factor to be considered in appropriately characterizing soil and groundwater at a disposal site, pursuant to 310 CMR 40.0923(3).

(2) Except as provided in 310 CMR 40.1012(3), Activity and Use Limitations shall be required:

(a) at all disposal sites or portions of disposal sites for which a Response Action Outcome and the risk characterization pursuant to 310 CMR 40.0900 used to support the RAO are based upon the restriction or limitation of Site Activities and Uses to achieve or maintain a level of No Significant Risk including:

1. any disposal site or portion of a disposal site for which a Response Action Outcome is based on MCP Method 1 or 2 Soil Standards and the Exposure Point Concentrations of oil and/or hazardous material exceed the S-1 standards but meet applicable S-2 or S-3 standards; and

2. any disposal site or portion of a disposal site where a Method 3 Risk Characterization performed pursuant to 310 CMR 40.0990 relies on reduced exposure potential due to the assumption of limited site use;

(b) at all disposal sites for which a Response Action Outcome relies upon Exposure Pathway elimination measures to prevent exposure to levels of oil and/or hazardous material that would otherwise pose a significant risk of harm to health, safety, public welfare or the environment; and

(c) at all sites where an existing private well(s) has been abandoned and the property(ies) served by the private water supply has been connected to a public water supply system in accordance with the provisions of 310 CMR 40.0932(5)(d).

(3) Activity and Use Limitations shall not be required but may be used to provide notice of the existence of residual contamination to future holders of an interest(s) in property that is located within:

(a) disposal sites or portions of disposal sites where the concentrations of oil and/or hazardous material have been reduced to background or where the requirements described in 310 CMR 40.0923(3)(b) have been met;

(b) disposal sites or portions of disposal sites where residual contamination is located at a depth greater than 15 feet from the ground surface;

(c) any portion of a disposal site where residual contamination is located within a public way or within a rail right-of-way;

(d) disposal sites or portions of a disposal site for which potential risks are characterized using Method 1 (310 CMR 40.0970) if the levels of oil and/or hazardous material in soil are at or below the applicable Method 1 category S-1 soil standards listed in 310 CMR 40.0975(6);

(e) at disposal sites or portions of a disposal site for which potential risks are characterized using Method 2 (310 CMR 40.0980) if the levels of oil and/or hazardous material are at of below the applicable category S-1 soil standards identified in 310 CMR 40.0984 and 40.0985;

EPA Region III Guidance on Handling Chemical Concentration Data Near the Detection Limit in Risk Assessments

Roy L. Smith, Ph.D.

Interim Final: November 4, 1991

Statement of the problem

Risk assessments often inappropriately report and handle data near the limits of detection. Common errors include (1) omission of detection limits, (2) failure to define detection limits which are reported, and (3) unjustified treatment of non-detects as zero. This guidance is intended to improve the quality and consistency of handling of data near the detection limit in risk assessments done in Region III.

A. Reporting DLs. The practice of omitting information on DLs from risk assessments is inappropriate, both technically and ethically, because it conceals important uncertainties about potential levels of undetected risk. For example, failure to detect trichloroethene in drinking water at a DL of 50 parts per billion does not establish acceptable levels of health risk; failure to detect TCE at 0.05 ppb does. If risk assessors neglect to consider DLs for analytical data, they may overlook serious health threats. Furthermore, DLs should appear both in data summary tables in the body of the risk assessment, and in tables of raw data in appendices.

In a generic sense, there are two types of analytical lower limits: detection limits (DLs) and quantitation limits (QLs). The DL is the lowest concentration that can reliably be distinguished from zero, but is not quantifiable with acceptable precision. At the DL, the analyte is proven to be present, but its reported concentration is an estimate. The QL is the lowest concentration which can be not only detected, but also quantified with a specified degree of precision. At the QL, the analyte is both proven present and measured reliably.

B. Non-detection v. zero concentration. The routine assump tion that site-related contaminants, if undetected, are absent from samples is often unduly optimistic. Some frequently-encountered carcinogens (e.g., vinyl chloride and tetrachloroethene in drinking water, beryllium in soil) are significant potential health risks at levels below DLs. Risk assessors should use professional judgment, augmented by the decision path described below, to decide if hazardous contaminants should be assumed present at levels below the DL.

Existing Guidance

Section 5.4 of the EPA *Risk Assessment Guidance for Superfund* (RAGS) IA recommends that all data qualifiers should be reported in the exposure assessment,

and that their implications be considered before the data are used for risk assessment. Section 6.5.1 suggests use of models when monitoring data are restricted by the limit of quantitation, and Section 5.3.1 contains guidance for re-analyzing samples and determining which data should be treated qualitatively.

EPA's *Guidance for Data Useability in Risk Assessment* (DURA) (October, 1990), Section 3.3.4, subdivides generic DLs and QLs, describing six different lower analytical limits. (1) The instrument detection limit (IDL) is three times the standard deviation of seven replicate analyses at the lowest concentration of a laboratory standard that is statistically different from a blank. (2) The method detection limit (MDL) is three times the standard deviation of seven replicate spiked samples handled as environmental samples. (3) The sample quantitation limit (SQL) is the MDL corrected for sample dilution and other sample-specific adjustments. (4) The contract required detection limit (CRDL) is the SQL which CLP laboratories are required to maintain for inorganic analytes. (5) The contract required quantitation limit (CRQL) is the SQL which CLP laboratories must maintain for organic analytes. (6) The limit of quantitation (LOQ) is the level above which analytes may be quantified with a specified precision, often +/- 30%. This precision is usually assumed to occur at ten times the standard deviation measured for the IDL. Section 4.2 of DURA describes a strategy for selecting appropriate analytical methods, which includes consideration of risk at the detection limit.

However, even with an optimum sample and analysis plan, risk assessors must still confront situations where significant risks can occur below the detection limit. Neither RAGS nor DURA presents a procedure for assessing risks from undetected, but potentially present, compounds, nor do they suggest a specific reporting format for detection limits. This Region III guidance document addresses these gaps in national risk assessment guidance. It is intended to augment, not replace, national guidance.

Discussion and Recommendations

A. Reporting DLs. Risk assessments should include analytical limits in all data tables, including summary tables. One of the following should be reported for all undetected analytes, in order of preference: SQL, CRDL (or CRQL), and LOQ (as described in DURA). Each data table in the risk assessment should clearly describe which limits are reported, and define them.

Risk assessments should use the format shown below for all data tables. Undetected analytes should be reported as the DL (*i.e.,* either the SQL, CRDL/CRQL, or LOQ, in that order) with the code "U". Analytes detected above the DL, but below the QL, should be reported as an estimated concentration with the code "J".

Compound	Concentration in Sample (code)					
Sample #	123		456		789	
trichloroethene	0.1	(U)	15		0.9	(J
vinyl chloride	0.2	(U)	0.2	(U)	2.2	

tetrachloroethene	5.5	3.1	(J)	0.1	(U

Non-detects are reported as the sample quantitation limit, defined as three times the standard deviation of seven replicate spiked samples handled as environmental samples, corrected for sample dilution and other sample-specific adjustments.

B. Non-detection v. zero concentration. Risk assessors have the following methods to choose from, for handling data below the DL:

1. Non-Detects handled as DLs - In this highly conservative approach, all non-detects are assigned the value of the DL, the largest concentration of analyte that could be present but not detected. This method always produces a mean concentration which is biased high, and is not consistent with Region III's policy of using best science in risk assessments.

2. Non-Detects reported as zero - This is the best-case approach, in which all undetected chemicals are assumed absent. This method should be used only for specific chemicals which the risk assessor has determined are not likely to be present, using the decision path below.

3. Non-Detects reported as half the DL - This approach assumes that on the average all values between the DL and zero could be present, and that the average value of non-detects could be as high as half the detection limit. This method (or method 4, below) should be used for chemicals which the risk assessor has determined may be present below the DL, using the decision path below.

4. Statistical estimates of concentrations below the DL - Use of statistical methods to estimate concentrations below the DL is technically superior to method 3 above, but also requires considerably more effort and expertise than the three simpler methods. Also, these statistical methods are effective only for data sets having a high proportion of detects (typically, greater than 50%). Therefore, statistical predictions of concentrations below the DL (as described by Gilbert [1987] and reviewed by Helsel [1990]) are recommended only for compounds which significantly impact the risk assessment and for which data are adequate.

C. Decision Path. Summarizing the discussion above, method 1 (non-detects = DL) consistently overestimates concentrations below the DL, and should not be used. Risk assessors should use the following decision path to select among methods 2 (non-detects = 0), 3 (non-detects = DL/2), and 4 (specialized statistics) to achieve the least biased estimate of reasonable maximum exposure. The choice of method should be based on scientific judgment about whether: (1) the undetected substance poses a significant health risk at the DL, (2) the undetected substance might reasonably be present in that sample, (3) the treatment of non-detects will impact the risk estimates, and (4) the database is sufficient to support statistical analysis. The decision path below, followed by examples of appropriate selections, is recommended:

1. Is the compound present at a hazardous concentration in any site-related

sample?

If no, assume non-detects are zero; if yes, continue. (Note that if the compound is not present in any sample at a hazardous level (*e.g.*, 10-6 risk or a hazard quotient of 1), it probably should be dropped from the risk assessment.)

2. Was the sample taken down-gradient of (or, if no gradient exists, adjacent to) a detectable concentration of the chemical?

If no, assume non-detects are zero; if yes, continue.

3. Do the chemical's physical-chemical characteristics (e.g., water solubility, octanol-water partitioning, vapor pressure, Henry's law constant, biodegradability, etc.), permit it to reasonably be present in the sample? Are other site-related compounds with similar characteristics present in the sample?

If no (to both questions), assume non-detects are zero; if yes (to either question), continue.

4. Does the assumption that non-detects equal DL/2 significantly impact route-specific quantitative risk estimates?

If no, assume non-detects equal DL/2; if yes, consider using statistical methods to estimate concentrations below the DL for that exposure route, assuming data quality permits.

D. Examples.

1. TCE is present in groundwater on site at 500 g/l, a potentially hazardous concentration. Elevated TCE concentrations are measured upgradient of a residential well, but TCE is not detected in the residential well itself. Other site-related chlorinated VOCs are detected in the residential well. The detection limit for TCE was 5 g/l (equivalent to 5 x 10-6 risk under the exposure scenario in the risk assessment).

Decision path: Step 1 - continue; step 2 - continue; step 3 - continue; step 4 - assume non-detects are DL/2. If multiple well samples are available, and TCE is detected in some, consider using specialized statistical methods.

2. Chromium is present in on-site soils at 10,000 mg/kg, a potentially hazardous concentration under direct contact exposure. Chromium is not detected in an adjacent off-site soil sample, although other site-related metals are. The detection limit for chromium in soil is 0.1 mg/kg, well below a hazardous concentration under the exposure scenario in the risk assessment.

Decision path: Step 1 - continue; step 2 - continue; step 3 - continue; step 4 - assume non-detects are DL/2, because using specialized statistics will not appreciably change the risk.

3. PCBs are not detected in 20 on-site soil samples. There is no history of PCB

disposal at the site, and PCBs were not detected in any other medium.

Decision path: Step 1 - assume non-detects are zero.

4. Vinyl chloride, a site-related contaminant, is measured in surface water downstream of the site boundary at 10 g/l, a hazardous concentration for a resident receptor. Five hundred meters upstream of the site, vinyl chloride is not detected at a DL of 0.1 g/l.

Decision path: Step 1 - continue; step 2 - assume upgradient non-detects equal zero.

5. 2,3,7,8-TCDD is detected in an unfiltered monitoring well sample at 5 ng/l, a potentially hazardous concentration. The next downgradient well has no detectable TCDD. Pentachlorophenol, also detected in the first well, is not detected in the second.

Decision path: Step 1 - continue; step 2 - continue; step 3 - assume non-detects of both TCDD and PCP equal zero because of low mobility in groundwater.

References

EPA. 1990. Guidance for Data Useability in Risk Assessment. EPA/540/G-90/008.

EPA. 1989. Risk Assessment Guidance for Superfund. Volume I, Human Health Evaluation Manual (Part A). EPA/501/1-89/002.

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

Helsel, D.R. Less than obvious; statistical treatment of data below the detection limit. Environ. Sci. Technol 24(12);1767-1774.

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No. 7923

THE 1993 MASSACHUSETTS CONTINGENCY PLAN

RISK CHARACTERIZATION AND EVALUATION

How Clean Is Clean Enough?

Massachusetts Department of Environmental Protection
Thomas Powers, Acting Commissioner

Bureau of Waste Site Cleanup
James C. Colman, Assistant Commissioner

April 1994

...N

wealth's Waste Site Cleanup Program has been redesigned
accelerate cleanup of releases of oil and hazardous material
nt. Amendments to the Massachusetts Superfund La
quiring the redesigned Program were enacted in July, 1992.
th these amendments, the regulations for assessing and
ses of oil and hazardous material (the Massachusetts
or "MCP", which was originally promulgated in 1988) were
ed and became effective on October 1, 1993. In addition,
Registration has started to issue licenses for managing
cleanups to experts meeting the licensing requirements.
Site Professionals", or "LSPs", must be hired by those
nse actions to make sure that the actions are performed in
M.G.L. c.21E, the MCP and the Department's standards.

RISK CHARACTERIZATION

establishes the standard for "***How Clean Is Clean Enough?***":
are complete when a condition of **"No Significant Risk"** of
fety, public welfare, or the environment exists or has been
site where a release has occurred. This standard requires
oth current and reasonably foreseeable uses of a site and
ea. In addition, the statute requires that a cleanup reach
azardous material that would exist in the absence of the
asible. This basic standard has not been changed in the
ts to the statute.

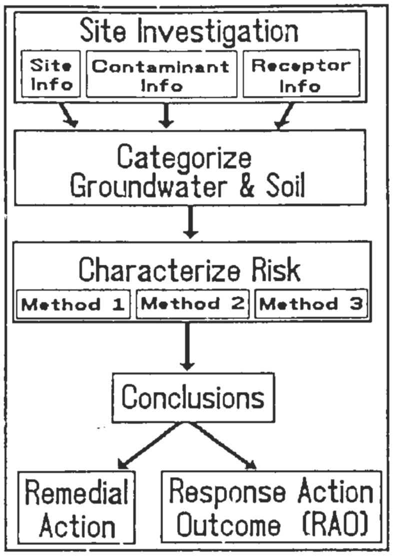
rization is the process of describing and evaluating the risk
and it is performed to determine whether or not further
essary. The 1993 MCP provides three options for defining
ficant risk" or "how clean is clean enough": **Method 1** uses
ndards for more than 100 common chemicals in soil and
thod 2 allows for some adjustments in these standards to
c conditions; and **Method 3** allows cleanup requirement
on the basis of a site-specific risk assessment. With some
ucting response actions can choose among these methods.
re described in Subpart I of the new MCP (310 CMR

rization is also used to identify site conditions which would
t risk of harm to health, safety, public welfare or the
se conditions were to exist *for even a short period of time*.

Such situations are considered to be **Imminent Hazards** und
and **Immediate Response Actions** are required to addres
conditions.

INFORMATION REQUIRED FOR RISK CHARACTERIZATION

An adequate site investigation is a prerequisite to risk characte
When describing site risks and determining their significar
following questions must be answered:



The validity of the conclusions reached concerning ie need for further remediation directly depends upon the quality of the site investigation.

Who **could be expose**
contamination? All of the
and the environment whi
be affected by contaminar
the disposal site are co
when identifying the **hun**
environmental receptors.
evaluation should focus
people, biota and habita
likely to be present and
at the site, taking into acc
only the current use of t
but also any expected futu
of the site and the surr
area. Receptors can
children, adults, workers,
plants and wetlands.

Where **are the receptors coming into contact w**
contaminants? The place where a receptor comes into cont
the oil or hazardous material is known as the **exposure poi**
is very important because the concentrations of oil or ha
materials - and the risks resulting from exposure t
concentrations - are measured and evaluated at the e
points, even if the exposure points are not at the disposal si
If the receptor is not physically at the disposal site, there
a **migration pathway** or a way for the oil or hazardous ma
travel to the receptor. Common migration pathways
groundwater and air.

;s of oil or hazardous materials are present and in what systematic assessment of site conditions examines the ypes of oil or hazardous materials present at the disposal and ground or surface water are the **environmental media** xamined. Contaminants may be present in one or mor concentration of a contaminant at the location where contact the material is the **exposure point concentration.**

ld the contaminants get to people or the environment? can enter a human body, animal or plant in a variety of rticular way in which a contaminant enters the organism is **te of exposure.** Common examples of routes of exposure **ng** contaminated groundwater, **absorbing** contaminants kin, and **breathing** them in the air.

e risk that a disposal site presents depends on the types, oncentrations of the oil or hazardous materials (some hazardous than others), the length of time someone may contaminant, the route of exposure, and the sensitivity of , the elderly, pregnant women and children are often more n contaminants than other receptors).

hes **Soil and Groundwater Categories** based upon the potential may result from the presence of oil or hazardous material in contaminated media. Once the soil and groundwater at a site ized, applicable standards can be identified.

categories span a range from *high exposure potential:* **Category** surficial soil in residential neighborhoods) to *low exposure* **egory S-3 Soil** (e.g. buried soil in a lightly used industrial area). ory is determined by four site-specific factors: accessibility of e of receptors present, frequency of use of the site and the e use of the site. Because the three soil categories describe a ntial exposures these categories are mutually exclusive: soil is 2 *or* S-3.

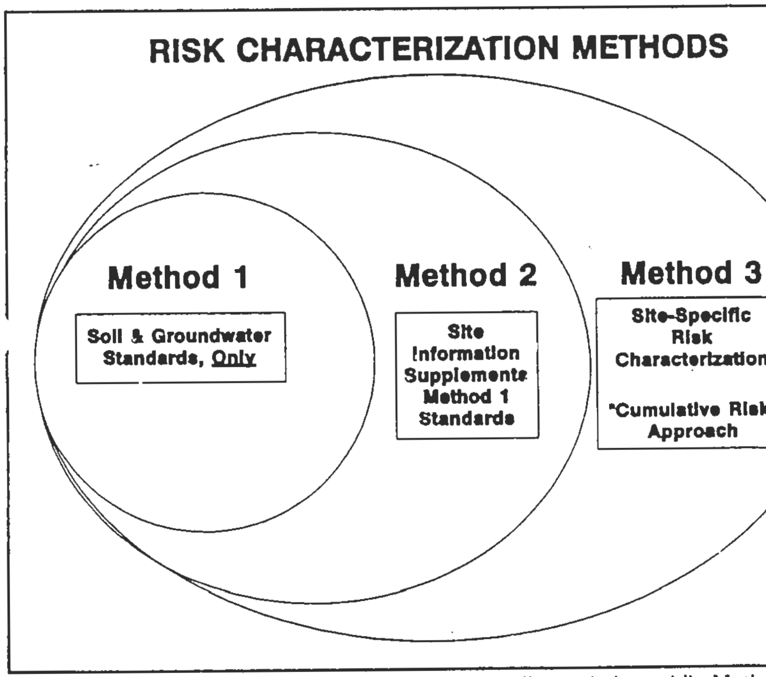
undwater categories describe different exposures which may ontaminated groundwater. **Category GW-1 Groundwater** is a ected for its current or potential future use as drinking water. **2 Groundwater** may act as a source of volatile material to indoor **GW-3 Groundwater** may discharge oil or hazardous material to As these categories describe *different* potential exposures, the categories are *not* mutually exclusive: *all* groundwater is entually discharge to surface water and thus all groundwater is W-3. Groundwater may also be GW-1 and/or GW-2 depending :ific factors.

EVALUATING RISKS FROM A DISPOSAL SITE

Once the nature and extent of the contamination is detern ootential receptors identified and the soil and groundwater cate the risks are evaluated to answer the questions:

1. *How serious is the risk?*
2. *Is a remedial action required?*
3. *To what extent must the disposal site be cleaned up?*

Three different methods of risk characterization are describ Contingency Plan so that the complexity of the assessment ca the complexity of the disposal site. It is important to note t method offers the same high level of protection to public he that, with some limitations, *any* method may be used at a disp to demonstrate that the site poses no significant risk of harm t safety, public welfare and the environment.



Method 3 may be used to characterize risk at *any* disposal site, while Metho are an option at most sites, with some limitations. *Please check the regulat*

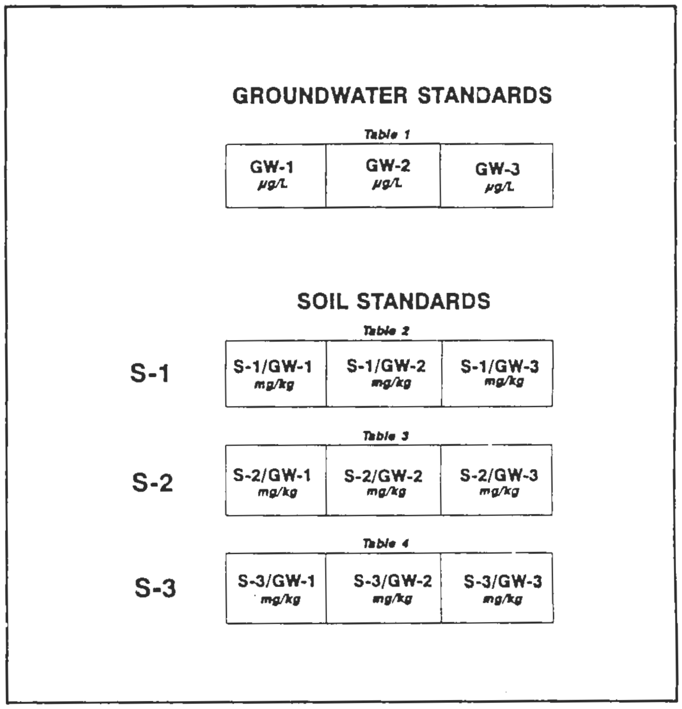
which of the three risk characterization methods is use, is characterized the same way. Site conditions are vhether they pose, or will in the future pose, a threat of odily injury to people. Examples of potential safety risks ce of corroded drums containing oil or hazardous material, explosive vapors.

sing Promulgated Standards In Soil And oundwater

ains lists of soil and groundwater standards developed in e (conservative) manner and corresponding to the oil categories described previously. Once the groundwater s have been identified for a disposal site, the applicable ead directly from the tables of Subpart I.

for groundwater categories GW-1, GW-2 and GW-3 are 10 CMR 40.0974(2)): when more than one groundwater o a site all the applicable standards must be considered. were developed considering both the risks associated with ith the contaminated soil and the potential for the ave the soil and contaminate the underlying groundwater. the applicable soil standards depends upon both the and the category of groundwater: **Table 2** (310 CMR s the standards for category S-1 soils overlying GW-1, GV undwater. **Tables 3** and **4** contain the applicable standards S-2 and S-3, respectively.

Characterization under Method 1 is simply the comparison to the applicable soil and groundwater standards. If the n oil or hazardous material is *greater* than an applicable soil andard then some form of remedial action is necessary. If, centrations reported at a site are *lower* than the applicable r standards, then a level of No Significant Risk exists, and l action is required unless it is feasible to reduce the levels loser to background.



Schematic of the MCP tables listing the numerical Method 1 standards.

Method 2 - Using Site-Specific Informatio omplement The Method 1 Standards

In developing the Method 1 soil and groundwater standar made many health-protective assumptions about potential ex and the movement of contaminants to ensure that the st represent a level of No Significant Risk at virtually all disposal which they are applicable. For any given disposal site, h investigations may reveal that the **fate and transport models** e to develop the Method 1 standards overestimate potential risks Method 2, site-specific information may be used to demonst document that a concentration of oil or hazardous materi exceeds an applicable Method 1 standard poses No Significant

such Method 2 demonstrations include:

of site-specific leaching models to document that residual ε
ll not result in an exceedance of an applicable groundwater
;

of site-specific volatilization models to document that
ater contaminants will not result in unacceptable indoor air
ations;

of site-specific migration models to demonstrate that the
ater will not pose a significant risk when it discharges to
vater.

ay also be used to "*fill in*" missing Method 1 standards. If
published a standard for a chemical of interest at a disposal
uations described in the regulations may be used to identify
at chemical in a manner identical to the way DEP developed
hod 1 standards. Such a Method 2 standard would be used
cterization process as if it had been developed by DEP.

ere are some Method 1 standards which cannot be modified
2. For example, groundwater protected as a current or
e of drinking water must meet the promulgated GW-1
in Table 1. Similarly, while some site-specific information
adjust the leaching-component of the soil standards, the
xceed soil standards based upon direct contact exposures.
ards are listed in **Table 5** (310 CMR 40.0985(6)).

haracterization process under Method 2 is similar to t
ethod 1: the comparison of site conditions to the applicab
vater standards as promulgated or as modified to reflect site-
d transport information. If the concentration of an oil or
rial is *greater* than these levels, then some form of remedial
ary. If, however, the concentrations reported at a site are
dentified standards, then a level of No Significant Risk exists,
emedial action is required unless it is feasible to reduce the
inants closer to background.

Method 3: Site-Specific Risk Assessment

Using Method 3 to characterize risk allows decisions about
r remediation and the appropriate level of cleanup required to
on a case-by-case basis. The risks of harm to health, public wel
the environment are evaluated independently by site.

Risk of Harm to Human Health

The risk of harm is evaluated by comparing current or e
exposure point concentrations to existing standards *and* by ev
all current and foreseeable site-related exposures and co
calculated cancer and non-cancer risks to risk limits promulgate
MCP. (Note that Method 1 standards are not applicabl
Method 3 as Method 1 is an ***alternative*** to Method 3.)

Potential negative health effects are divided into two cat
those which present an increased risk of developing canc
exposure to any amount of a potential cancer-causing substar
non-cancerous health effects (such as damage to the nervous
liver or other organs) caused by intake of more than a threshold
of a contaminant. A **threshold amount** is the level at which
health effects may be expected to occur.

The **Cumulative Receptor Cancer Risk** is an estimate of ho
a person's lifetime cancer risk is increased as a result of exposu
contaminants, that is, the excess risk due to the contaminants
site. The calculated Cumulative Receptor Cancer Risk is com
cumulative cancer risk limit of one-in-one hundred thousa
)0,000). That means that an individual's exposure cannot incr
lifetime cancer risk by more than 1 in 100,000. Anything abov
considered to be a significant risk and any cleanup solution mus
the excess risks below this level. This limit is very strict, e
since in the U.S. today the risk of an individual developing c
1 in 4.

The limit for **Cumulative Receptor Non-cancer Risk** (or t
risk) is also very protective. Exposure to contaminants which a
same organ system or which share the same mechanism of toxi
action is totalled and measured against safe levels of these c
to calculate what is known as the **Hazard Index**. Total daily e
to the contaminants cannot exceed the cumulative non-cancer
which is a hazard index equal to one.

: *Welfare*

erization of risk to public welfare considers factors such as nuisance conditions, loss of property value, and the loss of determine whether the community in the vicinity of tʰ experienced significant adverse impacts to public welfa also makes use of Upper Concentration Limits, which are concentrations (**Table 6**, 310 CMR 40.0996(4)) used to ential future risks to public welfare which may result from ls of untreated contaminants in the soil or groundwater.

Environment

harm to the wildlife and habitats at or near the disposal site essed. The environmental risk characterization looks first to r or not there is the potential for environmental receptors to he oil or hazardous material. If there is no potential for the disposal site does not pose a significant risk to the the potential exists for environmental receptors to come into e contaminants, then a more detailed environmental risk is required. In addition, Upper Concentration Limits are used ntal risk characterization to evaluate the potential future risk mental resources posed by high levels of untreated soil and groundwater.

G POTENTIAL IMMINENT HAZARDS

ome site conditions which warrant immediate attention, otification to DEP and the implementation of an **Immediat** (IRA). Immediate Response Actions must be undertaken releases of oil or hazardous material, **Imminent Hazards** an l conditions identified in the MCP.

ating whether site conditions pose an Imminent Hazard, an ld identify potential receptors who are or are likely to be ontamination as a result of current activities at the site (e.g., ontaminated drinking water, children playing in contaminated d people breathing contaminated indoor air). Such an arrower in scope than most c.21E risk assessments (which ential future exposures and conditions) in order to focus on rrent exposures and to answer the question: *Should action minimize or eliminate this exposure?* Quantitative Imminent ns are not required at all c.21E sites: the decision to conduct on depends upon many site-specific factors.

How Clean is Clean Enough?
The Need for a Permanent Solution

Once the risks are evaluated, cleanup solutions which eli these risks can be developed and carried out. Cleanups m two things:

Eliminate Significant Risk. The MCP defines a perm cleanup solution as one which eliminates significant risks f foreseeable period of time. If feasible, a permanent solution be accomplished at all disposal sites. A temporary solution n implemented when a permanent solution is not feasible, and i eliminate significant risk for the current uses of the sit surrounding environment.

There are many ways to eliminate significant risk at di sites, and a particular remedial action may use one or more t accomplish this. The cleanup may actually reduce exposure concentrations to acceptable levels by treating the contami In other instances, the cleanup may eliminate or minimize exp to the contaminants rather than reduce concentration Restrictions on the use of the site is one means of cont exposures to insure that no unacceptable risks occur. restrictions are called **Activity and Use Limitations**, and their described in Subpart J of the MCP.

Restore the Disposal Site to Background Levels. In addi eliminating significant risk, a permanent solution, if feasible, clean up the site to the levels which would exist in the abse the disposal site. This is known as restoring the disposal **background levels**.

For more information:

This fact sheet summarizes key features of the Massachusetts Contingency Plan relating to risk characterization and evaluation. It is not a substitute for the regulations. Copies of the MCP may be purchased from

State Bookstore
Room 116
State House
Boston, MA 02133
(617) 727-2834

Western Office of
the Secretary of State
436 Dwight Street
Springfield, MA 01103
(413) 784-1376

This fact sheet is one of a series published by DEP concerning the MCP. To find out about other fact sheets please call the ***MCP Hotline***, part of DEP's **InfoLine.** From area code 617 and outside of Massachusetts, call 617-338-2255. From area codes 413 and 508, call 1-800-462-0444. Or write to

MA DEP
Bureau of Waste Site Cleanup
Public Participation Staff
1 winter Street, 5th Floor
Boston, MA 02108

	IF YOU WANT TO KNOW MORE ABOUT...	REFER TO MCP SUBPART	
1.	General Provisions of the MCP and Definitions	Subpart A:	40.0000
2.	Roles and Responsibilities of the Various Parties	Subpart B:	40.0100
	Best Response Action Management Approach (BRAMA)		40.01
3.	Notification Regulations, "Entering the System"	Subpart C:	40.03
4.	Preliminary Response Actions and Risk Reduction Measures	Subpart D:	40.0400
5.	Tier Classification and Response Action Deadlines	Subpart E:	40.0500
6.	Transition Provisions	Subpart F:	40.0600
7.	Tier I Permits	Subpart G:	40.0700
8.	Conducting Site Investigations and Implementing Remedial Response Actions	Subpart H:	40.0800
9.	Risk Characterization and Evaluation Determining "How Clean is Clean Enough"	Subpart I:	40.0900
10.	Response Action Outcomes and Activity and Use Limitations "Getting Out of the System"	Subpart J:	40.1000
11.	Public Involvement and Technical Assistance	Subpart N:	40.1400
12.	The Numerical Ranking System (NRS)	Subpart O:	40.1500
13.	The Massachusetts Oil and Hazardous Material List	Subpart P:	40.1600

APPENDICES

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

1 PURPOSE

The Division of Environmental Remediation (DER) of the New York State Department of Environmental Conservation (NYSDEC) is faced with the challenging task of ensuring environmentally sound cleanup or other appropriate response actions at over 10,000 petroleum-contaminated sites annually. Recent experience indicates that the traditional approach of treating all sites equally and requiring every site to be remediated to non-detect or other empirically derived levels is technically and economically infeasible. Often this traditional approach results in an inconsistent decision, a delay in site closure, and is not conducive to cost-effective decision making. Whereas, the NYSDEC will not allow cost considerations to compromise public health or the environment, it recognizes the need to promote cost-effective site activities (both characterization as well as remediation) that are protective of human health and the environment. Thus, there is a need to develop a process that will streamline the cleanup and closure of petroleum-contaminated sites. Such a program would enable the responsible parties as well as NYSDEC to focus their efforts and finite resources on sites that pose unacceptable current or potential future risks.

In response to this need, the NYSDEC has developed this site closure guidance for the management (characterization, remediation, and closure) of petroleum impacted sites. This guidance is based on *The Emergency Standard Guide for Risk-Based Corrective Action* (RBCA) *Applied at Petroleum Release Sites (ES 1739-95)* issued by the American Society of Testing and Materials (ASTM). The ASTM standard has been altered to ensure consistency with the NYS regulations and policies. The overall objectives of this process are to protect human health and the environment in the most practical and resource effective manner using a scientifically defensible and consistent decision making process.

1.2 APPLICABILITY

This guidance shall be applicable to all petroleum-contaminated sites in New York State regulated pursuant to the New York State Navigation Law, Article 12. The determination whether or not petroleum contamination exists at a site is discussed under Section 4.0, Site Characterization. At this time, this guidance is not applicable to contaminates regulated under any other NYS regulatory program. In addition, if contamination by substances other than petroleum is identified, such information should be noted in the site characterization report for referral to the appropriate NYSDEC regulatory program.

This document establishes step by step procedures to determine:

- the necessity for, type, and extent of emergency response actions;
- the need for free product and gross contamination removal
- the type, quality, and quantity of data to be collected at a site;
- the criteria for site cleanup;
- the development of target cleanup levels;
- the need for activity use limitations (AULs);
- the need for site-specific remedial action(s);
- the closure criteria for petroleum spill sites; and
- the use of monitoring as a site management tool.

This document has been developed for environmental professionals with working knowledge and experience in the areas of site characterization, risk assessment, and remedial actions. It includes technical information that is necessary for developing a risk-based site closure including characterization, risk assessment, remedial action, and closure process as developed by the NYSDL Since the development of risk-based target levels is an integral part of the overall process of risk management and has not been described earlier in other state guidance documents it is described at length in Section 5.0 and Appendices B and C. However this document is not intended as a general guide to every aspect of the risk assessment practice. Prior experience or training will be necessary for an individual to correctly implement the risk-based corrective action process as part of the overall process of site closure.

1.3 COMPONENTS OF THE RISK MANAGEMENT PROCESS

Key components of risk management for petroleum-contaminated sites are presented in Figure 1-1. These include:

1. An emergency response action (after confirmation of a release) to abate, control, and prevent possible emergency situations (e.g., fire or explosion hazard, imminent threat to a water supply source). Although in most situations these response actions will occur shortly after discovery of the petroleum contamination, they can and should be implemented at any time the situation warrants such actions. In some situations the emergency response action may be sufficient to meet the criteria for site closure. Section 2.0 provides further guidelines for determining and implementing emergency response actions.

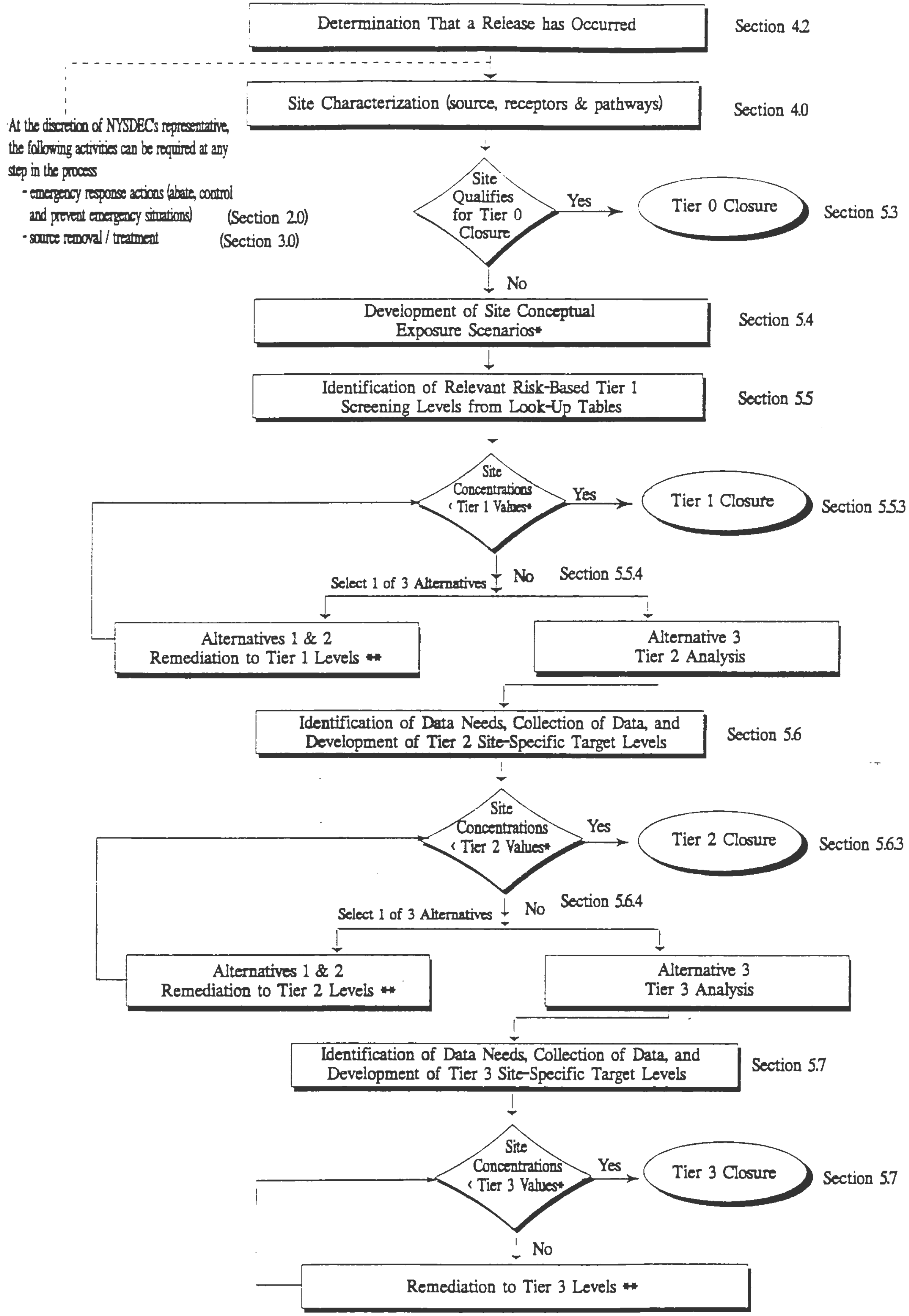
2. Removal and/or treatment of free product and grossly contaminated soils. Details for th activity are discussed in Section 3.0.

3. A site characterization to identify the nature and extent of the source, receptors, and the pathways by which contaminants may migrate from the source to the receptor(s). The scope of this data collection effort will vary significantly from site to site ranging from quite simple to extremely complex. However, in each case the effort should be focused on collecting data necessary to accurately define the contaminated zone and ultimately make specific decisions. Details are further discussed in Section 4.0.

4. Development of Site Conceptual Exposure Scenarios (SCES) that identify the source, contaminant release mechanisms, current and potential future receptors, pathways, and routes of exposure. Details of this step are presented in Section 5.4.

5. Identification of the relevant generic risk-based Tier 1 screening levels using the look- up tables presented in Appendix Q, Tables Q.1 - Q.5. The methodology and the data used to develop these levels are presented in Section 5.5 and Appendices B & C.

FIGURE 1-1: Components of the Risk-Based Corrective Action Process



* Activity Use Limitations can be considered at this step. (Section 5.10)

** This step will require either removal/treatment of hot spots and/or the development and implementation of a Corrective Action Plan

6. Comparison of representative site concentrations with the Tier 1 look-up table values (see Section 5.5.3). If the representative site concentrations are below the Tier 1 values, NYSDEC, for groundwater, will still require a monitoring program to verify t environmental concentrations are reduced to the levels predicted by the modeling results. site may be closed with no further action upon this verification. If the representative site concentrations exceed the Tier 1 levels, one of the following three alternatives may be selected:

   - minimal remediation to Tier 1 levels, e.g. hot spot removal;

   - development and implementation of a Remedial Action Plan (RAP) including consideration of Activity and Use Limitation(s) (see Section 5.10), as appropriate, to meet Tier 1 levels (see Section 7.0); or

   - performance of Tier 2 evaluation (see Section 5.6)

   This decision process is discussed in Section 5.5.3.

7. Identification of any additional data needs and collection of this data to conduct a Tier 2 analysis. The development of Tier 2 site-specific target levels (SSTLs) is discussed in Section 5.6.2.

8. Comparison of site concentrations with Tier 2 SSTLs (see Section 5.6.3). If the representative site concentrations are below the Tier 2 SSTLs, NYSDEC requires a monitoring program to verify that environmental concentrations are reduced to the levels predicted by the modeli results. The site may be closed with no further action upon this verification. If th representative site concentrations exceed the Tier 2 SSTLs , one of the following three alternatives may be selected:

   - minimal remediation to Tier 2 SSTLs, e.g. hot spot removal;

   - development and implementation of Remedial Action Plan (RAP) including consideration of Activity and Use Limitation(s) (AUL(s)), (see Section 5.10), as appropriate, to meet Tier 2 SSTLs (see Section 7.0).

   - performance of Tier 3 evaluation (see Section 5.7)

9. Identification of any additional data needs, and collection of this data to conduct a Tier 3 analysis. The development of Tier 3 SSTLs is discussed in Section 5.7.

10. Comparison of site concentrations with Tier 3 SSTLs. If the representative site concentrations are below the Tier 3 SSTLs, NYSDEC requires a monitoring program to verify that environmental concentrations are reduced to the levels predicted by the modeling results. The site may be closed with no further action upon this verification. If representative site concentrations exceed Tier 3 SSTLs, development and implementation of a Remedial Action Plan or implementation of AULs to meet Tier 3 SSTLs (see Sections 7.1 and 5.10) shall be implemented.

11. Application of the risk-based decision at any site will require compliance monitoring (Sections 6.0) and possibly implementation of AULs (Section 5.10).

For clarity purposes, the entire process of risk management of petroleum-contaminated sites in New York State, as discussed within this document, is referred to as the **RBCA process**. This process includes the entire gamut of site-specific activities: site characterization, emergency response actions, source removal, selection/development of target levels, site remediation, site monitoring, and site closure with or without AULs.

In the context of RBCA, the Remedial Action Plan at some sites may consist of monitoring only and/or AULs. In such situations, the intent would be to rely on natural attenuation processes (diffusion, dispersion, volatilization, absorptions, biodegradation, etc.) to remediate the site concentrations to the Tier 2 or Tier 3 SSTLs within a defined period of time. Guidance on natural attenuation is discussed in Section 7.5.

Note that as the site moves from lower to higher tiers of evaluation, it typically results in the following:

- The amount, complexity and the cost of data collection and analysis increases with the collection of additional site-specific data;

- The cost of analysis increases with the need for additional evaluation to develop SSTLs;

- While the cost of remedial action to achieve the higher SSTLs may be lower; the cost for developing SSTLs are generally higher. (Lower contaminant tier levels are designed to be more conservative than higher contaminant tier levels);

- The need for and the extent of regulatory oversight and review will increase with higher tiers; and

- The level of uncertainty and conservativeness in the decision may decrease due to the availability of more data.

With all of these differences among the four tiers, there is one very significant similarity. Each tier will result in an acceptable level of protection for the site-specific human and environmental receptors.

?.1 INTRODUCTION

Upon becoming aware of a release and/or spill, the NYSDEC and/or responsible party (RP) must determine whether or not a situation exists that requires **immediate containment and/or remedial actions.** Such actions are termed Emergency Response Actions (ERAs), and are to be conducted to ensure that the release does not threaten the immediate health and safety of on-site workers or the general public. ERAs can also serve the purpose of providing source removal to minimize impact, or monitoring to assure protection. The application of an ERA can also be made by the RP or NYSDEC at any time prior to site closure.

This section outlines the events that would necessitate short-term containment and remedial activities. By qualitatively identifying the source of contamination, receptors potentially at risk, and their proximity to the source, the urgency of the threat may be evaluated. By comparing this site-specific information with the examples provided in Appendix D, the required course of action may be determined.

2.2 DETERMINING NEED FOR AN EMERGENCY RESPONSE ACTION (ERA)

A review of Appendix D compared to the circumstances of the spill incident allow decisions for the appropriate ERA to be taken. This list of ERAs, while not exhaustive, provide enough guidance to understand the course of action that would be deemed acceptable.

It should be understood that the example ERAs in Appendix D are not prescriptive. Other alternatives, if they achieve the same goals of appropriateness of response, are acceptable. These alternatives, however, should be presented via a written proposal (if time allows, otherwise verbally with written follow-up) to the appropriate NYSDEC representatives for acceptance, prior to implementation.

An ERA can accomplish more than alleviating immediate problems. An ERA can also provide a strategy leading to an appropriate Tier 0 site cleanup and closure, as well as possible satisfying source removal requirements. By proceeding with a course of action, and not depending on the more formal RBCA analysis and evaluation, the contamination is addressed as soon as possible, potentially alleviating immediate and future impacts and minimizing further remedial costs.

Upon determination by either the RP or NYSDEC that an ERA is necessary, the prescribed actions described in Appendix D (or a NYSDEC approved substitute) shall be initiated and NYSDEC notified as to the actions taken and the results. A determination will then be made by NYSDEC pursuant to Section 5.0 of this policy as to whether or not the ERA accomplishes the goal of remediation to achieve closure requirements.

2.3 SELECTING THE TYPE OF EMERGENCY RESPONSE ACTION

The ERAs are recommendations. The ERAs themselves are an overview of how to respond, and are not meant to be detailed instructions on which protocols to follow. For further guidance, consult such references as NYSDEC's manual *"Spill Response- Basic Procedures and Requirements for Responsible Parties in New York State"* (NYSDEC Spill Responders should refer to the NYSDEC *Spill Response Guidance Manual - Volume I)*. In selecting the ERA to pursue, keep in mind that petroleum spills may cover several different scenarios. If you are uncertain how to proceed, consult with the appropriate NYSDEC regional spill staff person.

3.1 INTRODUCTION

Source removal is an integral part of NYSDEC's RBCA Process. It is the goal at every petroleum spill site that every reasonable effort be made to remove as much gross contamination as practically possible. By eliminating contaminated source material, the overall cost of developing a RBCA evaluation and implementation of a remediation scheme and subsequent cleanup will be greatly reduced, while increasing the environmental benefits. More importantly, however, source removal provides an immediate measure of protection to public health and safety and the environment. Source removal reduces the likelihood of migration through preferential pathways (i.e. sewer pipe bedding, bedrock fractures, coarse grain fill, etc.) that may not be readily apparent and/or quantifiable until after completion of a site characterization. Source removal will also accelerate plume stabilization minimizing the area of contamination that would have occurred if the gross contamination had not been removed or treated. By minimizing the opportunity for further migration, source removal reduces the immediate risk from vapors that cause fire/explosions, immediate health concerns from inhalation and nuisance odors as well as contaminated water supply wells.

3.2 CRITERIA

At a minimum, the following must be employed at every spill site where practically feasible:

1. Where a storage tank is involved, deactivate or remove the tank and ancillary equipment, if practically feasible (as per PBS Regulation 6 NYCRR Part 613.9).

2. Remove all free product. Free product will be considered to be present if there is 1/8" or greater amount of a petroleum product detected in a monitoring well or an amount floating in an open excavation that can be reasonably recovered.

3. Remove Grossly Contaminated Soil. The following procedure will be used to identify grossly contaminated soil:

   A. Organoleptic (visual and odor) inspection for petroleum saturated soil. For example, soil that exhibits a discoloration or odor contrary to the native soils may be indicative of gross contamination. For older spills, the soil will appear to be grey to almost black in color. The presence of petroleum contamination should be confirmed by field instrumentation such as a photoionization detector (PID) or a flame ionization detector (FID) using the procedures described in 4.3(B) below. (where?)

   B. Perform headspace analysis with a calibrated PID or FID. Although different soil types exhibit different responses, the goal is the removal of significant contamination. The target level is a headspace reading of 200 ppm for gasoline contaminated soils and 50 ppm for fuel oils (kerosene, fuel oil, diesel, etc.).

   C. Where gross contamination has been excavated, a PID or FID can be used to establish a trend for determining whether sufficient gross contamination has been removed. This can be accomplished by routine headspace screening of contamination during excavation and plotting the contaminant levels. When it becomes evident that screening levels have dropped significantly, then it can be assumed that the grossly contaminated soil has been removed. For example: Screening levels from excavated gasoline contaminated soil on a site exhibit consistent levels greater than 1,000 ppm. As excavation continues the screening levels drop to 75 ppm for 3 consecutive readings. It can therefore be assumed from three consecutive readings under the 200 ppm criterion, that the grossly contaminated has been removed.

Where excavation was chosen as the approach for source removal, confirmatory samples should be taken from the sidewalls and floor of the excavation for laboratory analysis for COCs. The need for further sampling or a RBCA evaluation will be based partially on these confirmatory sample analyses.

If the guidance values discussed in paragraph 3 above, are not met, the NYSDEC project manager must be consulted to determine acceptable screening levels and/or the next course of action. In certain situations, it may not be practically or economically feasible to achieve the objectives identified in this section (e.g., if the contaminated soil is under a building). The NYSDEC project manager should be advised and consulted in order to arrive at an acceptable solution.

When grossly contaminated soil and/or free product cannot be practically removed, an alternate remedial method must be employed. It is recommended that methods such as soil vapor extraction (SVE) be employed to ensure removal of the gross contamination. Methods such as SVE provide a cost effective means of removing gross soil or minor free product contamination. Pockets of grossly contaminated soil and/or minor free product remaining on-site (i.e., under a building) might cost a great deal more to cleanup in terms of both expenditures and liability if and when an ensuing downgradient plume develops. Therefore, a low tech and relatively inexpensive soil vapor extraction system should be installed directly in the open excavation at gasoline spills. Emission testing must be performed to ver success. In all cases, where practically feasible, free product must be removed along with the grossly contaminated material prior to evaluating the risks posed by residual contamination. Significant quantities of free product on groundwater may require much more involved and long term remedial methods such as pump and treat, or total fluids removal. These methods generally require an in-depth site characterization prior to implementation and may include collecting data applicable to a RBCA evaluation once free product is removed.

4.1 INTRODUCTION

Site characterization involves the collection, analysis and interpretation of site-specific data used to determine if petroleum contamination exists, and to implement proper corrective actions and site closure procedures for a spill site. The focus of the site characterization is to collect an adequate quantity and quality of data necessary to support a closure decision for the selected Tier level. It is a critical element in applying the risk-based procedure. While always important in the past, it will take on a greater emphasis in this policy. A phased approach may be used for data collection; however a well planned data collection program should be used to minimize mobilizations and corresponding time delays to complete the site characterization. A valuable tool in this regard, is the application of conceptual models as discussed in Section 4.3.

The first goal of the site characterization is:

1. to determine whether or not petroleum contamination exists at a suspected release site.

If contamination is found, the goals of site characterization are:

2. to determine the concentration and extent of contamination in all applicable media (soil, water and air).
3. to identify the source location(s) of the contamination.
4. to identify potential receptors.
5. to determine the factors controlling contaminant migration.
6. to determine the direction and rate of movement of contamination.

4.2 APPLICABILITY

A site characterization may be quite simple to extremely complex. For example, for some spill sites, the site characterization may be a simple visual determination that oil was discharged to the environment. A further visual observation could determine the extent and degree of contamination. However, site characterization for a complex spill site may involve subsurface exploration, sampling and analysis, monitoring wells and other involved, costly and time consuming work.

If the site characterization finds one or more of the following conditions, a petroleum spill exists and must be reported to the NYSDEC on the Spill Hotline at 1-800-457-7362:

1. Visual or olfactory observations of staining or spilled petroleum, or petroleum odors;

2. Field instrument readings above background (For Underground Storage Tank [UST] sites see Spill Prevention Operations Technology Series [SPOTS] #14 - Site Assessment of Bulk Storage Facilities for additional guidance).

3. Laboratory test results in excess of groundwater standards or soil guidelines (for NYSDEC Spill Technology & Remediation Series #1 [STARS] Petroleum-Contaminated Soil Guidance Policy);

4. UST tightness testing failure; or

5. Inventory records indicate a significant loss of product or unreconcilable gains.

During the site characterization, whether or not a potential source has been identified, if contamination is not visible and no petroleum odors exist, then samples should be analyzed using headspace analysis with a field instrument. If contamination is not detected, samples should then be sent to a laborat for confirmatory analysis. If the laboratory analysis also confirms no contamination exists, no fur activity is necessary. If contamination is detected, source removal may be necessary and further sampling may be necessary as well.

For sites with contamination from unknown sources, the amount of effort required for a site characterization depends on the site and potential impacts from the contamination. If the site is near an environmentally sensitive area or in an area that would affect the public health and safety (i.e. public or private water supply), then a more thorough site characterization must be done.

A site characterization may be required by a lending institution or by a purchaser when site ownership changes, or may be necessary during construction at a site. NYSDEC may require a site characterization to determine the extent and degree of known contamination of a site. However, New York State does not require a site characterization for property transfer or site construction. **The State will not become involved in any real property or other transactions verifying that a site is "free of contamination", or by reviewing plans, reports, investigation or laboratory results, or by assisting the parties of such transactions in any consultative basis.**

Complex site characterizations involving written reports should be done by a qualified environmental consultant. However, all work should follow a detailed plan subject to the responsible party's (RP) review and approval, as well as the approval of the appropriate NYSDEC Project Manager.

The environmental consultant must have a health and safety plan before performing any work on-si This plan should be designed to protect workers and the public. Occupational Safety and Heal Administration (OSHA) regulations provide guidance for a health and safety program (see 29 CFR Part 1910.120).

While cost considerations are important in designing field work (sample size, locations, instruments used, etc.) to evaluate contaminant levels at a site, it may prove cost effective to invest extra effort in the preliminary work. Incomplete or incorrect information may result in adopting an inappropriate and ineffective corrective action. This may necessitate a "redo" of the project. Every effort should be made to obtain all appropriate information to perform a complete and accurate site characterization without having to re-mobilize (for additional information see American Society for Testing & Materials (ASTM) Guide for Accelerated Site Characterization for Confirmed or Suspected Petroleum Releases).

4.3 CONCEPTUAL MODEL

The conceptual model is a thought process. It is a powerful tool, available to the project manager of an oil spill investigation, who is expected to make decisions in the field that will guide the project to a rapid and successful completion. Unlike a physical or mathematical model, the conceptual model is not necessarily expressed in any tangible sense, but rather may exist solely in the minds of those who create or employ it.

A conceptual model is based on the currently available data, as well as the past experience and knowledge of it's creator. Using this data, experience and knowledge, it is possible to construc framework of observations, inferences and hypotheses that describe the physical setting and processes which are controlling the distribution and migration of contaminants within the study area. **This framework is the conceptual model**, and it is into this framework that all new data must be fit.

During the creation of a conceptual model it is acceptable and appropriate to create several different interpretations of the same information (the current data set), even if some are mutually exclusive of others. This process is sometimes referred to as the formulation of multiple working hypotheses.

Where one begins building a conceptual model is at the discretion of the creator. Generally, the easiest place to begin is with the geography of the site because it is so readily observable. This would include cultural features such as buildings and utilities, drainage, and topography. To this should be added the available information about geology, hydrogeology, potential receptors, and environmental quality. The hypotheses included in the conceptual model should consider contaminant migration, and the mechanisms, pathways, and routes of receptor exposure.

As the investigation progresses it is common for the conceptual model to change. There will be times when it appears that site data falls outside of the conceptual model (the framework). When this occurs it is an indication the model needs to be modified or expanded, that there is a problem with quality assurance and quality control in the sample collection and/or analysis program, or that the data is being viewed at the wrong relative scale (for example, mistaking small scale heterogeneity for regional trends). As data acquisition continues, some of the working hypotheses will be shown to be null, and dropped, while those that remain to be tested will help guide decisions on further sampling. Eventually the conceptual model may be refined to a point where all new data can be accommodated without additional modifications.

Section 4.4 describes a variety of data collection activities that will take place during the characterization of most sites remediated under the this process. The products of these activities are all elements to be considered in the conceptual model.

.4 DATA COLLECTION

The following activities should be included in a site characterization. The RP should discuss each of these items with the environmental consultant.

4.4.1 Overall Data Requirements

As the RBCA process proceeds from Tier 0 to Tier 3, the general data requirements are similar; however, the required data becomes more detailed and more site-specific. Depending on the RBCA tier, the site characterization should gather the following data:

1. Source Characteristics
    - petroleum spilled and its location;
    - surface conditions at the source (e.g., paved vs. unpaved);
    - magnitude and the extent of spill;
    - duration and age of spill; and
    - extent and effectiveness of source removal during the response actions.
2. Media Characterizations
    - depth to groundwater (shallow as well as deep zones, as applicable);
    - site lithology and stratification;
    - direction and speed of groundwater movement;
    - soil properties (e.g., porosity, water content, bulk density, organic carbon content); and
    - infiltration rate.

3. Receptor Characteristics

- actual and potential receptors (present and future);
- location and exposure point relative to the source; and
- exposure factors (exposure duration, frequency, etc.) representative of the receptor(s).

Some data for each of the above categories is required for each tier evaluation. However, the level of detail would increase from Tier 0 to Tier 3. For example, Tier 1 look-up tables use conservative default values for several of these variables; thus, site-specific values may not be necessary except for high impact parameters (see Appendix G). For Tier 2 and Tier 3 analysis, site-specific values for several of these parameters may have to be measured. Appendix N can be used as a checklist to determine whether sufficient data is available to conduct a Tier 2 risk assessment.

4.4.2 Records Search

Site conditions may have changed significantly over the years. A records search can help establish the nature of past activities, indicate where certain activities took place and narrow the number and type of petroleum and chemicals that were used at the site. A records search should include the following:

- deeds
- operating logs (for a company)
- personnel records (for a company)
- historical documents
- permits, violations, variances
- ASTM Real Estate Assessment Standard
- Sanborne Maps (where available)
- site drawings

4.4.3 Interviews

Interviews with adjacent residents, current and previous employees, regulatory personnel, and others may be useful to obtain information on:

- what petroleum products were used at the site; where and how they were stored & used;
- what wastes were generated at the site; where and how they were stored, treated or disposed;
- information concerning accidents and spills; and
- locations of UST's, pump islands, dry wells, etc.

4.4.4 Site Inspection

A site inspection will gather additional information and determine whether observations at the site are consistent with data from records and interviews. Site inspections may assist in identifying:

- the on-site and off-site activities that may be affecting the site; and
- the receptors that may be affected.

A scaled map should be surveyed or obtained for the property and extended about 1,000 feet from the site. The map should show all buildings, any storage tanks below or above-ground, utilities, floor drains, storm and sanitary sewers, streams, ponds, wetlands, drainage ways, public or private drinking water wells, fences, roads, etc. on and adjacent to the site. Underground tanks may be located by looking for an above-ground vent pipe or fill pipe. Any indications of contamination such as oil shee odors, discolored or stained soils, and dead or stressed vegetation should be noted. If groundwate wells exist on the site, the water should be checked for odors and appearance.

4.4.5 Receptor Impacts

Receptors at or within a one quarter (1/4) mile from the site, (but could be greater, based on site-specific considerations) such as drinking water wells, surface water, building basements and utility manholes, must be identified. Contamination may travel to these receptors via groundwater, surface water or air. Potential pathways to these receptors must also be identified.

4.4.6 Hydrogeological Information

Hydrogeological information includes data on subsurface and surface soils, surface rock, bedrock and groundwater. This information may be obtained from the following sources:

- soil maps;
- hydrogeological reports;
- groundwater and aquifer maps;
- soil resistivity/soil chemistry data; and
- well records.

Government agencies (i.e. NYSDEC, USCG, Soil Conservation Service) may have this information. The site owner, as well as adjacent property owners, may also have some of this information.

A groundwater well survey may be necessary and should locate nearest private wells in all directions, and any public wells at a distance of at least one quarter (1/4) mile from the site, (but could be greater, based on site-specific considerations). Data on these wells, such as type of construction, screen depth and screen length, pumping rate, draw-down and water sampling results, should be obtained.

4.4.7 Subsurface Exploration

Several methods exist to initially investigate or locate subsurface features, such as underground tanks, bedrock or groundwater. These methods include the following:

- electrical resistivity;
- ground penetrating radar;
- magnetic survey;
- small diameter wells;
- monitoring wells;
- seismic refraction;
- soil gas survey; and
- test pits

Soil profiles should be developed with detailed lithologic descriptions using the Unified Soil Classification System and include any notes on sample color. Particular emphasis should be placed on characteristics that appear to control contaminant migration and distribution such as zones of higher or lesser permeability, changes in lithology, correlation between soil vapor concentrations and different lithologic zones. Obvious areas of soil discoloration, fraction organic carbon content, fractures (for bedrock) and other lithologic characteristics. Soil boring logs must be submitted for each hole drilled and each pit dug at the site. The logs must denote depth correlated to changes in lithology (with lithologic descriptions). Soil vapor analyses, occurrence of groundwater, total depth and any other pertinent data. When a monitoring well is installed, as-built diagrams with depth to groundwater denoted must be submitted for each well. Reduced data, both tabular and graphic, must be submitted for all geophysical and soil gas surveys.

The vertical and areal extent of subsurface contamination must be defined during the site assessment. At a minimum, discrete soil samples must be collected for laboratory analysis from the following intervals:

- zone of greatest impact based upon field screening results; and
- immediately above the saturated zone (this may also be the zone of greatest impact).

Additional samples may be necessary to fully characterize the soil contaminant distribution and expo
potential for a Tier 2 or Tier 3 evaluation or for the development of a remedial action plan.

The sampling plan should be adequate to determine average soil properties across the source area. The samples must also be representative of the soils that the contaminant migrate through to reach groundwater. These parameters must be determined using samples not impacted by the release (particularly in the case of fraction organic carbon content). Consideration must be given to collecting additional samples if multiple lithologies are present which might affect transport of the contaminant, or if the contaminants are contained within multiple lithologies. Site-specific physical soil properties may be utilized in Tier 2, and Tier 3 as input parameters for contaminant fate and transport models. However, default values for physical soil properties must be used to complete a Tier 1 evaluation.

If groundwater contamination is suspected, temporary sampling points may be used for rapidly screening concentrations in groundwater and to assist in the location of permanent monitoring wells. A sufficient number of monitoring wells should be installed to document contaminant migration aquifer parameters and groundwater flow. The groundwater monitoring system design should consider the need to define the:

- hydrogeologic conditions (hydraulic conductivity, gradient and effective porosity);
- concentration of contaminants in the source area;
- spacial and temporal proximity to potential or impacted receptor(s);
- occurrence and extent of non-aqueous phase liquids (NAPLs) at the site;
- groundwater usage.

Appropriate samples should be collected when COC migration is known or suspected to affect a surface water body. Sample selection should consist of sediment and/or water upstream, downstream, and/or radially from the discharge point(s).

4.4.8 Chemical of Concern (COC)

The NYSDEC is responsible for ensuring appropriate cleanup of all petroleum spills, including but not limited to the following types of petroleum products:

Gasoline
Kerosene
Fuel Oil
Diesel
Jet Fuel
Used Oil

Each of these petroleum products is a complex mixture of several hundred hydrocarbon compounds and other additives (anti-knock agents, corrosion inhibitors, anti-oxidants, etc.). The actual composition of the petroleum products varies depending on the source, age, temperature and other factors and conditions. Thus, no unique composition exists for any of these petroleum products. Further, the behavior of these petroleum products in the environment and their toxic effects depend on the properties of the individual constituents and their concentrations, and the effects of weathering.

The complex mixture of chemical constituents present in petroleum products cannot be easily determin
by present chemical analysis techniques. In addition, the toxicological properties of many of these ar
not presently known. Even though many of these chemical constituents can migrate through environmental media and result in environmental impacts and human exposure, only a small number an

be routinely analyzed in the laboratory and evaluated using risk assessment techniques. As scientific knowledge increases and improved analytical methods make it possible to analyze for more of the remaining constituents of petroleum products, and as the toxicological database for these compounds is developed, the list of chemicals evaluated in the RBCA process will be expanded. For example, the NYSDOH Wadsworth Center for Laboratories and Research is currently drafting a protocol for the analysis of total fuel oil in water. When this is completed, it will be evaluated for inclusion in the RBCA process.

The RBCA process focuses on a limited set of key contaminants, called **Chemicals of Concern (COCs)** that pose the majority of the known or presently quantifiable risk. The individual COC that will be used for the risk assessment of each petroleum product are listed in Appendix O, Table O.1. Appendix O, Tables O.2 and O.3 include the relevant physical, chemical, and toxicological properties for these chemicals. Initial laboratory analysis should address the full range of COCs which may be present, considering the petroleum products involved. In consideration of prior laboratory results, potential COCs may be eliminated from subsequent sampling analysis lists. As the COCs are identified or eliminated, it may be appropriate to change laboratory methods during a project, to avoid unnecessary laboratory expenses. In addition, it may be appropriate to discuss analytical work with the laboratory in terms of the actual compounds of interest rather than method numbers and their defined target compounds. The final laboratory results for a project, however, should address the same full range of COCs as the initial sampling results, to confirm that the interim results did not overlook the appearance of other compounds. For some spill sites, NYSDEC may require the consideration of additional COCs. For petroleum products not listed, contact the appropriate regional office for your site for assistance in identifying the COCs for those products.

The implications of the COC within the RBCA framework are twofold:

1. Depending on the petroleum product spilled, it may be necessary to sample air, soil and groundwater for the COC identified in Appendix O, Table O.1. The recommended analytical methods are specified in Section 4.4.9. At sites with historical spills, where data for these COCs has not been collected, NYSDEC may require additional data collection.

2. The selected COCs have to be carried through the risk assessment process. The Tier 1 risk-based screening levels are presented in Appendix Q. For Tier 2 and Tier 3 analysis, Site-Specific Target Levels (SSTLs) will have to be developed for each COC. Thus, once a COC has met a lower tier criteria, no higher tier evaluation needs to be done for that COC.

4.4.9 Sampling and Analysis

Sampling and laboratory analysis of surface soils, subsurface soils, surface water, groundwater and air may be necessary at a site. However, before any sampling is done, data quality assurance and quality control (QA/QC) procedures must be established. A QA/QC plan is recommended to be developed for the site to ensure accuracy, precision, comparability, representation and completeness of both the field measurement techniques and the laboratory analytical sampling results. Additional guidance is available in NYSDEC's manual *Sampling Guidelines and Protocols* and American Petroleum Institute (API) *Field Analytical Guidance*.

A sampling schedule is also necessary before the start of any sampling. The sampling program can be carried out in one continuous operation or as a series of steps. The choice of approach depends on site conditions, regulatory requirements, and cost and time constraints. Every effort should be made to minimize mobilizations to the site to avoid delays in data collection and evaluation.

Section 502 of the Public Health Law states that no environmental laboratory may perform any examination on samples collected in the State of New York unless the laboratory has been issued a Certificate of Approval for the testing. This law is implemented by NYSDOH's Environme Laboratory Approval Program (ELAP) though regulation, Part 55-2 NYCRR, which was amende December 1995.

Clearly, the law is applicable to any laboratory facility, and following discussions with the regulated laboratory community, the regulation was amended to permit mobile laboratories which may be especially appropriate for rapid on-site assessment of environmental emergencies. A mobile laboratory is a self-contained mobile facility for the examination of environmental samples. It must meet all the requirements of fixed-base laboratories, and must operate from a fixed address.

Additionally, it is recognized by the ELAP program that field screening, using portable instruments or test kits, is often carried out, especially at spill scenes. When such screening is used to assess the extent of pollution to facilitate cleanup or to determine where samples should be collected for subsequent laboratory analysis, this screening does not require ELAP approval. However, results of this screening may not be reported to any government agency for regulatory or compliance purposes, or be used to assess impact of pollution on the public health. Only data generated in an approved laboratory, fixed-base or mobile, may be used for these purposes.

Field sampling may be done before or during laboratory sampling and analysis. Field instruments provide immediate data on petroleum and chemical vapors in soil or water, and help determine locations for soil/water sampling or soil removal. Instruments most frequently used (see SPOTS #14 and ASTM's Provisional Standard *Guide for Accelerated Site Characterization for Confirmed or Suspected Petroleum Releases*) to obtain direct readings of vapors from contaminated water or soil are:

- explosimeters (or combustible gas indicators);
- photoionization detectors;
- flame ionization detectors; and
- calorimetric reading tubes.

Large complex sites often require a more lengthy sampling program. In this case, a multi-step or phased sampling approach may be necessary (but may be performed within one mobilization). This initial broad-based sampling, followed by focused and intensive sampling to more precisely define the contamination boundaries, provides a complete characterization. For source and pathway areas that have been identified previously, the initial sampling efforts may focus at those locations. Sampling will then proceed outward, in multiple directions, to define the extent of the contamination.

Sampling locations and the sample media (soil, water or air) need to be planned. Soil sample locations should be at typical source and pathway areas such as outlets from underground piping, valves or vents for storage tanks, stained soil, undocumented piles of soil, areas where vegetation appears dead or stressed, and sediments within underground drainage systems, sump tanks and surface water drainage ditches. Sediments from nearby streams that receive storm water flow from the site also may need to be sampled. Subsurface soil samples may be collected from test pits, soil borings, small diameter sampling points or monitoring wells.

Surface waters become contaminated from various sources, such as wastewater discharges, runoff fr contaminated areas, and discharges of contaminated groundwater into surface water. Potential receiving waters, generally within 1/4 mile of the site, should be included in the water sampling program.

Determining the groundwater flow direction and rate are important objectives that must be considered when selecting groundwater sampling points. Groundwater flow may follow the contours of the land. Other factors, such as the position of rock layers, can alter the direction of groundwater flow.

Groundwater monitoring wells are usually necessary to sample groundwater and determine groundwater flow direction. The depth and location of the wells will depend upon site activity, site geology, hydrogeology and the physical properties of the chemicals that may have been released.

Sampling of air within buildings may also be necessary. Indoor air in basements or cellars or near sumps may have contaminants from these sources. Air sampling may be a one-time event or continuous over an extended period of time.

When analyzing the results from site sampling, consideration should be given for the contributions of non-regulated background organic sources. In urban and industrialized areas, organic contaminants such as cinder ash, coal waste, decaying vegetation, buried marsh mats, etc. can contribute to polyaromatic hydrocarbon (PAH) levels in the soil and groundwater leading to "false positives" (i.e. conclusions that the site had a petroleum release when it had not) for such chemicals which are also found in petroleum products. Therefore, the placement of a boring/well in an area of the site where information indicates that no petroleum products were stored or used is appropriate to determine any non-regulated sources of organics that may be contributing to the site concentrations.

Two primary criteria must be met by the analytical method selected:

1. The method must analyze for the COC; and

2. The actual quantitation limit of the analysis, taking into account matrix effects and sample dilution, must be at a level below the Tier 1 look-up table value for the COC or below any calculated Tier 2 or Tier 3 value for the COC.

The NYSDEC recommends the use of EPA SW-846 Method 8021 + MTBE for suspected gasoline contaminated samples and SW-846 Methods 8021 + MTBE and 8270 (base/neutrals) for suspected fuel oil contaminated samples in soil and water matrices. For volatile organics in air, DOH 311-6 is the recommended method. For the COC metals, the recommended methods are either EPA 7000 Series (AA or Furnace) or 6010/6020 ICP, depending on required detection limits and laboratory instrumentation. Together these methods provide acceptable results for most spill sites. Other methods, such as 8260 + MTBE for gasoline, may be used provided the above criteria are met. The *Sampling Guidelines and Protocols* document provides additional guidance on method selection.

4.5 DOCUMENTATION

For complex sites, the site characterization should be summarized into a written report. The site characterization may require approval from NYSDEC before any remedial work begins. Documentation requirements should be discussed with the appropriate NYSDEC project manager, the environmental consultant/contractor and the RP prior to initiating the site characterization. As stated previously, if contamination is found during the site characterization, immediate notification is required to the NYSDEC Spill Hotline; however, a written report may be submitted at a later date.

A written report is not necessary for some spill sites, but is strongly recommended for all sites to document the closure decision. The site characterization may simply be a visual verification of a spill. Any ERA for these spills may, and should, begin immediately. For complex spills requiring written site characterization, the reports should summarize data and include conclusions and recommendations, and follow the format discussed in Appendix N. These should include answering the previously mentioned objectives; recommending further study, if necessary; applying risk assessment and propos remediation. Conclusions and recommendations should be discussed with NYSDEC before procee with further study or remediation. However, as discussed in Section 3, remedial response actions may be undertaken at any time to reduce the impacts of the spill site.

1 INTRODUCTION

This section describes the tiered risk-based decision process which determines the cleanup criteria most appropriate for the conditions at a petroleum spill site. This process has been developed to incorporate a risk assessment with good practices of site characterization and site-specific remedial actions to achieve site closure. The decision process incorporates increasingly sophisticated levels of data collection and evaluation. However, as with any risk assessment process, the validity of the outcome is predicated on the validity of the inputs and assumptions used to develop it.

As an evaluation proceeds through the tiered process, the decisions reflect more site-specific information and fewer potentially conservative default values, resulting in more suitable cleanup criteria for a particular site. Consequently, as the evaluation proceeds through higher tiers, data requirements will be more extensive. In each case, the process provides a level of protection that meets the target risk level established by the NYSDEC. Although typical, it is not required that every site go through each Tier process sequentially. The RP working with the regional project manager may decide to go directly to a higher tier.

.2 TIER DEFINITION

The RBCA process consists of four levels of cleanup goals for site closure following adequate site characterization and risk evaluation for the specific tier. Each of these levels is protective of human health and the environment; the primary difference is the level of site-specific information instead of conservative default values.

- **Tier 0 Evaluation -** A spill site may be closed without a quantitative evaluation of risk(s). A closure decision would be based on the Emergency Response Action (ERA) for certain types of spills and site conditions. Closure decisions require that spilled product and impacted soil be defined and removed. This tier is discussed in Section 5.3.

- **Tier 1 Evaluation -** A spill site may be closed if the on-site and off-site representative concentrations do not exceed generic Tier 1 risk-based screening levels (RBSLs). Details of this tier are discussed in Section 5.5.

- **Tier 2 Evaluation -** A spill site may be closed if the on-site and off-site representative concentrations do not exceed the site-specific target levels (SSTLs) using the methodology specified in this document, and approved by NYSDEC. Site-specific data may replace some or all of the default values used to develop the Tier 1 Look-Up Tables. Details of this tier are discussed in Section 5.6.

- **Tier 3 Evaluation** - This tier provides the most flexibility to the responsible party to develop Tier 3 site-specific target levels (SSTLs). It will involve a more sophisticated and hence, more costly evaluation to use site-specific information and computer modeling. Details of this tier are discussed in Section 5.7.

Under each tier, it is important to undertake source removal to prevent continuous releases to the environment as well as to remove any nuisance conditions (visual, odors, etc.). In determining the extent or degree of source removal, technical feasibility, cost, and environmental impacts associated with the removal process should be considered, as discussed in Section 3.0. Note that since each tier provides an acceptable level of protection to public health and the environment, a qualified professional may use good judgement regarding which tier to apply to a particular site. Thus, not every site must go through all the tiers.

5.3 TIER 0 EVALUATION

This evaluation is applicable to petroleum spill sites affected by spills where the emergency response action(s) or source removal successfully removed the product spilled. Examples of these spills include, but are not limited to, minor home heating oil spills, vehicle accidents, simple UST removals, or small quantity surface spills. These spills will have the following attributes:

1. A new or recent spill where the amount, location, and the petroleum product(s) spilled is known (necessary except in the UST situation); and

2. The emergency response action or source removal resulted in the removal of most if not all of the petroleum spilled and/or the impacted soil before any impacts to the surface water or groundwater occur (necessary in all cases); and

3. The qualitative risk assessment by the NYSDEC (based on past experience, consideration of site-specific conditions, completed emergency response actions, and potential receptors) is that the site does not and is not likely to pose an unacceptable level of risk because the spilled material has been removed (NYSDEC discretion); or sample analyses which satisfy the criteria whereby the concentration in a TCLP extraction does not exceed drinking water standards for the COC.

Under this evaluation, the site may be closed. Therefore, the specific details and the extent emergency response action or source removal should be discussed with and agreed upon by the NYSDEC project manager and the responsible party.

If a site cannot be closed based on emergency response actions or source removal it will be necessary for the responsible party to conduct a risk-based evaluation (RBCA) as discussed in the following sections. RBCA is **not** a remediation alternative; RBCA is a process for determining remediation goals or closure criteria.

5.4 SITE CONCEPTUAL EXPOSURE SCENARIO (SCES)

To make a risk-based corrective action decision, it is necessary to first conduct an evaluation to identify the mechanisms by which chemicals of concern may move from an affected source medium to the exposure point where contact with the receptor occurs for this exposure pathway. If this migration and contact is not possible (e.g., the exposure pathway is not complete) under current and reasonable future conditions, the site-specific chemicals will not pose a risk. This qualitative evaluation must be facilitated by developing site conceptual exposure scenarios.

5.4.1 Development of Site Conceptual Exposure Scenarios

A **Site Conceptual Exposure Scenario** (SCES) identifies the source of the COC(s), the chemical release mechanisms (underground tanks, etc.), the media of concern (air, water soil, etc.), the potential receptors (persons, structures, etc.), and the combination of factors that result in complete exposu pathways that could result in the uptake of chemicals. In short, a SCES consists of <u>all</u> complete exposure pathways associated with existing or future situations. The matrix of source-transport mechanism-route of exposure to be created for each site evaluation must also indicate which exposure pathways are incomplete and then provide an adequate technical justification why those pathways are considered incomplete and are not fully evaluated.

Receptors that must be included in this evaluation are:

- Resident
  - on-site (adult, child)
  - off-site (adult, child)
- Industrial\Commercial Worker
  - on-site, indoor
  - on-site, outdoor
  - off-site, indoor
  - off-site, outdoor
- Construction Worker
  - on-site, surficial
  - off-site, surficial
- Environmental
  - waterbody, wetlands
- Utilities

Exposure routes that must be included in this evaluation are:

- ingestion of groundwater
- dermal contact with groundwater
- inhalation of volatiles, indoor and outdoor
- inhalation of particulates, indoor and outdoor
- ingestion of soil
- dermal contact with surficial soil

At a minimum, three (3) SCESs must be developed: the first, representative of current site activities and conditions; the second, representative of reasonable potential future site activities and conditions; and the third, construction worker scenario.

While developing the SCES, it is important to specify the point of exposure for each receptor for each exposure pathway. Since dispersion reduces the concentration of a contaminant in air or water as the media flows away from the source of contamination, the closer the exposure point is to the site, the lower the risk-based target concentration levels. For Tier 1 analysis, all groundwater soil and vapor exposure points will be considered on-site. The technical rationale is that, if the clean-up target levels are protective of on-site receptors, they would also be protective of similar off-site receptors.

Tier 2 and Tier 3 analyses may propose reasonable alternative exposure point for NYSDEC consideration. As an example, consider a gas station where a release occurred. If the residual contamination cannot be remediated to pre-spill conditions, but the owner will stipulate (by an AUL) commercial use for the reasonable future. This AUL would effectively eliminate on-site groundwater use as a potential pathway. If the site is surrounded by residential areas, or if the surrounding area could be used for residences in the future, and where it is reasonable to install a potable supply well and use the groundwater, that potential drinking water well (future point of exposure) should be located at the downgradient property boundary. However, if a highway is located directly downgradient of the site, (no utilities within the highway boundary) the point of exposure for groundwater may be located across the highway. The appropriate point of exposure is used to back calculate the soil target cleanup levels (see Appendix B and C) and acceptable concentrations in the compliance monitoring well or sampling point (see Section 6).

The selected location of the groundwater point of exposure is based on site-specific considerations such as:

- whether the area is supplied by public water;
- proximity to sensitive receptors;
- any county restriction on drilling wells;
- any Activity Use Limitations (AULs) acceptable to the property owner and the state;
- proximity to areas of groundwater discharge to surface waters; and
- the location of well screens in existing private or public water supply wells to address the shallow water bearing soil unit vs. the deeper aquifer.

5.4.2 Pathway Selections By Policy

The list of receptor and exposure routes described in Section 5.4.1 is intended to be reasonably comprehensive, but is not an all-inclusive list. The following provides an explanation and/or rationale to be used for purposes of Tier 1 and Tier 2 RBCA evaluations.

The RBCA evaluation will **not** take into account the protection from exposure provided by other regulations. For example, a construction worker, working on a future on-site project, may be protected via OSHA regulations; however, such protection will not be used to screen out this exposure pathway. A spill site closed under the RBCA process must not pose a health risk to future construction workers where that would be a complete pathway.

The RBCA evaluation will consider no risks posed by other work place or environmental hazards. For example, gas station attendants' normal workday activities voluntarily expose themselves to hazards su as inhalation of petroleum product vapors; however, such existing risks will not be used to screen ou this commercial worker receptor. The intent of the RBCA process is to avoid the incremental increase of human health or environmental impacts resulting from a petroleum spill.

Underground utilities and structures (basement, tunnels) are viable migration routes for contamination. The conservative approach for a Tier 1 evaluation must assume that, if underground utilities exist, the potential receptor structure is located directly within/above the defined contaminant plume. There are times when an underground structure or utility (subways, utility lines) may also be considered a receptor. With the availability of additional site-specific information (that is, a Tier 2 evaluation), actual contaminant levels in that utility can be evaluated. Once contaminant levels are defined in the utility, assume no degradation or dispersion occur without site-specific supporting information.

One of the significant concerns regarding predicting the future land use of a spill remediation site is the location and size of any future building construction. In lieu of the responsible party controlling the construction location and size, **the RBCA evaluation must assume that a future building footprint will be subjected to the highest concentration currently on the site.** In this manner, a site closed under the RBCA process will be protective of the worst case scenario. To avoid such stringent cleanup levels, the responsible party may recommend an AUL suitable to be protective of an institutionally controlled future scenario.

5.4.3 Screening SCES

After all of the complete routes of exposure for all the receptors have been identified, it may be possible to screen out a few source-transport-mechanism-receptor combinations using qualitative considerations. For example, if there are on-site and off-site commercial workers, both exposed to COC via the inhalation route, it is reasonable not to quantify the risk to the off-site worker; the risk to the on-site worker will always be greater than the estimated risk to the off-site worker. Thus, if the site is remediated to levels that are protective of the on-site worker, then these levels will be protective for the off-site worker.

Quantitative analysis (identification of Tier 1 RBSLs values or the subsequent development of Tier 2 or Tier 3 SSTLs) will be necessary for all exposure pathways not screened out at this stage. The NYSDEC will review the rationale for screening out exposure pathways for acceptability.

It is important that the RBCA Evaluation Report list all the source transport mechanism combinations, clearly state those that are being eliminated from the evaluation, and present the rationale for eliminating the combination. Also, the final list of selected exposure pathways of concern should be clearly summarized. This will facilitate the review by the NYSDEC project manager and other interested parties.

5.4.4 Determination of Land Use

A risk assessment approach can be used to estimate potential human health risks from exposures to contaminants present in environmental media. The activities and uses of a site and the surrounding area determine the potential for exposures. In order to adequately evaluate potential exposures, the risk assessment must identify and describe the site activities and uses associated with the contaminated site, and the surrounding environment and community.

The terms "activity" and "use" are employed to describe human pursuits or environmental processes which could result in exposure to human or environmental receptors. For example, groundwater may discharge to a surface water where swimming or fishing activities occur. As used here, "use" refers to the property itself and is generally a broader term than "activity", which describes actions by a receptor which could affect the nature and type of exposure. Zoning terms such as residential, commercial, and industrial are helpful, but incomplete descriptors of exposure potential.

Knowledge about the current and future uses of the site is necessary to identify exposure points and pathways. The exposures to be evaluated in a human health or environmental risk assessment depend upon the activities which could occur under the current and foreseeable uses of the land and groundwater at the site.

A distinction exists between the current use of the site and the foreseeable use of the site. "*Current*" is actual or possible given current circumstances, while "*foreseeable*" has not yet occurred, is hypothetical and may be changed, managed, or avoided. Current uses and activities must be identified and evaluated to be protective of present receptors. Reasonably foreseeable uses and activities must be identified to be protective against future exposures which could occur after the site has been closed.

5.4.4.1 Current Site Activities and Uses

Any current site activities and uses that could result in exposure of human or environmental (plants, animals, and their habitats) receptors must be described in the SCES. The current *use* (again, *use* is the broader term) of the site may be consistent with a wide range of site *activities* (*activity* is the narrower term), some of which may happen to be occurring at the time of the risk assessment, or remediation, but all should be identified and assessed as a current activity.

For example, if a site with soil contamination is currently used as residential property, the risk assessment should evaluate exposures to children having contact with the soil, regardless of the age of the present residents. This policy requires that all activities which are consistent with the cur use of the site be evaluated, even if those activities are **not** occurring at the time of the characterization or assessment.

5.4.4.2 Future Site Activities and Uses

Future site activities and uses are defined as the reasonably foreseeable activities and uses. These should include **any** possible future activity or use with some important exceptions described below. Foreseeable uses must be evaluated if they would result in **greater** human or environmental exposures than the current site use; since the current site use(s) must be evaluated, there is little need to quantify foreseeable uses which would result in similar or lesser exposure. This is an important point in streamlining the process, since there are theoretically several possible exposure scenarios. For any given site, it is necessary to identify all complete exposure pathways, but quantify the risks only for the most exposed receptors for each pathway, and conclude that receptors experiencing similar exposures, but to a lesser degree, would face lesser risks than those quantified.

It should **not** be assumed that all groundwater is a foreseeable source of drinking water. The determination of whether or not the foreseeable use of site groundwater is drinking water will be based upon such characteristics as aquifer yield, natural water quality relating to drinking water standards, availability of municipal water supplies. By these criteria, groundwater which is either a current or potential future source of drinking water must be protected for this use. Excluding groundwater as a future receptor must be fully documented by the responsible party for review/approval by the NYSDEC. Appendix L outlines the decision process for determini groundwater use.

The owner of a property may rule out specific site uses or activities for that property through a deed restriction or other legally enforceable instrument. For example, if the present use of a site is commercial with activities which pose limited exposure potential for children, the receptor exposures could be evaluated based upon this commercial use/activity scenario. Exposures evaluated for the future use of the property would include foreseeable residential use with associated activities (including those for children) **unless** a deed restriction or other activity and use limitation (AUL) is implemented to restrict land use. This is an example of an institutional control for risk management. Any such institutional control must be recommended by the responsible party. Only NYSDEC has the authority to approve/deny an AUL recommendation. The implementation of an AUL would ensure that the future uses and activities for the property remain consistent with the current use or some other limited uses; in which case, the current exposures would also be the future exposures.

If the risk assessment is conducted prior to implementation of an AUL, but it assumes that certain exposures will be limited by the planned AUL, the risk assessment must clearly state the assumed exposure limitations, and that the results of the risk assessment will not be valid until the AUL is in place.

5.4.5 SCES Example

SCES may be presented in several different graphical or tabular formats. In each case, the objecti is to identify all complete and incomplete pathways of exposure considered and which of these pathways is complete. An example for developing SCES for a particular site presented in Appendix E.

5.5 TIER 1 EVALUATION

The Tier 1 evaluation is based on the comparison of site concentrations to pre-determined risk-based screening levels (RBSLs). The levels have been back calculated using the models described in Appendix C. There are over 70 parameters which are used to develop the Tier 1 risk-based screening levels (RBSLS) shown in Appendix Q. They consist of default exposure values and fate and transport values, which are used to calculate the RBSLs. Appendix P, Tables P.1 and P.2 identify these default values, many of which must be used in determining Tier 1 and Tier 2 values. **The NYSDEC believes that, while these default parameters are conservative and will be valid for many sites, they may not be appropriate for all sites. It is therefore imperative that the individuals responsible for developing RBCA submittals understand the use of these parameters and their impact on the site analysis.**

Appendix G is a sensitivity table which lists all the site physical parameters and their default values used to calculate the Tier 1 look-up tables. Also included, where appropriate, are ranges of values for these parameters along with a comment describing the impact each parameter has on the results. The impact of a particular parameter is not always the same depending on the exposure route. For example, while the fraction of organic carbon is significant when measuring subsurface soil leaching to groundwater, it is not a critical factor when measuring volatilization from groundwater to an enclosed space. Site parameters with large impacts are shaded in the appendix.

The Tier 1 evaluation is determined as follows:

1. **Determine the site conceptual exposure scenarios (SCES - Section 5.4).** This includes identifying the COCs, the chemical release mechanisms, the media of concern, and potential receptors. A SCES will need to be developed for current site conditions, reasonable future conditions, and future construction conditions. **The NYSDEC will not accept a RBCA submittal without a completed SCES.**

2. **Compare site-specific groundwater depth.** If the site-specific depth to groundwater is less than the default value of 9.8 feet (300 cm), Tier 2 SSCLs will need to be calculated and satisfied.

3. **Select the relevant Tier 1 RBSLs , based on complete routes of exposure identified in step 1, from the look-up tables in Appendix Q.** A RBSL must be selected for each COC.

4. **Comparison of the RBSLs selected in step 3 with the highest or area-weighted average site representative concentrations (see Appendix F) for soil, and with the highest representative concentration for water.** Any COCs which are not within the Tier 1 levels must either be remediated to Tier 1 levels or can be re-evaluated under Tier 2 or 3. COCs which meet the Tier 1 criteria need not be re-evaluated in subsequent Tiers.

5. **Select the next course of action.** Depending on whether the site concentrations meet the Tier 1 values in Appendix Q will determine whether additional analysis, remediation, monitoring or closure will occur.

5.5.1 Development of Site Conceptual Exposure Scenarios (SCESs)

The identification of the site conceptual exposure scenario is the most important part of the RBCA process. The SCES determines which exposure scenarios need to be evaluated. Identify SCESs for each site as described in Section 5.4. The evaluation must be conducted for current, reasonable future, and future construction conditions for residential and/or commercial scenarios. Any incomplete exposure route must be supported with appropriate documentation in order to be eliminated from consideration.

5.5.2 Selection of Relevant Values from Tier 1 Look-Up Tables

Generic Tier 1 Risk-Based Screening Levels (RBSLs) are provided for several commonly encountered routes of exposure. These include:

- enclosed space (indoor) air inhalation vapor levels from subsurface soil emissions;
- ambient (outdoor) air inhalation vapor levels from subsurface soil emissions;
- enclosed space (indoor) air inhalation levels from groundwater emissions;
- ambient (outdoor) air inhalation levels from groundwater emissions;
- inhalation of volatiles & particulates, ingestion, and dermal contact from surficial soil; and
- ingestion and domestic use of groundwater.

RBSLs have been developed using conservative exposure values shown in Appendix P, Table P.1, chemical-specific properties shown in Appendix O, Table O.2 and toxicity values in Appendix O, Table O.3. These levels are back-calculated using an individual excess lifetime cancer risk of 1×10^{-6} for each chemical of concern or each route of exposure, except for surficial soils. Similarly, for non-carcinogenic effects, Tier 1 levels were back-calculated using a hazard quotient of 1 for each chemical and each route of exposure (except for surficial soils). Note, for surficial soils, each chemical was treated separately, but the risk and hazard quotient for the four relevant routes of exposure (inhalation of vapors and particulates, dermal contact, and ingestion of soil) were cumulatively set equal to 1×10^{-6} or 1 respectively. See Appendix B for a detailed discussion of the back calculation procedure.

When the exposure occurs at a location or medium different from the source (an indirect exposure route), Tier 1 levels have been developed using conservative fate and transport models with conservative input parameters (Appendix P (.1)(.2)). An example of this is a downgradient drinking water receptor. **Groundwater, at the source of contamination, may exceed drinking water standards as long as any of the following are documented:**

- historical site data demonstrates a stable or shrinking plume and the reduction of contamination to allowable levels at the point of exposure; and/or

- a compliance monitoring program designed in accordance with the requirements of Section 6.0 is in place that will provide validation of the prediction of a fate and transport model which projects drinking water standards will not be exceeded at the exposure point, or in some cases at a point of compliance.

Details of the models used to develop RBSLs are shown in Appendices B and C.

However, for the groundwater ingestion and domestic use pathways (irrigation), drinking water standards are used at the exposure point and no additional Tier 1 calculations are required. Appendix Q (.1)(.2)(.3)(.4) show the Tier 1 RBSLs for residential adult, child, commercial, and construction worker scenarios for the following source-transport mechanism-pathway-receptor combinations:

1. Surficial soils (defined as 0 to 15.24 cm (6 inches deep) look-up values have been developed for direct ingestion of soil, dermal contact with soil and inhalation of volatiles and particulate emissions.

2. Subsurface soils (defined as 15.24 cm to 300 cm (0.5 feet to 9.8 feet): look-up values have been developed for the migration of vapors through the unsaturated zone and subsequent indoor and outdoor inhalation of vapors.

3. Groundwater (to 300 centimeters depth): look up values have been developed for migration of vapors through the unsaturated zone and subsequently indoor and outdoor inhalation of vapors.

4. Potable groundwater: to meet drinking water levels at the point of exposure, two sets of look-up values, discussed below, have been developed, both of which depend on the distance of the exposure point from the downgradient edge of the source.

The values presented in Appendix Q, Table Q.5 (Soil Concentrations Protective of Drinking Water Standards) are the allowable soil concentrations protective of groundwater to the drinking water standards at the receptor point. For example, referring to Appendix Q, Table Q.5, if the nearest potential drinking water well is 500 feet away, the allowable soil concentration of toluene is 12.3 mg/kg. This means if 12.3 mg/kg of toluene were left in the ground, the amount that would leach to the groundwater and ultimately move 500 feet downgradient would be reduced to the drinking water standard of 5 ug/L. Note, these target soil concentrations were developed assuming no attenuation in the unsaturated zone, i.e., the contaminated soil is assumed to be directly above the water table.

The set of values presented in Figure 5-1 and Table 5.1 are the dilution attenuation factors (DAF) that can be used to estimate target groundwater concentrations at compliance points located at different distances from the exposure point. For example with the potential drinking water (exposure) well at 500 feet, the allowable toluene concentration in a compliance well located 300 feet from the source, i.e., 200 feet upgradient from the exposure well is $C_{allow} = C_t \times (DAF_E/DAF_x) = 5 \times (126/46.1) = 13.6$ mg/L, where C_t is the target well concentration. The target compliance well concentrations are used to establish compliance monitoring requirements (see Section 6.0). Appendix M.2 presents a more detailed discussion of the dilution attenuation factor.

For each complete source-transport mechanism-pathway-receptor combination identified in the SCES in Section 5.4, target levels should be selected from the appropriate look-up table. Appendix E describes a more detailed example application of this table. For the groundwater pathway, NYSDEC may require compliance point monitoring as discussed in Section 6.0.

5.5.3 Comparison of Site Concentrations with Tier 1 Levels

After the Tier 1 target levels have been identified for each chemical of concern in each media, they have to be compared with the representative on-site concentrations. Representative site concentrations may be determined using the highest concentration or an area-weighted averaging (AWA) method, depending upon the media in question as, as described below.

Surficial Soil

Representative site concentrations for each COC in surficial soil will consist of the highest concentration in the surficial soil at the site. **AWA cannot be used for surficial soil analysis.** Surface soil RBSLs shall be compared with surficial soil values and not subsurface soil values. Surficial soils are defined as the first six inches of soil which exists below the ground surface.

Subsurface Soil

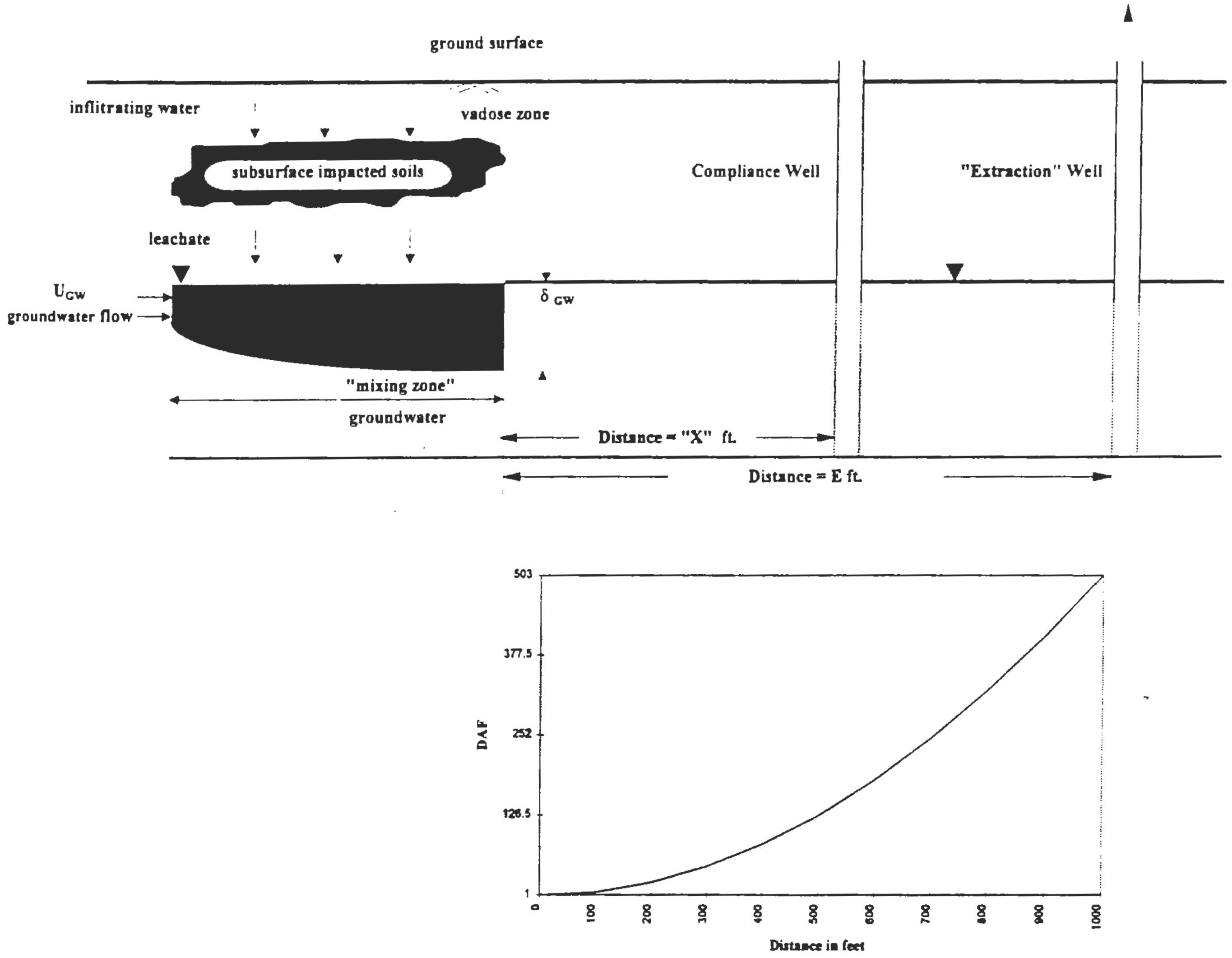
Representative subsurface soil concentrations for each COC may be either the highest on-site concentration or the AWA. Appendix F discusses the calculation of the area-weighted aver concentrations. When calculating the AWA concentrations, care should be taken not to include n detect values outside the impacted area.

The choice of using the highest or the area-weighted average to determine the representative subsurface soil concentration is up to the responsible party (RP). It may be useful to first analyze the site using the highest concentration. If all criteria are satisfied the site may be closed. If all criteria are not met the RP can then calculate the AWA and use it as the representative site concentration. The AWA will result in a less stringent allowable concentration, but it will also require more data and subsequently incur a higher cost. There must be sufficient sample data to support an AWA value. The RP should have their site investigation plan approved prior to commencing analysis.

Groundwater

Representative groundwater concentrations will consist of the highest concentration identified at the site. **AWA cannot be used for groundwater analysis.** Groundwater data is entered into the Domenico model where it is attenuated by natural dispersion. The DEC has decided that since the representative concentration will be dispersed via the model, it is inappropriate to reduce the value initially through mathematical averaging.

If data from several soil sampling events at different times is available, it is best to compare the Tier 1 levels with the most recent values assuming these are representative of site conditions. For comparing the groundwater concentrations measured at the compliance point with the back-calculated compliance point concentrations refer to Section 6.0. If groundwater data is available for several years, the m recent two years, or eight quarters of data should be used to account for seasonal fluctuation.



Allowable Concentration in compliance well located at distance X ft. from source = C_t * (DAF_E/DAF_X)
C_t = Target well concentration

Figure 5-1. Dilution Attenuation Factor (DAF) in the Subsurface Zone (Used to Estimate Acceptable Compliance Point Concentration)

TABLE 5.1
TIER 1 STEADY-STATE DILUTION ATTENUATION FACTORS IN THE SATURATED ZONE ASSUMING NO CHEMICAL DECAY

Distance to Compliance Point (in feet)	Dilution Attenuation Factor
0	1
100	5.9
200	21
300	46.1
400	81.2
500	126
600	182
700	247
800	322
900	408
1000	503

5.5.4 Selection of the Next Course of Action

If the representative site concentrations are less than or equal to the Tier 1 RBSL(s) and no nuisance conditions (see Section 5.9) exist at the site, NYSDEC may grant site closure without any further activity at the site. In some cases, depending on the assumptions used in developing the SCES, AUI and/or compliance point monitoring (see Sections 5.9 and 6.0) may be necessary.

If the site concentrations exceed the Tier 1 look-up values three risk management alternatives are available as presented in Figure 1-1. These alternatives are discussed below:

- **Alternative 1:** Localized exceedences (hot spots). Site concentrations exceed the Tier 1 values in a small portion of the site. The responsible party, working closely with the NYSDEC project manager, may choose to conduct remediation/removal action to meet Tier 1 levels. This action is different from an emergency response action in that the latter focuses on abatement of potential or real emergency conditions. Following the successful completion of interim response actions, NYSDEC may grant site closure. An example of this scenario is a small volume of soil (hot spot) near a recent leak that exceeds the Tier 1 levels. Removal or treatment of this soil may be sufficient to achieve closure based on the Tier 1 evaluation.

- **Alternative 2:** Remediation to Tier 1 Levels. The responsible party may elect to develop a formal remedial action plan, have it approved by the NYSDEC, and implement the plan. This plan should include specific completion criteria (e.g., RBSLs monitoring and sampling requirements, etc) to determine the successful completion of the project. NYSDEC will grant closure when these criteria have been met. Details of the remedial action plan are discussed in Section 7.1.

- **Alternative 3:** Proceed with Tier 2 RBCA evaluation. The responsible party may elect conduct a Tier 2 evaluation as discussed in Section 5.6.

The selection of Alternative 1, 2 or 3 will most likely be based on technical feasibility and cost-benefit considerations. For example, where the cost of cleanup is low (relative to the cost of additional data collection and analysis, and potentially lower cleanup costs to meet Tier 2 levels), it may be most expeditious to adopt the Tier 1 screening levels as the cleanup levels.

The responsible party should carefully review the site conditions and propose one of the three alternatives listed above.

.6 TIER 2 EVALUATION

5.6.1 Overview

A Tier 2 evaluation is similar to that of Tier 1 in that it involves:

- the evaluation of all the complete source-media-receptor combinations identified by the SCES;
- the back-calculation of allowable or target concentrations using site-specific data and site-specific points of exposure; and
- their comparison with the site-specific representative values.

Tier 2 values will be calculated using the same uptake and fate and transport models used for Tier 1. The principle difference from Tier 1 is that Tier 2 cleanup levels must be calculated (no look-up table) using site-specific physical data. The Tier 2 cleanup or target levels are likely to be higher (less stringent) than the Tier 1 values, i.e., the site could potentially require less remediation because Tier 1 values are designed to be very conservative. Also, the point of exposure may be different from the point of exposure considered in Tier 1. **Tier 2 levels need only be developed for those chemicals and source-transport mechanism-receptor combinations that exceed the Tier 1 levels.**

5.6.2 Development of Site-Specific Target Levels (SSTLs)

Tier 2 target levels are site-specific target levels (SSTLs) and should be developed using the steps identified in Appendix B. For direct routes of exposure, fate and transport models are not required. **All Tier 1 default exposure factors identified in Appendices O and P.1 must be used when developing Tier 2 SSTLs. For indirect routes of exposure, fate and transport models will be required. The models used for the Tier 1 evaluation must be used for the Tier 2 evaluation.** The important difference is that Tier 2 models will use site-specific fate and transport data (Appendix P, Table P.2). Additional field work and analysis may be necessary before conducting a Tier 2 evaluation if the previous site work plan did not fully address Tier 2 data requirements. Not all Tier 2 parameters need to be site-specific. A combination of default and site-specific parameters may be used as long as the default data is equal to or more conservative than the site-specific data. All site-specific data used to calculate SSTLs must be clearly defined, documented and justified in the RBCA report submittals (see Appendix N).

The target risks for Tier 1 and Tier 2 are the same. For known or suspected carcinogens, target concentrations should be back-calculated using individual excess lifetime cancer risk of 1×10^{-6}. The hazard index should not exceed 1 for non-carcinogens. The target level for downgradient drinking water shall be no higher than the drinking water standard (i.e., either the drinking water standard or the groundwater standard shall be used).

In Tier 2, the future scenario site-specific exposure point will be selected in consultation with NYSDEC for each complete route of exposure. As an illustration, consider an inactive gas station site adjacent to (and upgradient of) a currently undeveloped property in a mixed (commercial-residential) land use setting. The future land use may be considered residential with residential receptors located on the property. Thus the exposure point for drinking water (assuming the shallow water bearing zone can developed) would be the property boundary. However in Tier 2, alternative exposure conditions a land use data may be evaluated. For example, if the adjacent property is earmarked for the development of a retail center with the site used as a parking lot, the Tier 2 evaluation need only consider a commercial scenario. NYSDEC may require deed notification or other appropriate institutional controls (see Section 5.10) to ensure that the land use does not change. In the event of a land use change the potential groundwater exposure point may now be beyond the retail center. The responsible party must provide sufficient justification to support the alternative compliance point as well as the data used.

5.6.3 Comparison of Site Concentrations with Tier 2 Levels

After the Tier 2 target levels have been identified for each COC in each media, they have to be compared with the representative on-site concentrations. Representative site concentrations may be determined using the highest concentration or an area-weighted averaging (AWA) method depending upon media in question, as described below.

Surficial Soil

Representative site concentrations for each COC in surficial soil will consist of the highest concentration in the surficial soil at the site. **AWA cannot be used for surficial soil analysis.** Surface soil RBSLs shall be compared with surficial soil values and not subsurface soil values. Surficial soils are defined as the first six inches of soil which exists below the ground surface.

Subsurface Soil

Representative subsurface soil concentrations for each COC may be either the highest on-site concentration or the AWA. Appendix F discusses the calculation of the area-weighted average concentrations. When calculating the AWA concentrations, care should be taken not to include non-detect values outside the impacted area.

The choice of using the highest or the area-weighted average to determine the representative subsurface soil concentration is up to the responsible party (RP). It may be useful to first analyze the site using the highest concentration. If all criteria are satisfied the site may be closed. If all criteria are not met the RP can then calculate the AWA and use it as the representative site concentration. The AWA will result in a less stringent allowable concentration, but it will also require more data and subsequently incur a higher cost. There must be sufficient sample data to support an AWA value. The RP should have their site investigation plan approved prior to commencing analysis.

Groundwater

Representative groundwater concentrations will consist of the highest concentration identified at the site. **AWA cannot be used for groundwater analysis.** Groundwater data is entered into the Domenico model where it is attenuated by natural dispersion. The DEC has decided that since the representative concentration will be dispersed via the model, it is inappropriate to reduce the value initially through mathematical averaging.

If data from several soil sampling events at different times is available, it is best to compare the Tier 2 levels with the most recent values assuming these are representative of site conditions. F comparing the groundwater concentrations measured at the compliance point with the back-calculated compliance point concentrations refer to Section 6.0. If groundwater data is available for several years, the most recent two years, or eight quarters of data should be used to account for seasonal fluctuation.

5.6.4 Selection of the Next Course of Action

If the representative site concentrations are less than or equal to the Tier 2 levels and no nuisance conditions exist (see Section 5.9), NYSDEC may grant site closure without any further activity at the site. In some cases, depending on the assumptions used in developing the SCES, institutional controls and/or compliance point monitoring may be necessary. The application of institutional controls and compliance point monitoring are discussed in Sections 5.10 and 6.0 respectively.

If the site concentrations exceed the Tier 2 SSTLs, three risk management alternatives are available as presented in Figure 1-1. These alternatives are discussed below:

- **Alternative 1:** Localized exceedences (hot spots). Site concentrations exceed the Tier 2 values in a small defined portion of the site. The responsible party, working closely with the NYSDEC project manager, may choose to conduct remediation/removal action to meet Tier 2 SSTL(s). Following the successful completion of this activity, NYSDEC may grant site closure. An example of this scenario is high localized soil concentrations (hot spots) that exceed the Tier 2 SSTL(s). Removal of this soil may be sufficient to obtain closure based on Tier 2 evaluation.

- **Alternative 2:** Remediation to Tier 2 Levels. The responsible party may elect to develop a formal corrective action plan, have it approved by the NYSDEC, and implement the plan. This plan should include specific completion criteria (e.g., cleanup levels, monitoring or sampling requirements, see Section 7.1) to determine the successful completion of the project. NYSDEC may grant closure when these criteria have been met.

- **Alternative 3:** Proceed with Tier 3 RBCA evaluation. The responsible party may elect to conduct a Tier 3 evaluation as discussed in Section 5.7.

The responsible party should carefully review site conditions and propose one of the three alternatives listed above. The selection of Alternative 1, 2 or 3 will most likely be based on technical feasibility and cost-benefit considerations. For example, where the cost of cleanup is low (relative to the cost of additional data collection, analysis, risk assessment, and cleanup to potentially higher (less stringent) Tier 3 levels), it may be most expeditious to adopt the Tier 2 target levels as the cleanup levels. In summary, Tier 2 is different from Tier 1 in that:

- site-specific physical parameters are used and
- site-specific target levels (SSTLs), based on-site data, are calculated; and there are no look-up tables in Tier 2.

5.7 TIER 3 EVALUATION

Tier 3 provides the option to determine site-specific corrective action goals for both direct and indirect exposure pathways based on site-specific data, site-specific compliance points, site-specific exposure values and using fate and transport models different from the model used in Tiers 1 and 2. **These models will need to be made available to NYSDEC, should have a track record of having been used on similar sites, will need to be validated for the site in question and subjected to open peer review.**

The acceptable level of risk and the hazard index are the same as for Tier 1 and Tier 2, that is, the individual excess lifetime cancer risk should not exceed 1 x 10^{-6} and the cumulative hazard index for chemicals affecting the same organ should not exceed 1. The target level for downgradient drinking water should be no higher than the drinking water standard (i.e., either the drinking water standard or the groundwater standard shall be used). Tier 3 provides the most flexibility for developing site-specific levels and, hence, requires the most sophisticated analysis. In general, a Tier 3 evaluation will requ more regulatory review and oversight. This has the potential of increasing the time required to evalu and approve the activities proposed by the responsible party. NYSDEC requires that, before conducting a Tier 3 evaluation, the responsible party discuss the specifics with the NYSDEC project manager, prepare a work plan and have it approved by NYSDEC. Tier 3 evaluation is expected to vary significantly from site to site and specific guidance cannot be provided here.

In Tier 3, site-specific cleanup values should be compared with site-specific representative concentrations as described in Tiers 1 and 2 (per Section 5.5.3 and 5.6.3). If the site-specific cleanup values are exceeded the responsible party should develop a corrective action plan to achieve the Tier 3 cleanup levels and/or implement AULs.

5.8 ENVIRONMENTAL PROTECTION (Ecological Impacts)

Environmental issues and other routes of exposure may be of concern in addition to human health considerations. For example, this would be the case where impacted groundwater discharges into surface water bodies or where it is believed high surface soil concentrations might adversely impact site-specific flora and fauna. At all sites, it will be necessary to determine whether an environmental concern exists; and if necessary, develop a strategy to address the environmental concern. Currently, standardized protocols to identify and define environmental concerns or to develop quantitative target concentrations do not exist, although several state, federal, EPA and trade organizations are working on this issue. The NYSDEC and the NYSDOH believe produce and other plants grown over petroleum contaminated soil will not be impacted unless the root systems of such plants enter the contaminat zone. Low level hydrocarbon vapors from subsurface soil contamination are not considered to have a negative effect on surface plant life. If it is determined however that plant life may be a concern because of its close proximity to the contaminated soil, then the analysis can be expanded to include an estimation of contaminant levels in vegetation from root uptake. The methodology for this estimation is provided in Appendix H. In the absence of standardized protocols, at sites where environmental issues are expected to be of concern, NYSDEC recommends the following:

1. Conduct a qualitative description of the observed impacts to the flora and fauna on or near the site.

2. Identify and describe any sensitive habitats near the site based on a site visit.

3. Identify threatened or endangered species on-site or in the immediate vicinity of the site. Species of economic or sport interest in an impacted water body should be identified by contacting federal and/or state fish and wildlife service organizations.

If such issues are identified, additional site-specific studies may be required to ensure protection of the environment. At a minimum, scientifically valid and published numeric standards and criteria for surface water bodies (i.e., SPDES Discharge Permits) and sediments should be identified and considered as target levels. Also, conditions that may make a currently usable natural resource unfit for use in the future should be considered. Finally, if root uptake is an issue or if the look-up tables do not have the specific route of exposure relevant for a particular spill scenario, the NYSDEC should be contacted f guidance.

5.9 MANAGEMENT AND CONTROL OF NUISANCE CONDITIONS

Contaminated soil and groundwater must not exhibit any discernible petroleum-type odor or other nuisance characteristic at their exposure points. Such characteristics are unacceptable regardless of whether the contaminant concentrations satisfy RBCA human health or ecological criteria.

While it is not expected that subsurface soil will present a nuisance problem, it is possible for surficial soil to create such a condition. Similarly it is conceivable that groundwater, which has satisfied all drinking water standards for the chemicals of concern, may still exhibit objectionable petroleum taste and odor characteristics at the exposure point.

In either of the above cases, and unless it can be proven that the nuisance is from other than the petroleum contamination, steps must be taken to remove the nuisance. Any engineering controls used to satisfy the nuisance condition must be approved by the NYSDEC.

5.10 ACTIVITY AND USE LIMITATION (AUL)

5.10.1 Overview

To minimize or eliminate potential exposure to a chemical(s) of concern, the use or access to a site or resources can be restricted. This restriction is called an Activity and Use Limitation or AUL. The NYSDEC will evaluate the need for AULs on a site-by-site basis. Generally, AULs are required to validate the land use assumption used to develop risk-based levels and allow for certain concentration of contaminants to remain on-site. However, **no AUL is required if the contaminant concentration does not preclude unrestrictive residential use of the property and all media (surface water, groundwater, soil, air).**

AULs serve several purposes. They provide notice to future owners of a property, adjacent property owners, local officials and NYSDEC as to what uses and activities are consistent with risk-based closure decision for the site. Conversely, they describe conditions under which the site may pose a significant risk of harm, and the AUL establishes a duty to evaluate such conditions **prior to** any change in site use. Thus AULs are declarations of the acceptable and unacceptable uses and activities for a site. They are not intended to permanently restrict changes in site use as much as to ensure that any proposed changes are evaluated considering the residual contamination and any increased exposure likely to result from changes in use. An AUL may apply to an entire property, an entire site or to a specified portion of a property or site. AULs may be used to eliminate entire exposure pathways which would otherwise require consideration in the evaluation of future site use.

An AUL may apply as part of a temporary solution, such as the construction of a temporary cap on contaminated soil that needs to be maintained during a long-term remediation solution or where a groundwater pump-and-treat system will remain in operation for a long period of time. When foreseeable exposures are excluded from a risk assessment because of an AUL, documentation and description of the AUL are fundamental components of the risk assessment. In such cases the risk assessment is only valid when an adequate and appropriate AUL is in place.

5.10.2 Applicability

An AUL would be used anytime the risk characterization is performed assuming some restrictions site use or site activities. An AUL may be used to limit the number of site uses and/or activities wh would otherwise be evaluated as reasonably foreseeable, thereby reducing the scope of the risk characterization. The most common application of an AUL would be to limit the site use and activities to those which are currently occurring. Remediation goals which would achieve a level of acceptable risk for the current site use would then be acceptable for the foreseeable future.

An Activity and Use Limitation is not required if the site is acceptable for unrestricted use. This would include sites where:

- A satisfactory Tier 0 evaluation has been completed;
- For sites characterized using Tier 1, the concentration of COCs are less than or equal to applicable Tier 1 RBCA cleanup values for all pathways and receptors; or
- For sites characterized using Tier 2, with no limitations on-site use assumed or implied in the risk characterization. For example, residential use of the site, including unrestricted access to all soil, including soil at depth, is assumed and evaluated and the concentration of COC(s) are less than or equal to applicable Tier 2 SSTL(s).

Another situation that does not require an AUL is residual contamination located within a public highway or railroad right-of-way. These areas have been exempted because the deeds are held differently than those for private property, and are less amenable to the application of AULs. **Howeve the residual contamination must be protective of construction worker exposure pathway.**

An AUL is also **not** required if the groundwater is determined **not** to be a current or foreseeable source of drinking water, based upon NYSDEC criteria. While this is a restricted-use scenario, the fact that the criteria used in this determination were developed by NYSDEC negates the need for an AUL.

The results of the risk assessment are based upon the exposure assumptions utilized in the process. The exposure assumptions in turn are based upon the current and foreseeable uses of the site. The conclusions of the risk assessment must therefore discuss all limitations in detail. When an AUL is placed on the site, the risk assessment is only valid and applicable in conjunction with the AUL.

5.10.3 Limitations on the Use of an AUL

A planned or proposed AUL may **never** be used to limit the current use/activities of a site for the evaluation of current exposure. Note, however, that if an AUL is already in-place and effective, it is part of the current use of the site; therefore, any limitations on activity or use which it achieves can be considered in the risk assessment. For example, if a site is currently used as an adult residential property, the risk assessment must evaluate all exposures associated with residential occupancy such as: child and adult contact with contaminated soil and incidental ingestion of soil. If, however, prior to the risk assessment a limitation was placed on the property identifying the property as an adult only residence, and that AUL is determined to be effective, then the risk assessment need not evaluate exposures to children. If no AUL is in place at the time of the risk assessment, exposures to childr must be evaluated whether or not such activities are currently occurring. The application of AUL(s) to a property depends upon the extent to which the property owner wishes to restrict the use of that property.

The application of these limitations to groundwater, however, is somewhat restricted. A groundwater aquifer is a State resource and therefore its foreseeable use is determined by the State and not by the individual property owner. As noted previously, the determination of whether or not the groundwater is a drinking water resource is determined in accordance with the criteria listed in Appendix L. The only situation in which groundwater that has been classified as a drinking water source may be subjected to an AUL is when the groundwater is classified as a drinking water source solely on the basis of the presence of private drinking water wells within 500 feet. An AUL may be applied to restrict the use of groundwater if and only if:

- the private wells are abandoned;
- the properties previously supplied with drinking water by those wells are connected to a public drinking water distribution system; and
- the affected property owners agree to place an AUL deed restriction on their property.

5.10.4 Procedures for Initiating an AUL

The current property owner is the only individual or entity who can limit site activities and uses through the use of an AUL. In addition, unless appropriate statutory or regulatory authority is promulgated, NYSDEC may not impose an AUL at contaminated sites where it has conducted response actions or at sites where the property owner fails to record or register an AUL.

Although the property owner is ultimately responsible for placing and maintaining an AUL on the site, the decision to use an AUL should be made during or immediately after the performance of a risk assessment such that the costs and benefits of using AULs can also be evaluated.

The contents of the AUL are specified in Appendix K and includes what uses and activities are prohibited on the property, conditions necessary to maintain a level of no significant risk and a description of the permitted activity and uses. The AUL must be very specific as to which portion of the site it applies.

The properly executed AUL must then be recorded. As an example, the restriction could serve to prohibit the placement of private wells or to reactivate closed wells on the property in the reasonably foreseeable future.

11 DOCUMENTATION OF THE RBCA EVALUATION

The results of a RBCA evaluation should be clearly documented in a "stand-alone" risk assessment report. All the data used for the evaluations and all assumptions made should be clearly stated in an "user friendly" format. An individual reviewing the report should not have to struggle to identify the data used in the calculations or the assumptions made. This report may be included as an appendix to the closure report with the summary and recommendations included in the main report. NYSDEC will only accept risk evaluation reports in the format presented in Appendix N.

1 INTRODUCTION

A compliance monitoring program is an integral part of a risk-based corrective action program and consists of monitoring the concentrations of the chemicals of concern at locations for a specified period of time or until specified objectives have been achieved (e.g., no indication of increasing concentrations below an SSTL for 4 consecutive quarters). Compliance monitoring may be required in one or more media, e.g., soil, groundwater, and/or air. Specific requirements for compliance monitoring will be recommended on a case by case basis by the RP and reviewed for approval by the NYSDEC project manager.

Compliance monitoring is a late part of the risk management process of a petroleum release site. At earlier stages, the problem has been well defined based upon an adequate site characterization, which must include defining any dissolved plume and its leading edge, and the identification of the most likely receptor if the plume expands. Site characterization will cross property lines if the dissolved plume crosses property lines. Plume expansion refers to contaminant concentrations increasing or the vertical or horizontal movement of contamination.

Throughout a site-specific RBCA evaluation, cleanup levels and closure decisions have been identified based on fate and transport predictions. Monitoring must be conducted such that the prediction is demonstrated to be accurate, or that actual impacts are less than those predicted.

Professional judgement is the best tool for developing a compliance monitoring program. The primary objective of compliance monitoring is **to ensure that the specified objectives of the cleanup have been met; and, in the case where the objectives are set by fate and transport modeling, to demonstrate the accuracy of the predictions of contaminant migration (i.e., fate and transport modeling).** The level-of-comfort with predicted protection from impacts will dictate the complexity of the monitoring program. The level-of-comfort must be based on all of the following:

- source removal effectiveness (complete vs. unfeasible);
- target levels (Tier 1 vs. Tier 2);
- basis for predictions (available site-specific data vs. mathematical modeling);
- timing of exposure pathway(s) (reasonable future vs. current); and
- sensitivity of receptors (industrial vs. residential user).

These criteria are listed chronologically (e.g., RBCA evaluation steps), not by priority. The receptor sensitivity is the most important criterion. Within the parentheses above, the first item listed provides a higher level-of-comfort with a corrective action decision. Using the first bullet as an example, complete source removal provides a higher level-of-comfort. This higher level-of-comfort may indicate a less extensive compliance monitoring program. The phrase "less extensive", as used here, may refer to the number of sampling points, analytical parameters, or frequency and duration of monitoring.

.2 TIER REQUIREMENTS

RBCA tiered evaluations range from very conservative (using default values for some parameters) with limited site-specific data to less conservative with the use of more site-specific data. A Tier 0 closure requires <u>no compliance monitoring</u>. Virtually all of the released product has been removed and a qualitative determination has been made that there would be no impacts to human health or the environment.

Although Tier 1 is the most conservative tier evaluation and Tier 2 is less conservative than a Tier 1 evaluation, both evaluations are typically based on computer modeling. Until specific computer models have been adequately calibrated and tested for a range of site-specific circumstances, complia monitoring must be implemented at all release/remediation sites. At a minimum, Tier 1 and Tier 2 si must be monitored for one year after active remediation systems have been shut down. Where private or public drinking water supplies are current or plausible future receptors, compliance monitoring for a minimum of two years after active remediation systems have been shut down or after a "no remedial action" determination has been made.

Subsequent monitoring frequency and duration will be determined based on available knowledge, considering both site-specific circumstances and model-specific history or track record. **These monitoring programs must demonstrate that the plume is stable or shrinking, that the appropriate receptors are protected, and that contaminant levels are less than or equal to model predictions.**

6.3 PLAN DEVELOPMENT

The frequency of compliance monitoring will be based on available data. The frequency of sampling will be a function of spill-specific information. For example, a new or newly discovered release must have quarterly sampling to determine seasonal variations in contaminant levels. After the seasonal variation has been determined (which could take 1 to 4 years), it may be acceptable to reduce the monitoring frequency to semi-annual or annual sampling **for a stable or shrinking plume**. The number and location of monitoring points will be based on the size or extent of the plume. After an adequate site characterization, existing monitoring points may be supplemented with additional compliance monitoring points to confirm modeling predictions of contaminant migration and/or corrective actions. For example, if modeling indicates that contamination will not impact point X, then point X should monitored for confirmation.

Another objective of compliance monitoring is to demonstrate successful remediation of a contaminant plume. Therefore, the monitoring plan must consider the remediation technologies to confirm their effectiveness. Dilution and attenuation modeling may be a viable means of predicting the effectiveness of natural attenuation (NA). Therefore, whenever this modeling is used, the compliance monitoring program should be at least the same as for NA. Remediation technologies may demand different schemes to address their effectiveness.

6.4 GROUNDWATER

6.4.1 Location and Number of Compliance Wells

The location of groundwater compliance monitoring wells is a site-specific decision and depends on many factors. These include, but are not limited to: the groundwater flow direction and speed; location of the exposure points; physical accessibility; acceptability by the property owner (if located off-site) and the NYSDEC project manager; and the objective of the compliance monitoring well. Typically, multiple compliance monitoring wells will be necessary; the specific number of compliance monitoring points to adequately monitor a specific site will depend upon the size and complexity of the site.

Three examples are presented below to provide general guidance for the location of compliance wells:

1. If the objective of monitoring is to determine whether the pump-and-treat, air sparging, or natural attenuation processes have remediated the plume and whether modeling predictions are accurate, then one series of groundwater compliance monitoring well(s) shall be located <u>along</u>

the centerline of the plume. Additional wells must be located throughout the plume to its lateral edges.

2. If the objective of the corrective action is to contain the plume, then the groundwater compliance monitoring well(s) should be located immediately outside the downgradient edge(s) of the plume.

3. If the objective of monitoring is to verify the accuracy of the mathematical or computer model used to back-calculate risk-based contaminant levels and to provide an early warning in the event that the model is not accurate, then the groundwater compliance monitoring well(s) should be located at about one to two-years travel time from the leading edge of the plume. Additional wells are also required to ensure that the plume does not expand beyond the distance and concentrations predicted by mathematical modeling, especially if there are downgradient receptors. The minimum distance between the groundwater compliance monitoring well and the source can be estimated using the following conservative equation:

$$D = T \times \frac{V_S}{R} \tag{6-1}$$

where:

D = distance between the groundwater compliance monitoring well and the source [feet]
T = travel time [year]
V_s = groundwater seepage velocity [feet/year]
R = chemical-specific retardation factor[-]

The retardation factor is calculated using:

$$R = 1 + \frac{\rho_b k_d}{\theta} \tag{6-2}$$

where:

ρ_b = soil bulk density [g-soil/cm^3-soil]
k_d = soil water partition coefficient [g/g-soil/g/cm^3-water]
θ = porosity [cm^3 /cm^3]

For plumes with multiple COC present, the retardation factor for each COC should be calculated. Then the largest individual retardation factor should be used to calculate the distance for the groundwater compliance monitoring well.

At petroleum release sites that have no groundwater impact yet, these equations do not account for the travel time for leachate from the vadose zone into the groundwater. Therefore, the equation will under estimate the travel time to the compliance monitoring well. A compliance monitoring well must be located to intercept the first groundwater which may be impacted. Compliance monitoring would include monitoring the soil for vertical migration through the vadose zone to confirm that the groundwater is not impacted.

NYSDEC will typically require multiple compliance groundwater monitoring wells. The site-specific number will depend on site-specific conditions. These include the number and location of sensitive receptors (human and ecological), the extent of the plume, groundwater flow direction, seasonal variations, size of the plume, and distance between the source and the receptors.

6.4.2 Duration of Monitoring

The duration of monitoring is very difficult to specify prior to the start of the compliance monitor Often, the duration of monitoring will have to be determined by a careful evaluation of the resu obtained from the compliance monitoring program. Termination or decrease of frequency of the monitoring program may be acceptable if one of the following are observed:

1. Concentrations indicate a clear downward trend **and have not exceeded compliance levels at compliance points;**
2. Concentrations fluctuate, remaining consistently less than the acceptable compliance monitoring concentrations; or
3. Concentrations reach asymptotic levels that are either acceptable or may require a change in the corrective action plan.

The RP may request termination or a reduced frequency of the compliance monitoring when the results indicate that these or similar conditions have been satisfied. The NYSDEC will use professional judgement to accept or reject that request. The RP (or NYSDEC for state funded sites) will not terminate sampling if the concentrations show an upward trend or are consistently above the estimated acceptable levels. **Additional corrective action (see 3. above) must include the development of an additional compliance monitoring plan.**

6.4.3 Frequency of Sampling

The frequency of sampling depends on the groundwater seepage velocity. The higher the groundwater seepage velocity, the higher the frequency of sampling. At a minimum, quarterly sampling is required at the start of the compliance monitoring program. This frequency may be reduced to semi-annual or annual monitoring after 1 or 2 years of data have been collected and the data indicates decreasing trends, small variability in concentrations, low or non-detect levels, etc. In areas where the retarded seepage velocities are demonstrated to be very low, semi-annual or annual sampling may be sufficient.

6.5 SOILS

Compliance monitoring for soils will be used primarily to determine the effectiveness and/or the completion of a corrective action. As an example, a one-time sampling event may be sufficient to confirm that the extent of soil excavated and removed from the impacted area is sufficient and that the remaining soils meet the RBSL or SSTL (or target risk levels). If the concentrations of contaminants in the soils remaining after excavation are above the risk-based target levels, additional excavation or treatment may be necessary. Thus, although soil sampling may not be required on a regular basis, multiple sampling events may be necessary. For existing sites, the soil sampling data may be "too old" (non-representative of current conditions) and additional data may be necessary.

The number of sampling locations will depend on the variability in soil concentrations, the acceptable level of accuracy, and the confidence or significance level. Statistical approaches may be proposed by the RP.

6.6 AIR

Depending on the location of the receptors relative to the impacted groundwater or soil, complete routes of exposure, and receptor condition (confined space vs. open outdoor space), NYSDEC may require air monitoring before, during, or after the completion of the remedial action.

An important consideration in designing an air sampling plan is that models used to estimate migration of vapors to indoor air through cracks in floors have not been adequately verified to the same extent as the groundwater models. NYSDEC may require compliance monitoring at sites where the "air transport models" indicate potentially high risks due to inhalation or where odors have been noticed in the building or other receptor locations.

Sampling during a variety of atmospheric (wind speed, atmospheric stability) and soil conditions may be required. Periodic sampling should be continued until sufficient evidence is available that the remedial action has reduced the risk to specified target levels either by reducing the concentrations (e.g. soil removal, ventilation), or by removing the pathway (e.g. paving the site).

7.1 INTRODUCTION

The risk evaluation described in Section 5.0 will result in a determination for either remedial action or site closure. This section describes the process and documentation requirements that must be satisfied before NYSDEC can issue a closure letter, as discussed in Section 7.3. Where remedial action is necessary to meet the COC concentration(s) identified pursuant to Section 5.0 of this document, a technology selection decision must be made and documented, as discussed in Section 7.2. The technology selected and its implementation must comply with all applicable federal, state, and local requirements, including those for the handling of spill residuals and debris. Information on active remedial technologies for petroleum contaminated are available from the Environmental Protection Agency (EPA), NYSDEC and the private sector. NYS also allows consideration of natural attenuation as a remedial approach. Section 7.5 outlines the acceptability and role of natural attenuation in meeting the objectives for site closure.

7.2 PURPOSE OF A REMEDIAL ACTION PLAN (RAP)

A Remedial Action Plan (RAP) should clearly define the goals to be achieved, the tasks to be done, the completion schedule, and the termination criteria. These expectations should be formally documented before work begins, and kept current reflecting work progress or problems. However, where a remedial measure is needed immediately to prevent or mitigate potential or actual imminent threats to health or the environment, a formal written pre-approved RAP is not needed prior to performing work.

Where the spill investigation and cleanup are to be relatively straightforward and short term (i.e. less than a few weeks or months) a series of brief letters between the responsible party (RP) and the NYSDEC, may be adequate documentation for a RAP. On the other hand, a long-term and particularly complex petroleum spill investigation and cleanup may require, under NYSDEC policy, a Stipulation Agreement (STIP) or Voluntary Cleanup Agreement. Both agreements will contain specific milestones to be achieved and provide for NYSDEC approval of submitted documents.

7.2.1 Content of a RAP

While specific form or format requirements for a RAP do not exist, some content suggestions are described below. The required detail will depend upon the nature and magnitude of spill, site-specific factors, and the cleanup Tier selected (refer to Section 5.0). Appendix I has an example of an acceptable RAP. The RAP should address, at a minimum:

- Risk Evaluation and Report (discussed in Section 5.11) and Appendix N.
- A discussion of the remedial alternatives considered, the alternative(s) selected, and the schedule for their implementation. The level of detail and sub-task breakdown should be sufficient to demonstrate that the corrective action is implementable and has been adequately planned.
- A discussion of how cleanup progress will be measured and monitored and how frequently progress reports will be provided.
- An explanation for any Activity Use Limitations (AULs) if the planned corrective action is based on the use of AULs as part of the risk-based decision.

7.2.2 Non-attainment of Clean-up Criteria

If the cleanup criteria is not achieved, the RP has the option to submit a modification to the appro RAP to address the changes that need to be implemented to achieve the cleanup criteria. In the ev this option is not feasible, the project would advance to the next tier. If Tier 3 clean-up levels can not be achieved, the RP may suggest performance or technology based standards for discussion with NYSDEC.

7.3 SITE CLOSURE DETERMINATION

It is the ultimate objective of NYSDEC's RBCA Process to reach the site closure stage. Site closure occurs after a Tier 0 remedial action (and a determination by NYSDEC project manager there is no significant risk to the public health, safety, and the environment), or a demonstration that Tier 1 RBSLs, Tier 2 or Tier 3 SSTLs have been met .

7.3.1 Documentation of Findings

Closure of a spill requires that sufficient documentation has been collected and submitted to the NYSDEC project manager, to allow anyone who reviews the documentation to know what has been done and the justification for the closure decision.

In order for the NYSDEC project manager to close a spill the following documentation must have been submitted:

1. Tier 0: No additional documentation other than what is specifically requested by NYSDEC project manager is necessary.

2. Tier 1, 2, or 3:

    - RBCA Evaluation Report;
    - RAP (if applicable);
    - STIP (if applicable);
    - Compliance Monitoring Sampling Results and Evaluation with cleanup criteria established as discussed in Section 5.0;
    - Activity and Use Limitations (if applicable) i.e., recorded deed restriction(s) as discussed in Section 5.10;
    - Natural Resource Damage Assessment Report (if applicable); and
    - Public Notification documents and Public Meeting minutes (if applicable).

7.3.2 NYSDEC Acceptance Process

The NYSDEC will accept the spill or site for closure provided the following conditions are met:

1. All documentation requirements identified in Section 7.3.1 have been met.

2. The RAP has been satisfactorily complied with as follows:

    a. The site must be adequately characterized, including, but not limited to a description of site geology/hydrology, extent of soil and groundwater contamination, extent of free phase and dissolved product plume, etc.

b. A detailed evaluation of area receptors within a 1/4 mile of the site (but could be greater based on site-specific considerations) must be completed. This should include but not limited to nearby utilities (sewers, electrical conduits, gas and water mains, etc.) and industrial, municipal and domestic water wells, etc. Their assessment should include a tiered approach of off-site assessment as detailed in Section 4.4.

c. All sample results and reports including reporting frequency are to be evaluated as per the requirements of the RAP.

d. The remediation technology and/or engineering controls have been outlined in the RAP, accepted by NYSDEC and subsequently implemented. Changes to the RAP must have been mutually agreed to by the RP and the NYSDEC project manager.

e. Reports submitted for NYSDEC review as per the RAP must be complete and on time. Responsibility for the spill should be documented when known and the RP notified.

3. The site contamination levels meet the agreed upon criteria established pursuant to Section 5.0, as verified pursuant to Section 6.0.

4. Activity and Use limitations, if applicable, utilized in the corrective action and closure decision have been properly recorded.

5. All public participation requirements (if applicable) identified in Section 7.4 have been met.

6. All Natural Resource Damage Assessment requirements identified in Appendix R have been met.

Requests for a site closure letter must be submitted to the NYSDEC's project manager within thirty (30) days after completion of the corrective action. Within sixty (60) days after receipt of a request for closure, the NYSDEC will make a determination that all requirements have been met and forward a Site Closure Letter (see Appendix J).

7.4 PUBLIC PARTICIPATION

Notification, response, cleanup and other spill related decisions are frequently based on site-specific factors such as the quantity and type of material spilled; the degree and extent of the impacts potential and actual, to the public and the environment; and the physical location, to name a few. These as well as such site-specific factors as public interest and media attention are also used to determine the information needed, audience and communication method to satisfy what is commonly called "public participation" for each site. It should also be noted there are public participation requirements that must be satisfied pursuant to federal regulations governing corrective action for UST systems containing petroleum or hazardous substances (40 CFR Part 280, Sub-part F) and the National Oil and Hazardous Substance Pollution Contingency Plan (40 CFR) 300.155. Participation in NYSDEC's Voluntary Cleanup program also has specific public participation requirements that must be achieved.

For each confirmed release, the RP (NYSDEC for state funded sites) should provide notice to the public by means designed to reach those members of the public directly affected by the release and the planned corrective action, and the closure decision. This notice may include, but is not limited to, personal contacts by field staff, letters to individual households, public notice in local newspapers and/or the

Environmental News Bulletin (ENB), block advertisements, public service announcements, or publication in a state register. Table 7.1 identifies suggested minimum levels of contact for specific spill categories. If the implementation of an approved remedial action plan does not achieve the establish clean-up levels in the plan and termination of that plan is under consideration, NYSDEC must g public notice as described in the previous paragraph.

For further explanation and guidance on Public Participation, NYSDEC staff should refer to *NYSDEC Spill Response Guidance Manual*. Potential Responsible Parties (PRP) and Responsible Parties should refer to *SPILL RESPONSE: Notification, Containment, Cleanup, Removal - Basic Procedures and Requirements for Responsible Parties in New York State.*

TABLE 7.1
MINIMUM REQUIREMENTS FOR PUBLIC NOTIFICATION AT PETROLEUM-CONTAMINATED SITE CLEANUPS

SPILL SITUATION	MINIMUM REQUIREMENTS
Minor incident or cleanup, i.e. vehicle accident, minor homeowner fuel tank release, no off-site impacts.	None
Potential or actual impact to soil, water or air on a limited number of adjacent properties.	Personal contact with individuals directly impacted. Personal contact should also be made to individuals where there is a strong possibility they and/or their property will be impacted.
Potential or actual impact to environmentally sensitive areas, i.e. wetlands, waterfowl, etc. or significant surface water spills.	Contact local municipal officials.
Evacuation of residences, extensive number impacted private water supplies, impacted or potentially impacted public water supplies.	Contact local municipal officials, personal contact with individuals directly impacted, as deemed appropriate by the NYSDEC official. A public meeting should be held if there is sufficient public interest.
RAP requires institutional controls to restrict the land use or limit the resource use.	Notice must be provided to the public directly impacted by the release and the planned corrective action as well as appropriate local municipal officials.

7.5 NATURAL ATTENUATION

One alternative remedial approach for a petroleum spill site is Natural Attenuation (NA). Synonyms include passive bioremediation, intrinsic remediation, intrinsic bioremediation, etc. NA should not be considered a default or no action remedy; it is a potentially appropriate method for the residual contamination in soil and groundwater to be remediated.

NA relies on the natural processes of biodegradation, dispersion, dilution, and adsorption to degrade and dissipate petroleum constituents to achieve remedial goals. The dilution/attenuation modeling in Tiers 1 and 2 attempts to quantify the reduction with distance or time due to these natural processes. The objective of this technology is the overall reduction of concentration, mass or mobility of the COC(s) with distance and with time via these natural processes.

7.5.1 Applicability

NA may be considered as a remedial alternative as part of the RBCA Process. The NYSDEC's RBCA Process and this NA guidance being applied in **this document are only for petroleum release** sites.

As with any remedial alternative, the selection of NA must be based on an adequate site characterization, an assessment of current and potential risks, and an evaluation of the effectiveness as compared to other viable remediation technologies. The NYSDEC will only rely on the primary lines of evidence, as that term is recognized in the industry, at this time. The primary and secondary lines of evidence refer to existing data used to demonstrate that a contaminant plume is stable or shrinking. **The NYSDEC has determined that NA is not applicable to an expanding plume.**

A stable plume indicates that the contaminant mass is being sustained at the same rate as the natural processes are able to remove the contaminant mass from the plume. When this condition exists for a period of 2 or more years, an appropriate active remediation of the source must be initiated to allow the NA technology to achieve the site-specific target levels over time.

At spill sites where a stable or shrinking plume extends beyond the property line, formal acceptance of the NA remedial technology by the neighboring property owner(s) must be obtained. In lieu of such acceptance, a more intensive remedial technology appropriate to the particular release site must be initiated.

7.5.2 Advantages and Disadvantages

The end products of the biodegradation of petroleum hydrocarbons consist of carbon dioxide and water. Contaminants are not transferred to another place or location. There are minimal disturbances or disruption of site operations by the NA technology. Implementation poses no greater risk to potential receptors than the contamination being remediated.

NA can be a long-term activity. The evaluation of applicability may require 1 or 2 years of site characterization and monitoring. Subsequent monitoring would be necessary until remedial goals were achieved, which could be decades. Land use cannot change during this remedial activity. In the interim, the perception may reflect that of a "do nothing" remedial alternative.

As with any remedial technology, the evaluation of NA as a remedial technology requires an adequate definition of the plume, past and present, to predict and confirm NA technology effectiveness.

7.5.3 Remedial Goals

The NA technology is more amenable to achieving performance-based remedial goals. If the site-specific goal is plume containment or demonstrated reduction in contaminant concentrations, either over time or with distance from the source area, then NA is viable. The potentially longer time frame for remediation may require institutional controls to manage risk and prevent exposures, and **may not be appropriate for sites considered for property transfer.**

7.5.4 Site Characterization (Plume Status) Monitoring

At a minimum, four (4) groundwater monitoring wells are necessary along the plume center line: upgradient, at the source, downgradient of source, and at the leading edge of the plume. These would be necessary to adequately define an expanding, stable, or shrinking plume. Additional groundwater wells are necessary if the plume is more than 200 feet long or 50 feet wide. These would be necessary to adequately assess the entire plume.

7.5.5 Quantifying Natural Attenuation Rates

As discussed, the primary line of evidence for NA is proper plume definition with sufficient time-related data to describe a stable, shrinking or expanding plume. No calculations are required because the rate of degradation is not quantified. As stated above, NA is not applicable to an expanding plume.

The secondary line of evidence is semi-quantitative, including estimates of the rate of contaminant degradation. The site-specific mechanism or natural process for NA is not determined, but the net effect of combinations of mechanisms may be estimated with an adequate data base.

Any mass balance calculation would be inappropriate for evaluating NA rates. The method assumes an on-going source of contaminant release from the source area, but the NYSDEC RBCA process requires Source Removal prior to developing clean-up goals. If source removal is ineffective or infeasible, some type of active remediation system must be initiated. **NA can be considered an acceptable remediation alternative only after satisfactory source removal. When complete source removal is unachieveable or infeasible, the source needs to be at least contained and contributing additional mass at a rate less than the rate of degradation within a plume.**

Graphical and regression techniques for determining NA rates for shrinking and stable plumes are relatively straight forward methods. These methods require adequate data over time since the release occurred and over distance from the source. The transport processes have been shown to be first-order attenuation rates.

Data from 3 or 4 monitoring wells located along the plume centerline must be used to graphically demonstrate a stable plume. On a semi-log graph, plot the log of contaminant concentrations versus distance from the point of release. A straight line with a negative slope would indicate plume stability and the slope of that line estimates the rate of NA.

At a petroleum release site where the leading edge is defined and not moving downgradient, data from a single monitoring well within the plume over time can be used to graphically demonstrate a shrinking plume. On a semi-log graph, plot the contaminant concentrations versus time since source mitigation. A straight line with a negative slope would indicate that the plume is shrinking and the slope of that line estimates the rate of NA.

7.5.6 Current Policy

The industry of risk assessment and management is in the process of developing technical guidance and compiling case histories. Available literature is growing such that the NYSDEC policy NA ma change in the future.

At this time, NA will only be considered as a viable remediation action after source removal and for shrinking or stable plumes, not expanding plumes. NA rate estimates must be compound specific; that is, graphs and rates provided for benzene independently instead of considering BTEX as a single indicator parameter.

The implementation of NA as a remedial technology will require long-term monitoring until contaminant levels are reduced to site-specific target levels. As such, the RP has long-term liability for the spill and its remediation.

APPENDIX A
DEFINITIONS OF SELECTED TERMS

Active Remediation - Actions taken to reduce the concentrations of chemicals of concern (COC).

Activity Use Limitation - The restriction on use or access (for example, fences, deed restrictions, restrictive zoning) to a site or facility to eliminate or minimize potential exposure to a chemical(s) of concern.

Attenuation - The reduction in concentrations of COC in the environment with distance and time due to processes such as diffusion, dispersion, adsorption, chemical degradation, biodegradation, etc.

Chemicals of Concern (COC) - Specific chemical and chemical compounds that are identified for evaluation in the risk assessment process.

Contamination - The existence of chemicals not normally found under natural conditions in that portion of NYS. Does not imply the contaminate is a threat to public health, safety and the environment.

Corrective Action - Activities conducted to protect human health, safety, and the environment in response to a suspected or confirmed release. These activities include one or more of the following: site characterization, Emergency Response Actions, Source Removal, evaluating risks, making no further action decisions, implementing institutional controls, designing and operating cleanup actions and equipment, monitoring of progress and termination of remedial action.

Corrective Action Plan (CAP) - A document outlining proposed corrective actions.

Direct Route of Exposure - A mechanism by which a petroleum material or COC comes into contact with a receptor, including, but not limited to, ingestion, inhalation, dermal absorption and transpiration.

Engineering Controls - Modifications to a site or facility (e.g., capping, point of use water treatment, etc.) to reduce or eliminate the potential for exposure to a COC.

Engineering Report (ER) - A document outlining the proposed technical equipment specifications of a corrective action system.

Exposure - Contact of an organism with COC.

Exposure Evaluation - The determination or estimation (qualitative or quantitative) of the magnitude, frequency, duration, and route of exposure.

Exposure Pathway - The course a COC takes from the source area(s) to receptor. An exposure pathway describes a unique mechanism by which an individual or population is exposed to a COC. Each exposure pathway includes a source or release from a source, an exposure point, and an exposure route.

Exposure Point - The point at which it is assumed that a receptor, either potential or actual, can come into contact, either now or in the future, with the COC.

Exposure Route - The manner in which a COC comes in contact with an organism (i.e., ingestion, inhalation, dermal contact).

Gas Chromatograph (GC) - An instrument used to analyze soil and groundwater samples.

Hazard Index (HI) - The sum of two or more hazard quotients for multiple chemical(s) of concern or multiple exposure pathways, or both.

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

Indirect Route of Exposure - An exposure route for which the receptor is located at a point away from the source or in a different media.

Institutional Controls - The restriction on use or access (e.g., fences, deed restrictions, restrictive zoning, conditions for a no further action decision) to a site or facility to eliminate or minimize potential exposure to a COC.

Initial response - Activities conducted to mitigate fire and safety hazards and to prevent further migration of hydrocarbons in their vapor, dissolved, or liquid phase.

Intrinsic Remediation - The verifiable reduction of a COC through naturally occurring microbial activity and/or other attenuation mechanisms.

Maximum Contaminant Level (MCL) - A standard for drinking water established by USEPA under the Safe Drinking Water Act which is the maximum permissible level of a COC in water which is used as a drinking water supply.

Non-Aqueous Phase Liquid (NAPL) -

Point(s) of Compliance - A location(s) selected between the source area and the exposure point(s) where COC must be less than or equal to the determined target levels in media (i.e., soil, groundwater, etc.).

Reasonably Anticipated Future Use - Future use of a property or adjacent property which can be predicted with a high degree of certainty given current land use, recent trends in land use and local government planning and zoning.

Receptors - Persons, structures, utilities, surface water, aquifer and water supply wells that are, or may be, adversely affected by a release.

Remedial Action Plan (RAP) - A document outlining proposed remedial actions.

Remediation/Remedial Action - Activities conducted to protect human health, safety and the environment. These activities include evaluation risks, emergency response action, designing and operating cleanup systems, monitoring source removal, institutional controls and engineering controls.

Risk Assessment - An analysis of the potential for adverse health effects caused by a COC from a release to determine the need for remedial action. Also used to develop target levels where remedial action is required.

Risk Reduction - The lowering or elimination of the level of risk posed to human health or the environment through initial response actions, corrective action, or institutional or engineering controls.

Risk-Based Screening Levels (RBSL) - Risk based, non site-specific target levels for COC (NYS Drinking Water Standards are also used). Levels less than or equal to RBSLs indicate the site has contaminant levels that are potentially acceptable for site closure. Levels greater than RBSLs imply site needs to be evaluated further.

Sensitive Habitat - Fresh and salt water fisheries, fish habitats including shell fish areas, coastal and inland wetlands, and habitats of threatened or endangered species.

Site - The area defined by the likely physical distribution of the COCs from a source area. A site could be an entire property or facility or a defined area or portion of a facility or property. One facility may contain multiple sites. A site is not confined by the limits of property boundaries.

Site-Specific Target Levels (SSTL) - Risk-based corrective action target levels for COC in air, water and soil developed for a particular site under the Tier 2 and Tier 3 evaluations (NYS Drinking Water Standards are also used).

Source Area - Defined as either the location of free-phase hydrocarbons or the location of highest soil and groundwater concentration of the COC.

Tier 1 Evaluation - A risk-based analysis where non-site-specific values (RBSL) based on conservative exposure factors, the NYS Drinking Water Standards, potential exposure pathways, and land use are evaluated to determine appropriate actions.

Tier 2 Evaluation - A risk-based analysis applying the RBSL at the exposure point, development of SSTL for potential indirect exposure pathways based on site-specific conditions, and establishment of points of compliance.

Tier 3 Evaluation - A risk-based analysis to develop values for potential direct and indirect pathways at the exposure point based on site-specific conditions.

B.1 INTRODUCTION

B.2 STEPS IN BACK-CALCULATING TARGET LEVELS

- B.2.1 Step 1: Identify Acceptable Risk and Hazard Quotient
- B.2.2 Step 2: Estimate the Toxicity of the Chemicals of Concern
- B.2.3 Step 3: Estimate the Allowable Dose
- B.2.4 Step 4: Estimate the Allowable Exposure Point Concentration
- B.2.5 Step 5: Estimate the Allowable Source Concentration

B.3 IMPLEMENTATION OF THE ABOVE STEPS FOR NYSDEC's RBCA PROCESS

.1 INTRODUCTION

The back-calculation of risk-based target concentrations essentially answers the question *How clean is clean?* This procedure can be used to answer the following types of questions :

What residual concentrations can be left in the soil such that concentrations in a potential drinking water well do not exceed the NYS Drinking Water Standard for the chemical of concern?

What residual concentrations can be left in the soil such that the risk due to inhalation of volatile emissions from the soil to an on- or off-site receptor does not exceed an acceptable level?

What residual concentrations can be left in the soil such that the risk due to accidental ingestion, direct contact, and inhalation of volatiles does not exceed an acceptable level?

In each of these cases, the estimated or back calculated soil concentrations are termed as the risk-based target levels. Calculation of these concentrations depend on a variety of factors including the acceptable level of risk, receptor characteristics (commercial vs. residential; child vs. adult), transport mechanisms, properties of the chemical, distance between the receptor and the source, etc.

While performing these calculations it is important to distinguish between direct and indirect exposure pathways. Direct exposure pathways are those in which the receptor comes in direct contact with the affected medium. Examples of direct exposure pathways include accidental ingestion of soil, and dermal contact with soil. Indirect pathways are those where the exposure occurs away from the source. For example, volatilization of chemicals from subsurface soil may result in exposure by inhalation to off-site receptors, or leaching of chemicals to the groundwater may result in exposure by ingestion of water from an off-site well. Note, for indirect exposure pathways the back-calculation procedure requires the use of chemical fate and transport models.

The following section presents a step-by-step method to back-calculate the target levels.

B.2 STEPS IN BACK-CALCULATING TARGET LEVELS

B.2.1 Step 1: Identify Acceptable Risk and Hazard Quotient

The acceptable individual excess lifetime cancer risk for carcinogenic effects and the acceptable hazard quotient for non-carcinogenic effects is a policy choice. For the assessment and closure of petroleum impacted sites, NYSDEC currently uses values of 1.0E-6 (one in one million) for carcinogenic effects and one (1) for non-carcinogenic effects. The estimated cleanup levels are linear with respect to this value. Thus if the acceptable risk level were 1.0E-5 (one in one hundred thousand) with all other factors remaining the same, the target level would increase by a factor of 10. Similarly if the target hazard quotient is reduced to 0.5, the target levels would reduce by a factor of 2.0.

B.2.2 Step 2: Estimate the Toxicity of the Chemicals of Concern

The toxicity of chemicals with carcinogenic effects is quantified using the slope factor or the pote value. For non-carcinogenic effects, the toxicity is quantified using the reference dose. For each the chemicals of concern included in the spilled product, these toxicity values are tabulated in Appendix O, Table O.3. These values should be used unless there is a strong reason to use alternative values. Any alternative values must be approved by the NYSDEC and NYSDOH personnel.

B.2.3 Step 3: Estimate the Allowable Dose

For carcinogenic health effects, the allowable dose for the chemical of concern is estimated by dividing the acceptable risk (refer to Step 1) with the potency value (refer to Step 2). For non-carcinogenic adverse health effects, the acceptable dose is equal to the hazard quotient (refer to Step 1) multiplied by the reference dose (refer to Step 2).

B.2.4 Step 4: Estimate the Allowable Exposure Point Concentration

The allowable exposure point concentration is estimated using the uptake equations for the relevant route of exposure and appropriate exposure factors (see Appendix C for examples). For Tier 1 evaluation, default exposure factors and fate and transport parameters presented in Appendix P, Table P.1 and P.2 were used. For Tier 2, the default exposure parameter in Appendix P, Table P.1 must be used, but the fate and transport parameter (Table P.2) may be substituted with site-specific values. For Tier 3 it is possible to use site-specific exposure factors as well as fate and transport parameters. Howev it is the responsibility of the person/organization conducting the analysis to provide justification for the use of these alternative values and get the concurrence of the NYSDEC project manager.

For direct routes of exposure, the estimated concentration will be the risk-based target level. However for indirect routes of exposures, the estimated target concentrations are applicable at the point of exposure. Additional evaluation as presented in the following step is necessary to relate the exposure point concentrations to the source concentrations.

B.2.5 Step 5: Estimate the Allowable Source Concentration

This step varies depending on the specific indirect route of exposure and the transport mechanism from the source to the receptor point. However, the objective in each case is to quantitatively relate the allowable exposure point concentration estimated in Step 4 to the source concentration. Two examples are presented below:

Example 1: Estimation of subsurface soil concentrations protective of inhalation exposures.

(Refer to Figure B-1) For this exposure pathway, the concentration estimated in Step 4 would be the concentration in the air that the receptor is breathing. A two-step procedure may be used to estimat allowable soil concentrations. Initially, if the receptor is located on-site, a box-model may be used estimate the allowable emission rate. If the receptor is off-site, a Gaussian air dispersion model may be used to estimate the allowable emission rate. Secondly, using an emission model the estimated allowable emission rate is related to the allowable soil concentration. Implementation of these two models, requires several input parameters. It is important that the responsible party clearly identify the data used and provide adequate justification for the specific values used for Tier 2 and Tier 3 evaluation.

Example 2: Estimation of soil concentrations protective of ingestion of groundwater.

(Refer to Figure B-2). For this exposure pathway, the concentration estimated in Step 4 would be the concentration in the exposure well. Instead of using Steps 1 to 4, NYSDEC may require the use of chemical-specific drinking water standards as the allowable exposure point concentration. The allowable leachate concentration at the source is calculated as the allowable concentration at the exposure point multiplied by the dilution attenuation factor (DAF).

The dilution attenuation factor is the ratio of the concentration at the source to the concentration at the receptor (termed as the concentration reduction factor, or dilution attenuation factor, or the natural attenuation factor), and is estimated using a fate and transport model. The DAF (greater than or equal to one) depends on several factors such as the distance to the well, groundwater velocity, chemical properties, size of the source etc. that are site-specific and are accounted for by the groundwater model(s). Several coupled models may be required to estimate the dilution attenuation factor, e.g., an unsaturated zone transport model, a saturated zone mixing model, and a saturated zone transport model. The allowable leachate concentration is finally converted to an allowable soil concentration either by using the results of a site-specific leachate test or by assuming equilibrium partitioning between the soil concentration and the leachate concentration.

B.3 IMPLEMENTATION OF THE ABOVE STEPS FOR NYSDEC's RBCA PROCESS

The specific equations used to implement the above steps for Tier 1 look-up values are presented in Appendix C.

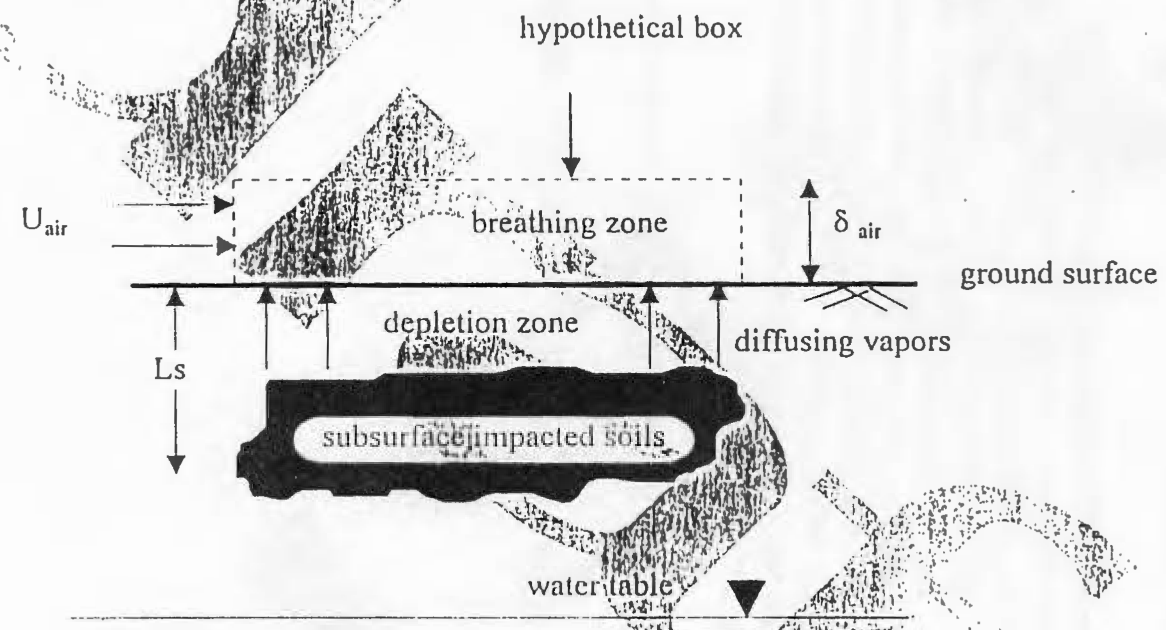
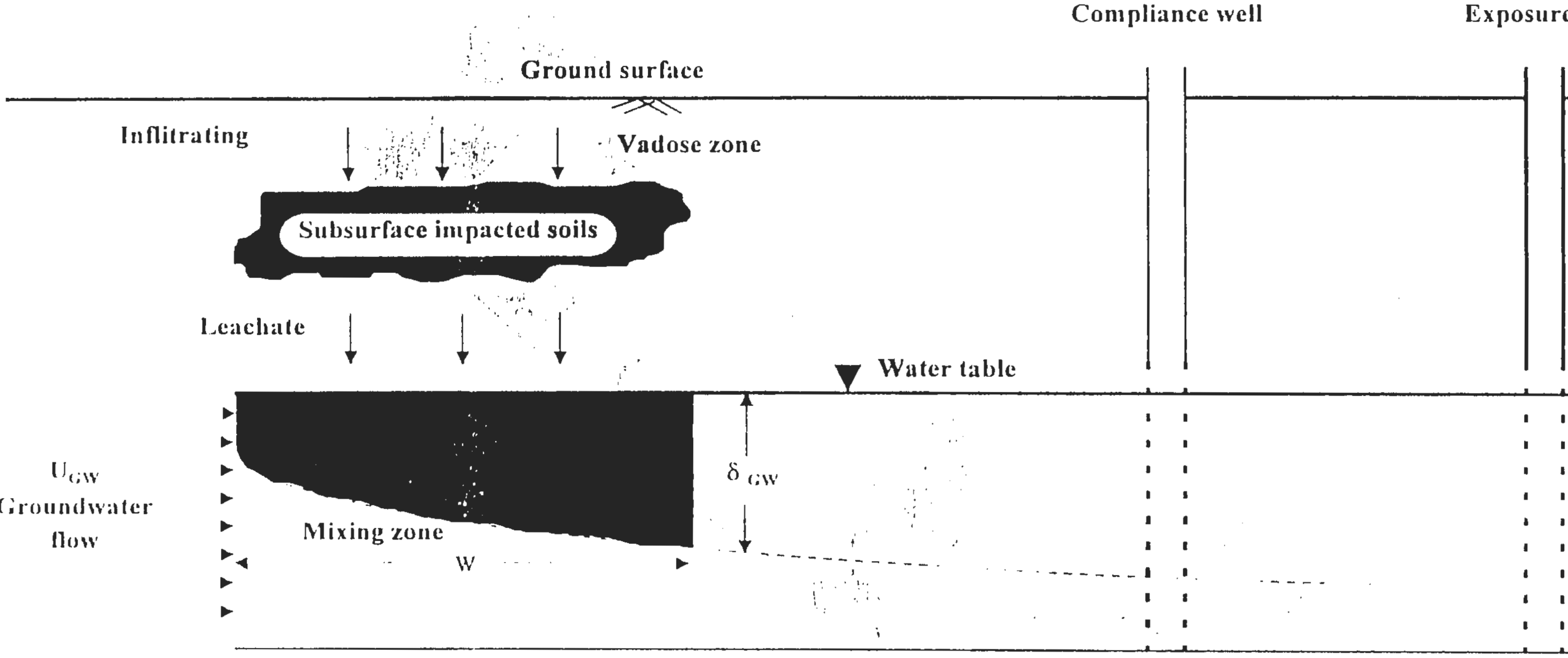


Figure B-1. Volatilization from Subsurface Soils to Ambient Air

Figure B-2. Leaching from Subsurface Soils to Groundwater



APPENDIX C
ESTIMATION OF RISK-BASED SCREENING LEVELS

This appendix contains the equations and parameters used to construct the "Look-Up" tables in Appendix Q. These same equations must be used to calculate Tier 2 site-specific target levels. The parameters and their default values are defined in Appendices G and P. These equations and the assumptions used in their derivation are taken from ASTM "Guide for Risk-Based Corrective Action at Petroleum Release Sites", E 1739-95. It is important that the user of this guidance document become very familiar with the ASTM guide and should use it, among other sources, as a guide in understanding the risk-based assessment process. When conducting a Tier 2 analysis they need to understand the impacts each parameter has on the equations and take specific care when defining these parameters on a site specific basis. As with any model, the quality of the results are directly related to the quality and understanding of the data used for input.

C.1 INHALATION OF VAPOR EMISSIONS

The screening level concentration in air for this route for **carcinogenic effects** is estimated using:

$$RBSL_a = \frac{TR * BW * AT_c * 365}{IR * ED * EF * SF_i} \qquad \text{(C-1)}$$

where:

$RBSL_a$ = Risk-based screening level in air [mg/m^3]
TR = Target risk or the increased chance of developing cancer over a lifetime due to exposure to a chemical [---]
BW = Body weight [kg]
AT_c = Averaging time for carcinogens [years] Note: 365 converts years to days
IR = Inhalation rate [m^3/days]
ED = Exposure duration [years]
EF = Exposure frequency [days/year]
SF_i = The chemical-specific inhalation slope factor [(mg/kg-day)$^{-1}$]

The screening level concentration in air for inhalation for **non-carcinogenic effects** is estimated using:

$$RBSL_a = \frac{THI * BW * AT_{nc} * 365 * RfD}{IR * ED * EF} \qquad \text{(C-2)}$$

where:

AT_{nc} = Averaging time for non-carcinogens (years)
RfD = The chemical-specific reference dose [(mg/kg-day)]
THI = Target hazard index for individual constituents [--] and the other remaining parameters are the same as in Equation C-1.

C.2 SOIL CONCENTRATIONS PROTECTIVE OF GROUNDWATER

Consider the leaching of chemicals from the soil to a down-gradient exposure well as shown in Figure C-1. The acceptable concentrations in the exposure well are the drinking water standard presented in Appendix Q, Table Q.5. Thus the acceptable soil concentration protective of the exposure well is:

$$RBSL_s = \frac{RBSL_w * DAF}{LF_{sw}} \qquad \text{(C-3)}$$

where:

$RBSL_s$ = Risk-based screening level in soil [mg/kg-soil] = C_{soil} (allowable)
$RBSL_w$ = Chemical-specific drinking water standard [mg/l] = C_{water} (ingestion)
LF_{sw} = Leaching factor which accounts for (i) the equilibrium conversion of the soil concentration to the leachate concentration, and (ii) the mixing of the leachate with the groundwater directly beneath the site [(mg/l-H_2O)/(mg/kg-soil)]
DAF = The dilution attenuation factor for the migration of dissolved phase from the edge of mixing zone site to the exposure point.

In Equation C-3, LF_{sw} is calculated as:

$$LF_{sw} = \frac{\rho_s}{(\theta_{ws} + K_s * \rho_s + H * \theta_{as}) * (1 + \frac{U_{gw} * \delta_{gw}}{I * W})} \qquad \text{(C-4)}$$

where:

ρ_s 1.7 = Soil bulk density [g-soil/cm^3-soil]
θ_{ws} 0.12 = Volumetric water content of soil in the impacted zone [cm^3-H_2O/cm^3-soil]
K_s = Chemical-specific solid-water partition coefficient [g-H_2O/g-soil]
K_s = Koc * foc (water partition coefficient * fraction organic carbon)
H = Dimensionless form of the Henry's Law Constant [(cm^3-H_2O)/(cm^3-air)]
θ_{as} = Volumetric air content in the impacted zone soil [cm^3-air/cm^3-soil]
U_{gw} = Groundwater Darcy velocity [cm/yr]
δ_{gw} = Groundwater mixing zone thickness [cm]
I = Infiltration rate of water through soil [cm/yr]
W = Width of source area parallel to the groundwater flow direction [cm]

As mentioned above, LF_{sw} accounts for (i) the reduction in concentration due to mixing of the leachate with the groundwater and (ii) the conversion of liquid phase concentration to soil concentration.

In equation C-3, DAF is estimated using Domenico's steady-state model (see Figure C-2) along the centerline of the plume without decay that is given by:

$$\frac{C_x}{C_{source}} = \left\{ erf\left[\frac{S_w}{4\sqrt{a_y x}} \right] \right\} * \left\{ erf\left[\frac{S_d}{4\sqrt{a_z x}} \right] \right\} \qquad \text{(C-5)}$$

where:

x = Distance in feet along the centerline of the plume
C_x = Concentration at distance "x" [mg/L]
C_{source} = Concentration at the property edge of the impacted zone [mg/L]
S_w = Source thickness perpendicular to the flow in the horizontal direction [ft]
S_d = Source depth in the vertical direction [ft]
α_x = Longitudinal dispersivity [ft] (= $x/10$)
α_y = Transverse dispersivity [ft] (= $\alpha_x/3$)
α_z = Vertical dispersivity [ft] (= $\alpha_x/20$)
erf = Error Function (see Appendix M.1)

C.3 INHALATION OF VAPORS AND PARTICULATES, DERMAL CONTACT AND INGESTION OF CHEMICALS IN SURFICIAL SOIL

The screening level soil concentration protective of a receptor simultaneously exposed to chemicals from these three routes of exposure for carcinogenic effects is estimated using:

$$RBSL_s = \frac{TR * BW * AT * 365}{EF * ED * [(SF_o * 10^{-6} (IR_s * RAF_o + SA * M * RAF_d)) + (SF_i * IR_a (VF_{ss} + VF_p))]} \qquad \text{(C-6)}$$

where:

SF_o = Oral cancer slope factor [(mg/kg-day)$^{-1}$]
IR_s = Soil ingestion rate [mg/day]
RAF_o = Oral relative absorption factor [---]
SA = Skin surface area [cm^2/day]
RAF_d = Dermal relative absorption factor [---]
M = Soil to skin adherence factor [mg/cm^2]

and all the remaining parameters are the same as previously defined.

In Equation C-6, the VF_{ss} factor accounts for the volatilization of vapors from soil to air and is the lower of the two values calculated using Equation C-7 or Equation C-9 (shown below).

$$VF_{ss} = \frac{2 * W * \rho_s}{U_a * \delta_a} * \sqrt{\frac{D_s^{eff} * H}{\pi * [\theta_{ws} + K_s * \rho_s + H * \theta_{as}]\ \tau}} * 10^3 \qquad \text{(C-7)}$$

where:
W = Width of source area parallel to wind, or groundwater flow direction [cm]
ρ_s = Soil bulk density [g-soil/cm^3-soil]
U_a = Wind speed above ground surface in the ambient mixing zone [cm/s]
δ_a = Ambient air mixing zone height [cm]
D_s^{eff} = Effective diffusion coefficient in soil based on vapor-phase concentration [cm^2/s]
H = Chemical-specific Henry's Law constant [(cm^3-H$_2$O)/(cm^3-air)]
θ_{ws} = Volumetric water content in vadose zone soils [cm^3-H$_2$O/cm^3- soil]
K_s = Chemical-specific solid-water sorption coefficient [g-H$_2$O/g-soil]
θ_{as} = Volumetric air content in the vadose zone soils [cm^3-air/cm^3-soil]
τ = Averaging time for vapor flux [s]
10^3 = Conversion factor [(cm^3-kg)/(m^3-g)]

In Equation C-7, the effective diffusion coefficient D_s^{eff} is calculated as:

$$D_s^{eff} = \left[D^a * \frac{\theta_{as}^{3.33}}{\theta_T^{2.0}} \right] + \left[D^w * \frac{1}{H} * \frac{\theta_{ws}^{3.33}}{\theta_T^{2.0}} \right] \qquad \text{(C-}$$

where:
D^a = Chemical-specific diffusion coefficient in air [cm^2/s]
θ_T = Total soil porosity in the impacted zone [cm^3/cm^3-soil]
D^w = Chemical-specific diffusion coefficient in water [cm^2/s]

and the remaining parameters are the same as in Equation C-7.

An alternative expression for VF_{ss} is:

$$VF_{ss} = \frac{W * \rho_s * d}{U_a * \delta_a * \tau} * 10^3 \qquad \text{(C-9)}$$

where:
W = Width of source area parallel to wind, or groundwater flow direction [cm]
ρ_s = Soil bulk density [g-soil/cm^3-soil]
d = Thickness of surficial soil zone [cm]
U_a = Wind speed above ground surface in ambient mixing zone [cm/s]
δ_a = Ambient air mixing zone height [cm]
τ = Averaging time for vapor flux [s]
10^3 = Conversion factor [(cm^3-kg)/(m^3-g)]

Equations C-7 and C-9 are calculated and the smaller of the two is used in Equation C-6.
See Appendix M, Section M.5.

In Equation C-6 the VF_p factor accounts for the volatilization of particulates from soil to air. VF_p is calculated as:

$$VF_p = \frac{P_e * W}{U_a * \delta_a} * 10^3 \tag{C-10}$$

where:

VF_p = Volatilization factor from soil to ambient air (particulates) [(mg/m^3-air)/(mg/kg-soil)]
P_e = Particulate emission rate [g/cm^2-s]
W = Width of source area parallel to wind or groundwater flow direction [cm]
U_a = Wind speed above ground surface in ambient mixing zone [cm/s]
δ_a = Ambient air mixing zone height [cm]
10^3 = Conversion factor [(cm^3-kg)/(m^3-g)]

The screening level concentration in soil protective of a receptor simultaneously exposed to chemicals from these routes of exposure for **non-carcinogenic effects** is estimated using:

$$RBSL_s = \frac{THI * BW * AT * 365}{EF * ED * \left[\dfrac{10^{-6} * \left(IR_{soil} * RAF_o + SA * M * RAF_d\right)}{RfD_o} + \dfrac{\left(IR_a * \left(VF_{ss} + VF_p\right)\right)}{RfD_i} \right]} \qquad \text{C-11}$$

where:

RfD_i = The chemical-specific reference dose for inhalation [(mg/kg-day)]
THI = Target hazard index for individual constituents [--]

and the remaining parameters are the same as in Equation C-7.

Note that the factors VF_{ss} and VF_p are estimated using Equations C-7, C-9 and C-10.

C.4 SUBSURFACE SOIL CONCENTRATIONS PROTECTIVE OF AMBIENT AIR (Outdoor) VAPOR INHALATION

Consider the subsurface soil emissions to ambient air as shown in Figure C-3. The screening level for subsurface soil for inhalation of vapors emitted to ambient air for **carcinogenic effects** is estimated using:

$$RBSL_s = \frac{RBSL_a}{VF_{samb}} \tag{C-12}$$

where:

$RBSL_s$ = Risk-based screening level for inhalation of vapors from subsurface soils [mg/kg-soil]
$RBSL_a$ = Risk-based screening level for inhalation of air [mg/m^3-air] and estimated using equation C-1.
VF_{samb} = Volatilization factor from subsurface soil to ambient (outdoor) air [(mg/m^3-air)/(mg/kg-soil)]

In Equation C-12, VF_{samb} is calculated as:

$$VF_{samb} = \frac{H * \rho_s}{(\theta_s + K_s * \rho_s + H * \theta_{as}) * \left[1 + \frac{U_a * \delta_a * L_s}{D_s^{eff} * W} \right]} * 10^3 \qquad \text{(C-13)}$$

where:

H = Henry's Law constant $[(cm^3\text{-}H_2O)/(cm^3\text{-air})]$

ρ_s = Soil bulk density $[g\text{-soil}/cm^3\text{-soil}]$

θ_{ws} = Volumetric water content in vadose zone soils $[cm^3\text{-}H2O/cm^3\text{-soil}]$

K_s = Chemical-specific soil-water sorption coefficient [g-H2O/g-soil]

θ_{as} = Volumetric air content in vadose zone soils $[cm^3\text{-air}/cm^3\text{-soil}]$

U_a = Wind speed above ground surface in ambient mixing zone [cm/s]

δ_a = Ambient air mixing zone height [cm]

L_S = Depth to subsurface impacted soil [cm]

D_s^{eff} = Effective diffusion coefficient in soil based on vapor-phase concentration $[cm^2/s]$

10^3 = Conversion factor $[(cm^3\text{-kg})/(m^3\text{-g})]$

The screening level soil concentration for **non-carcinogenic effects** is estimated using the $RBSL_a$ estimated in Equation C-2 in Equation C-12.

C.5 GROUNDWATER CONCENTRATIONS PROTECTIVE OF AMBIENT AIR (Outdoor) VAPO INHALATION

Consider the groundwater emissions through unsaturated zone to the ambient air as shown in Figure C-4. The screening level concentration in water protective of ambient air vapor inhalation for **carcinogenic effects** is estimated using:

$$RBSL_w = \frac{RBSL_a}{VF_{wamb}} \qquad \text{(C-14)}$$

where:

$RBSL_w$ = Risk-based screening level in water $[mg/l\text{-}H_2O]$

$RBSL_a$ = Risk-based screening level in air $(mg/m^3\text{-air})$

VF_{wamb} = Volatilization factor from groundwater to ambient air $[(mg/m^3\text{-air}/(mg/l\text{-}H_2O)]$

and $RBSL_a$ is calculated as described in Equation C-1.

In equation C-14, VF_{wamb} accounts for volatilization from groundwater through the vadose zone to ambient air. VF_{wamb} is calculated as:

$$VF_{wamb} = \frac{H}{1 + \left[\frac{U_a * \delta_a * L_{GW}}{W * D_{ws}^{eff}} \right]} * 10^3 \qquad \text{(C-15)}$$

where:

H = Dimensionless form of Henry's Law constant [(cm^3-H_2O)/(cm^3-air)]
U_a = Wind speed above ground surface in ambient mixing zone [cm/s]
δ_a = Ambient air mixing zone height [cm]
L_{GW} = Depth to groundwater [cm]
W = Width of source area parallel to wind, or groundwater flow direction [cm]
D_{ws}^{eff} = Effective soil diffusion coefficient between groundwater and soil surface [cm^2/s]
10^3 = Conversion factor [1/m^3]

In Equation C-15, D_{ws}^{eff} is calculated as:

$$D_{ws}^{eff} = (h_{cap} + h_v) * \left[\frac{h_{cap}}{D_{cap}^{eff}} + \frac{h_v}{D_s^{eff}} \right]^{-1} \qquad \text{(C-16)}$$

where:

h_{cap} = Thickness of capillary fringe [cm]
h_v = Thickness of vadose zone [cm]
D_{cap}^{eff} = Effective diffusion through capillary fringe [cm^2/s]
D_s^{eff} = Effective diffusion through vadose zone [cm^2/s]

In Equation C-16, D_{cap}^{eff} is calculated as:

$$D_{cap}^{eff} = \left(D^a * \frac{\theta_{acap}^{3.33}}{\theta_T^{2.0}} \right) + \left(D^w * \frac{1}{H} * \frac{\theta_{wcap}^{3.33}}{\theta_T^{2.0}} \right) \qquad \text{(C-17)}$$

where:

D^a = Diffusion coefficient in air [cm^2/s]
θ_{acap} = Volumetric air content in capillary fringe soils [cm^3-air/cm^3-soil]
θ_T = Total soil porosity [cm^3/cm^3-soil]
D^w = Diffusion coefficient in water [cm^2/s]
H = Dimensionless form of Henry's Law constant [(cm^3-H_2O)/(cm^3-air)]
θ_{wcap} = Volumetric water content in capillary fringe soils [cm^3-H2O/cm^3-soil]

The screening level concentration in water for **non-carcinogenic effects** is estimated using $RBSL_a$ from Equations C-2 in Equation C-14.

C.6 SUBSURFACE SOIL CONCENTRATIONS PROTECTIVE OF ENCLOSED SPACE AIR (Indoor) VAPOR INHALATION

Consider vapor emissions from subsurface soils to enclosed air space as shown in Figure C-5. The screening level for indoor inhalation of subsurface soil emissions for **carcinogenic effects** is estimated using:

$$RBSL_s = \frac{RBSL_a}{VF_{sesp}} \qquad \text{(C-18)}$$

where:

$RBSL_s$ = Risk-based screening level for inhalation of vapors from subsurface soils [mg/kg-soil]
$RBSL_a$ = Risk-based screening level for inhalation of air [mg/m^3-air] and estimated using Equation C-1.
VF_{sesp} = Volatilization factor from subsurface soil to enclosed space (indoor) air [(mg/m^3-air)/(mg/kg-soil)]

In Equation C-18, VF$_{sesp}$ is calculated using either C-19 or C-21, whichever is less.

$$VF_{sesp} = \frac{\dfrac{H * \rho_s}{[\theta_{ws} + K_s * \rho_s + H * \theta_{as}]} * \left[\dfrac{D_s^{eff} / L_s}{ER * L_B}\right]}{1 + \left[\dfrac{D_s^{eff} / L_s}{ER * L_B}\right] + \left[\dfrac{D_s^{eff} / L_s}{\left(D_{crack}^{eff} / L^{crack}\right)\eta}\right]} * 10^3 \qquad \text{(C-1}$$

where:

H = Henry's Law constant [(cm^3-H$_2$O)/(cm^3-air)]
ρ_s = Soil bulk density [g-soil/cm^3-soil]
θ_{ws} = Volumetric water content in vadose zone soils [cm^3-H2O/cm^3-soil]
K_s = Soil-water sorption coefficient [g-H2O/g-soil]
θ_{as} = Volumetric air content in vadose zone soils [cm^3-air/cm^3-soil]
L_S = Depth to subsurface impacted soil sources [cm]
L_B = Enclosed space volume/infiltration area ratio [cm]
L_{crack} = Enclosed space foundation or wall thickness [cm]
ER = Enclosed space air exchange rate [1/s] (liters/sec)
D_s^{eff} = Effective diffusion coefficient in soil based on vapor-phase concentration [cm^2/s] which is expressed as in Equation C-8.
$D_{crack}{}^{eff}$ = Effective diffusion coefficient through foundation cracks [cm^2/s]
η = Areal fraction of cracks in foundation walls [cm^2-cracks/cm^2-total area]
10^3 = Conversion factor [(cm^3-kg)/(m^3-g)]

In Equation C-19, D_{crack}^{eff} is calculated as:

$$D_{crack}^{eff} = \left[D^{a} * \frac{\theta_{acrack}^{3.33}}{\theta_{T}^{2.0}} \right] + \left[D^{w} * \frac{1}{H} * \frac{\theta_{wcrack}^{3.33}}{\theta_{T}^{2.0}} \right] \qquad \text{(C-20)}$$

where:

D^a = Diffusion coefficient in air [cm^2/s]
θ_{acrack} = Volumetric air content in foundation/wall cracks [cm^3-air/cm^3-total volume]
θ_{wcrack} = Volumetric water content in foundation/wall cracks [cm^3-H_2O/cm^3-total volume]
D_{crack}^{eff} = Effective diffusion coefficient through foundation cracks [cm^2/s]

Alternatively, VF_{sesp} is calculated as:

$$VF_{sesp} = \frac{\rho_s * d_s}{L_B * ER * \tau} * 10^3 \qquad \text{(C-21)}$$

where:

ρ_s = Soil bulk density [g-soil/cm^3-soil]
d_s = Thickness of the subsurface impacted soil [cm]
L_B = Enclosed space volume/infiltration area ratio [cm]
ER = Enclosed space air exchange rate [1/s] (liters/sec)
τ = Averaging time for vapor flux [s]
10^3 = Conversion factor [(cm^3-kg)/(m^3-g)]

Equations C-19 and C-21 are calculated and the smaller of the two is used in Equation C-18. See Appendix M, Section M.5.

The screening level for **non-carcinogenic effects** is estimated using $RBSL_a$ from Equation C-2 in Equation C-18.

C.7 GROUNDWATER CONCENTRATIONS PROTECTIVE OF ENCLOSED SPACE (Indoor) AIR VAPOR INHALATION

Consider vapor emissions from impacted groundwater to enclosed air space as shown in Figure C-6. The screening level concentration in water for this route for **carcinogenic effects** is estimated using:

$$RBSL_w = \frac{RBSL_a}{VF_{wesp}} \qquad \text{(C-22)}$$

where:

$RBSL_w$ = Risk-based screening level in water [mg/L-H_2O]
$RBSL_a$ = Risk-based screening level in air (mg/m^3-air)
VF_{wesp} = Volatilization factor from groundwater to ambient air [(mg/m^3-air)/(mg/l-H_2O)] and $RBSL_a$ is calculated as described in Equation C-1.

In Equation C-22, VF_{wesp} accounts for volatilization from groundwater to enclosed space air and calculated as:

$$VF_{wesp} = \frac{H * \left[\frac{D_{ws}^{eff} / L_{GW}}{ER * L_B}\right]}{1 + \left[\frac{D_{ws}^{eff} / L_{GW}}{ER * L_B}\right] + \left[\frac{D_{ws}^{eff} / L_{GW}}{\left(D_{crack}^{eff} / L_{crack}\right)\eta}\right]} * 10^3 \qquad \text{(C-23)}$$

where:

H = Henry's Law constant [$(cm^3\text{-}H_2O)/(cm^3\text{-air})$]

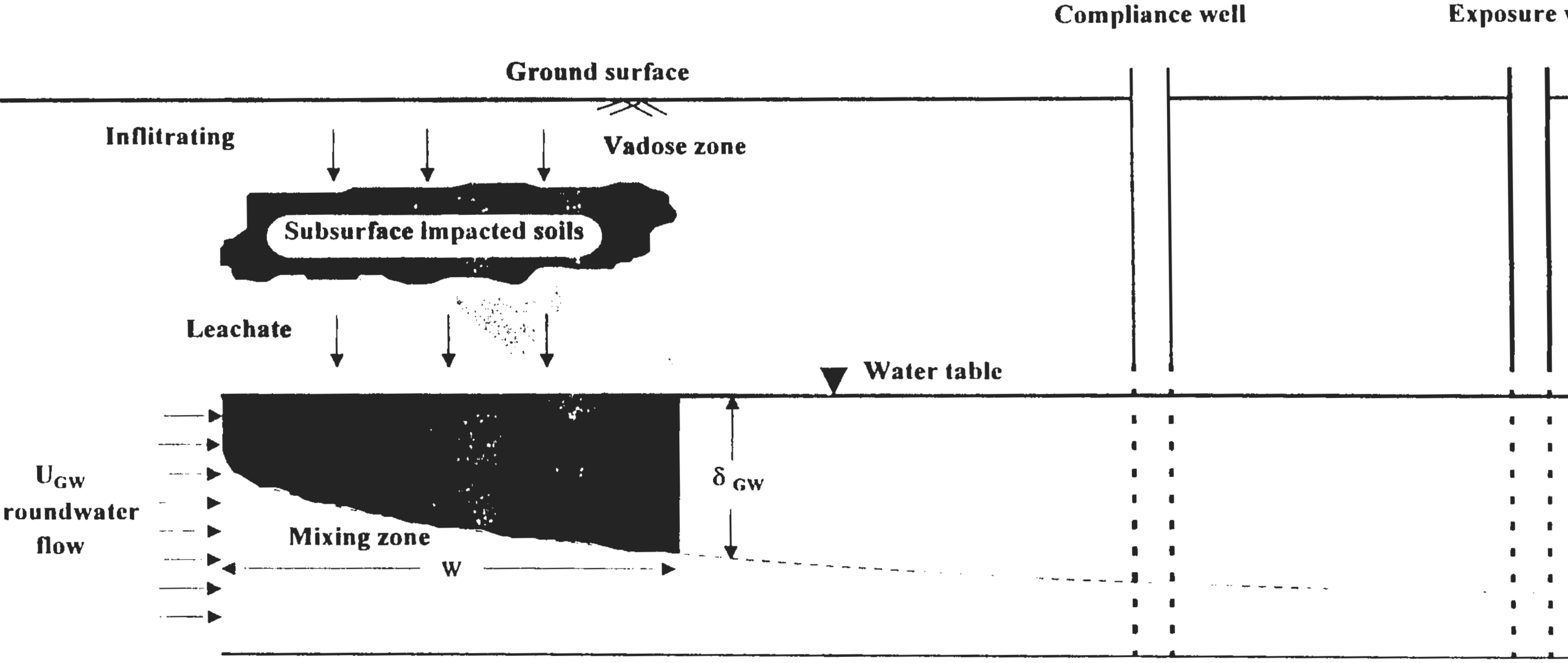
L_{GW} = Depth to groundwater [cm]

D_{ws}^{eff} = Effective diffusion coefficient between groundwater and soil surface [cm^2/s] which is expressed as in Equation C-16

and all the remaining parameters are as previously defined.

The screening level in water protective of indoor air vapor inhalation for **non-carcinogenic effects** is estimated using $RBSL_a$ from Equation C-2 in Equation C-22.

Figure C-1: Leaching from Subsurface Soils to Groundwater



gure C-2. Selected Contaminant Fate and Transport Models for Leaching from Subsurface Soils to Groundwater

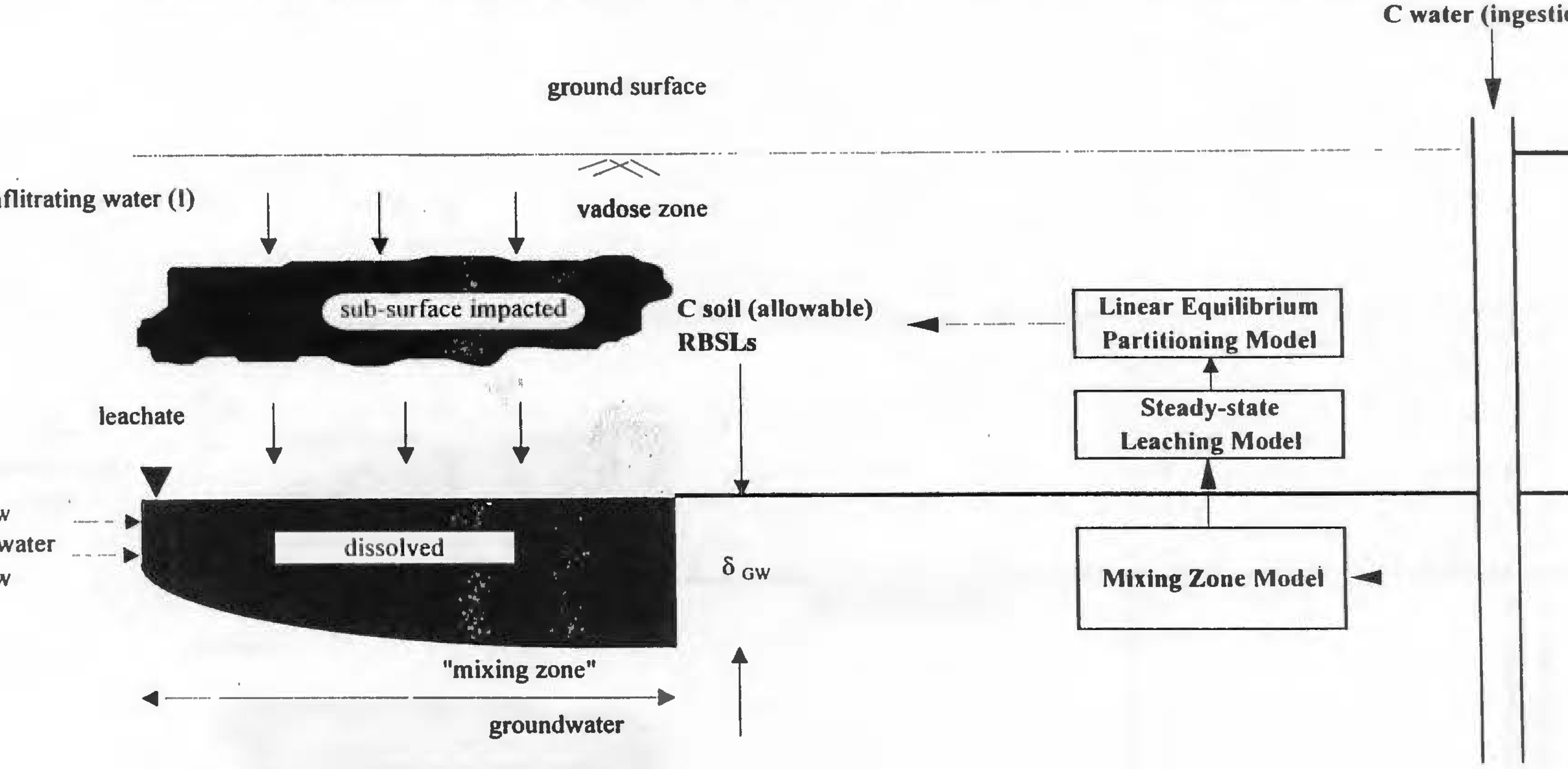


Figure C-3. Volatilization from Subsurface Soils to Ambient Air

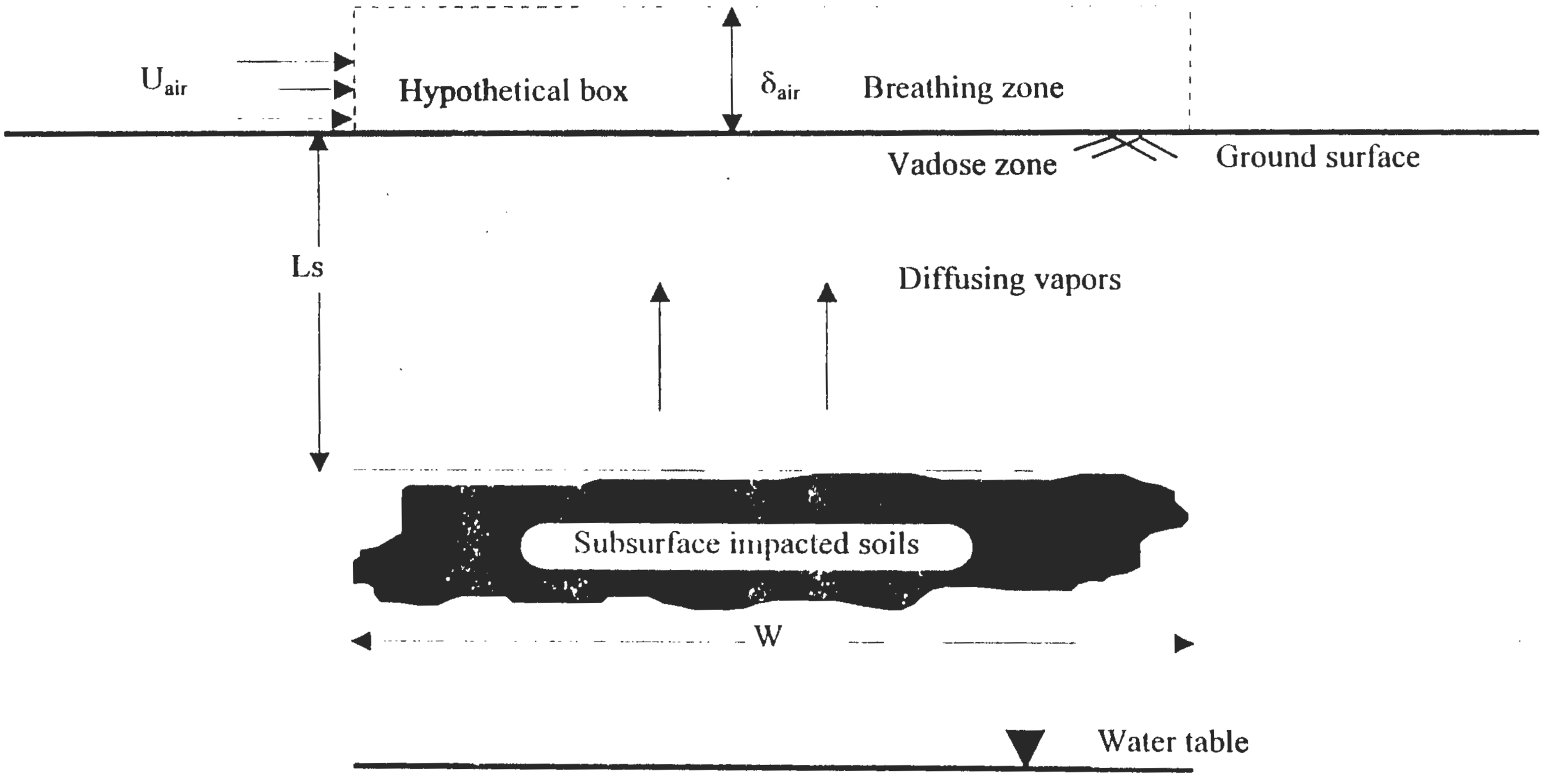


Figure C-4. Volatilization from Groundwater to Ambient Air

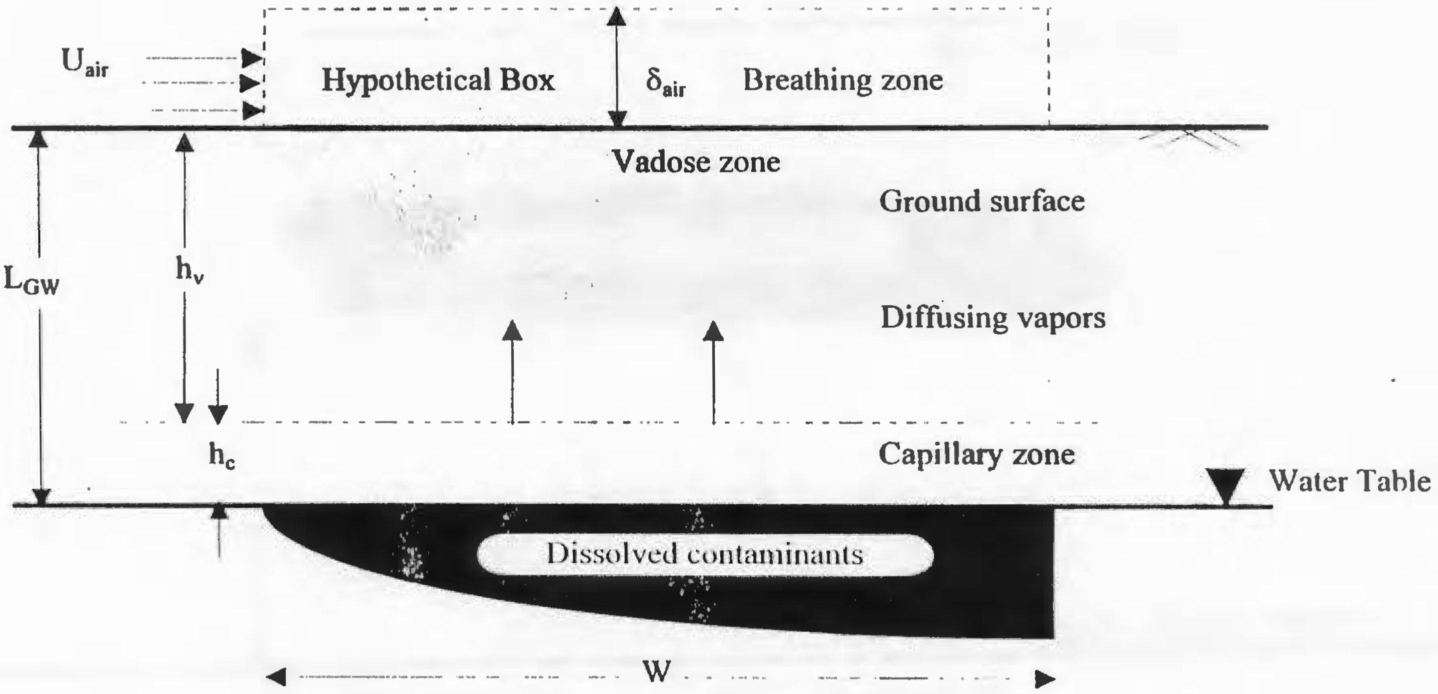


Figure C-5. Volatilization from Subsurface Soils to Enclosed Space

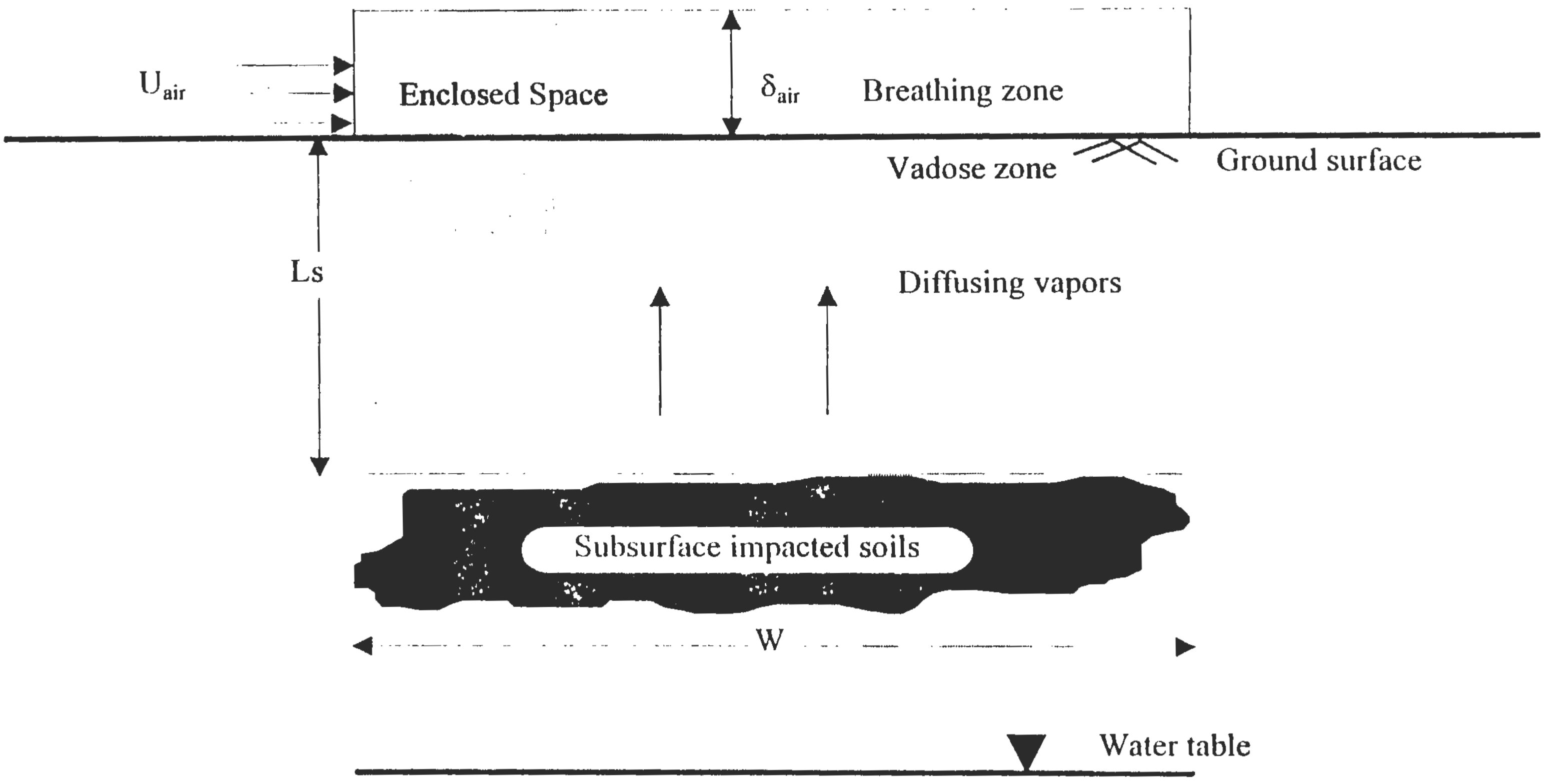
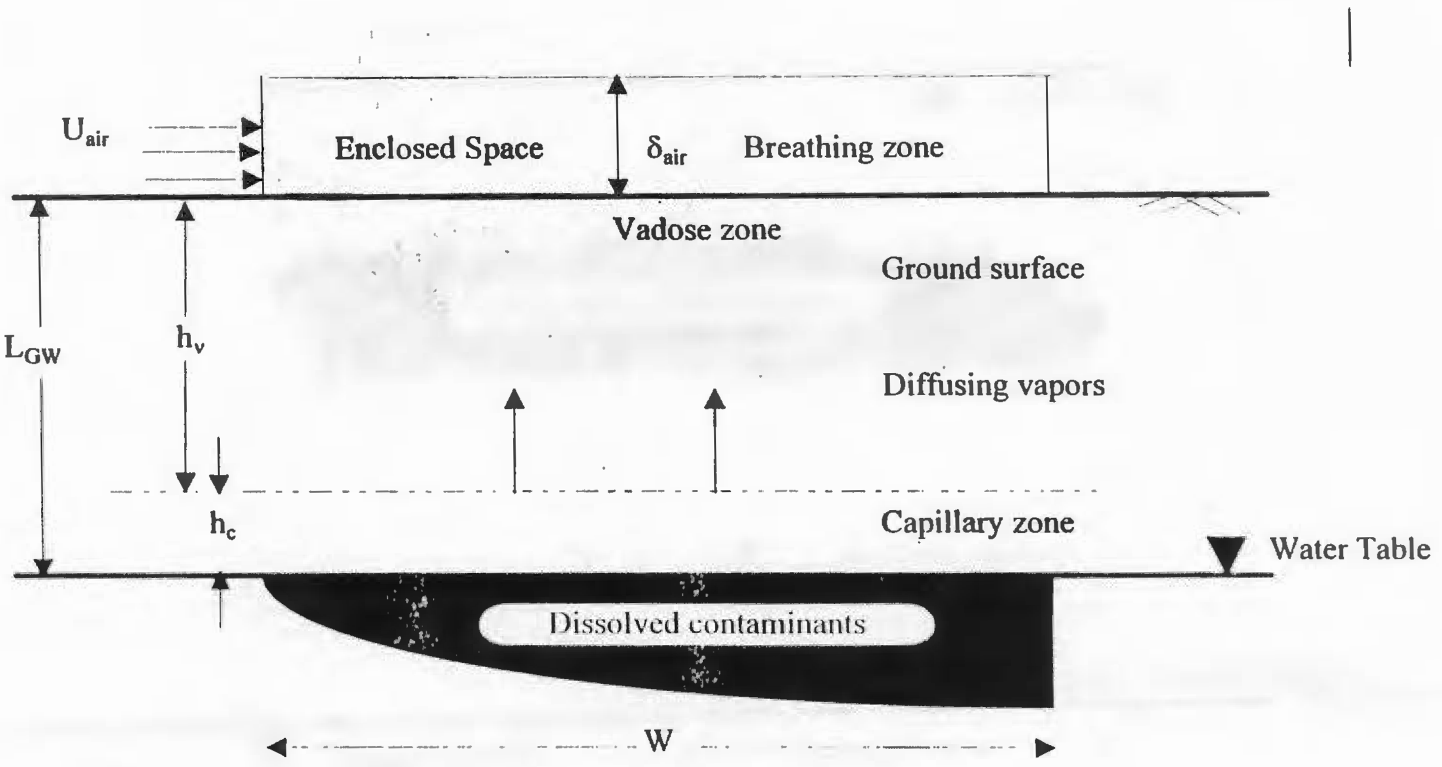


Figure C-6. Volatilization from Groundwater to Enclosed Space



APPENDIX D
SCENARIO/RESPONSE ACTION TABLE FOR DEVELOPING EMERGENCY RESPONSE ACTIONS

CLASSIFICATION - SCENARIO	*RECOMMENDED EMERGENCY RESPONSE ACTION*
A. - Known release that produces an immediate threat to human health, safety, sensitive environmental receptors, and/or subsurface inhabited structures.	Notify appropriate authorities, property owners, and potentially affected parties, and evaluate need to:
1. Explosive levels, or concentrations of vapors that could cause acute health effects, are present in a residence or other building.	1. Evacuate occupants, begin abatement measures, such as subsurface ventilation, or building pressurization.
2. Explosive levels of vapors are present in subsurface utilities, but not in buildings.	2. Begin abatement measures such as ventilation.
3. Free product is present in recoverable quantities at ground surface, on surface water bodies, in utilities other than water supply lines, or in surface water runoff.	3. Prevent further free-product migration by appropriate containment measures, institute free product recovery, restrict area access.
4. An active public water supply well, public line, or public surface water intake is impacted or immediately threatened by dissolved phase plume.	4. Notify users, provide alternate water supply, hydraulically control contaminated water, and treat water at point-of-use.
5. Ambient vapor concentrations exceed concentrations of concern from acute exposure or safety viewpoint.	5. Install vapor barrier (capping foams, etc.), remove source, or restrict access to affected areas.
6. A sensitive environmental receptor (e.g., a threatened or endangered species, sport fish, economically important species, etc.) are impacted.	6. Minimize extent of impact by containment measures and implement habitat management to minimize exposure.

CLASSIFICATION - SCENARIO	*RECOMMENDED EMERGENCY RESPONSE ACTION*
B. Known or probable release, where, without action, there is a potential within approximately two years, for a fire/explosion hazard (indoors or outdoors), contamination of groundwater, or significant releases that would affect surface waters or sensitive environmental receptors.	Notify appropriate authorities, property owners, and potentially affected parties, and evaluate the need to:
1. There is a potential for explosive levels, or concentrations of vapors that could cause acute effects, to accumulate in a residence or other building.	1. Assess the potential for vapor migration (through monitoring/modeling) and remove source (if necessary), or install vapor migration barrier.
2. The presence of shallow contaminated surface soils that are open to public access, and dwellings, parks, playgrounds, day care centers schools or similar use facilities that are within 500 ft of those soils.	2. Remove or cover soils, and/or restrict access.
3. A non-potable water supply is impacted or immediately threatened.	3. Notify owner/user, evaluate the need to install point-of-use treatment, hydraulic control, or alternate water supply.
4. Groundwater is impacted, and a public or domestic water supply well producing from the impacted aquifer is located within two years projected groundwater travel distance down-gradient of the known extent of contamination.	4. Institute monitoring, then evaluate if natural attenuation is sufficient or if hydraulic control is required.
5. Groundwater is impacted, and a public or domestic water supply well producing from a different water-bearing zone is located within the known horizontal extent of contamination.	5. Monitor groundwater well quality, and evaluate if control is necessary to prevent vertical migration to the supply well.
6. An impacted surface water, storm water runoff, or aquifer discharges within 500 ft of a sensitive habitat, or surface water body used for potable water supply or contact recreation.	6. Institute containment measures, restrict access to areas near discharge, and evaluate the magnitude and impact of the discharge.
7. Tank test failures or unexplained inventory losses for UST system that do not have acceptable secondary containment.	7. Conduct initial tank test for an inventory loss, or excavate, isolate, and retest to confirm/ isolate the leak found from a system test. If the leak is confirmed, empty the leaking system, and initiate a soil contamination investigation.

CLASSIFICATION - SCENARIO	*RECOMMENDED EMERGENCY RESPONSE ACTION*
C. - Known release, where if no action were taken, it would take longer than two years for the threat of fire and an explosion , contamination of groundwater, or release that would affect surface waters or sensitive environmental receptors.	Notify appropriate authorities, property owners, and potentially affected parties, and evaluate need to:
1. Subsurface soils (> 3 ft below grade surface) are impacted, and the vertical distance between the impacted soils and the first potable aquifer is less than 50 ft.	1. Monitor groundwater, and determine the potential for future contaminant migration to the aquifer.
2. Groundwater is impacted, and either subsurface inhabited structures or potable drinking water supply wells producing from the impacted water-bearing zone are located greater than 2 years groundwater travel time from the dissolved plume.	2. Monitor the dissolved plume, and evaluate the potential for natural attenuation and the need for hydraulic control or remediation. Notify well/structure owners.
3. Groundwater is impacted, and either subsurface non-inhabited structures or non-potable water supply wells producing from the impacted water-bearing zone are located greater than 2 years groundwater travel time from the dissolved plume.	3. Identify water usage of the well, assess the effect of potential impact, monitor the dissolved plume, and evaluate whether remediation, hydraulic control or natural attenuation are appropriate control measures.
4. Groundwater is impacted, and either subsurface non-inhabited structures or non-potable water supply wells that do not produce from the impacted water-bearing zone are located within the known extent of contamination.	4. Monitor the dissolved plume, determine the potential for vertical migration, notify the user, and structure owners, and determine if any impact is likely.
5. Impacted surface water, storm water, or groundwater discharges within 1500 ft of either a sensitive environmental receptor or a surface water body used for potable or recreational use.	5. Investigate if there is a current impact on a sensitive environmental receptor or surface water body, restrict access to the area of discharge (if needed), and evaluate the need for containment/ control measures.
6. Contamination occurs in shallow (<3 ft) surface soils that are subject to public access, such as parks, playgrounds, day care centers, schools, or similar use facilities that are within 500 ft. of those soils.	6. Restrict access to the impacted soils, either through isolation of materials (if no vertical migration of contaminants threatens groundwater/subsurface structures) or physical removal of the soils.

CLASSIFICATION - SCENARIO	*RECOMMENDED EMERGENCY RESPONSE ACTION*
D. - A possible petroleum release that shows no demonstrable long-term threat to human health or safety, via fire/explosion potential, migration to groundwater, releases to surface waters, or impact to sensitive environmental receptors.	Notify appropriate authorities, property owners, and potentially affected parties, and evaluate need to:
1. Contamination occurs in a non-potable aquifer with no existing local use impacted.	1. Monitor the groundwater, and evaluate the need for remediation of the dissolved plume.
2. Impacted soils located more than 4 ft below grade surface and greater than 50 ft above nearest aquifer.	2. Monitor the groundwater, and evaluate the need for remediation, as outlined in Section 5.
3. The groundwater is impacted, and non-potable wells are located downgradient outside the known extent of contamination, and they produce from a non-impacted water-bearing zone.	3. Monitor the groundwater, and evaluate the need for remediation, as outlined in Section 5.
4. A tank test failure or unexplained inventory loss involving an UST system that has acceptable secondary containment .	4. Examine interstice of secondary containment for evidence of contamination. If contamination is found, take system out of service, test integrity of secondary containment system, and conduct soil investigation if the containment system is breached.

CLASSIFICATION - SCENARIO	*RECOMMENDED EMERGENCY RESPONSE ACTION*
E. - Site characterization indicates that no spill occurred.	No further action or notification required. Close the spill report

APPENDIX E
EXAMPLE APPLICATION OF TIER 1 LOOK-UP TABLES

This appendix has been developed for illustration only. The objective is to demonstrate the use of Tier 1 look-up tables (Appendix Q, Tables Q.1 - Q.5).

1 SITE CONCEPTUAL EXPOSURE SCENARIOS

The use of Tier 1 look-up tables requires the development of site conceptual exposure scenarios for current and potential future conditions. Consider the following for a gas station site:

The site had three 10,000 gallon underground storage tanks (UST). A leak was detected at the former UST area. The gas station was decommissioned and the UST and associated piping were removed from the site. Following this, several investigations were conducted at the site to determine the areal extent and magnitude of groundwater and soil contamination.

Sub-surface soil and groundwater were found to be impacted near the former UST area 100 feet from the down-gradient property boundary. An off-site water well is located at a distance of 300 feet down-gradient from the source at a residence. Monitoring of this well indicated that it has not been impacted by the release.

The primary chemicals of concern for these pathways were identified to be benzene, toluene, ethylbenzene, and mixed xylenes due to a confirmed release of gasoline at the gas station, and subsequent analysis of contaminated media.

Currently, the decommissioned gas station site is used by a restaurant and it is anticipated that it will be used for commercial purposes in the future. This was ascertained by reviewing the historical use of the site, the location, and through discussions with the current owner of the property. A site sketch is included as Figure E-1.

The following sub-sections list the receptors, media, and the complete routes of exposure at the gas station site.

E.1.1 Current Conditions

Under current conditions, the following receptors are likely to be exposed to the contamination at the site. The primary pathway, route and media through which exposure is likely to occur are also identified. Note that exposures to an off-site commercial worker may currently exist, however, the site conceptual exposure scenarios include the same exposure scenarios for an on-site commercial worker, which would be greater human exposure.

- An on-site commercial worker is exposed to subsurface soil by inhalation of vapors in indoor air.
- An on-site commercial worker is exposed to groundwater by inhalation of vapors in indoor air. (See Figure E-2).
- An off-site resident is exposed to groundwater from a well 300 feet down-gradient from the source. (See Figure E-3).

E.1.2 Future Conditions: Short-Term Construction Activity

Under future conditions, construction activity may occur at the site. This construction activity involve the excavation of the site at or near the impacted area. The following receptor is likely to be exposed to contamination at the site during such construction activities. The primary pathway, route and media through which exposure is likely to occur is also identified.

- A construction worker is exposed to the subsurface soil by dermal contact, accidental ingestion, and inhalation of particulates. (See Figure E-4)

E.1.3 Future Conditions: Long-Term

Since the site is located in mixed residential/commercial areas and the local land use trends are towards residential, future use of the adjacent property is assumed to be residential. This ensures the protection of human health to the highest degree. Based on this assumption, following are the likely receptors who may be exposed to contamination at the site. The primary pathway, route and media through which exposure is likely to occur are also identified. Note that potential future exposures of an off-site commercial worker and an off-site construction worker exist; however, the site conceptual exposure scenarios include the same exposure scenarios for an on-site commercial worker and an on-site construction worker, which would be greater human exposures. Also note that the on-site commercial worker site conceptual scenarios for future use are the same as those for current use; therefore, there is no need to repeat them on Figure E-4.

- An off-site resident is potentially exposed to groundwater from a well located at th downgradient edge of the property boundary, that is, 100 feet from the source. (See Fig E-5).

E.2 SELECTION OF TIER 1 LOOK-UP VALUES

The Tier 1 look-up values for this case are as follows:

E.2.1 Current Conditions

Table E.1 shows the screening levels for soil obtained from the Tier 1 look-up tables for the relevant routes of exposure from Appendix Q.3 and Q.5.

Table E.2 shows the screening levels for a compliance well located at the down-gradient edge of soil contamination. These groundwater concentration values are estimated by multiplying the drinking water standards by the appropriate dilution attenuation factor (DAF). From Table 5.2, the DAF factor is 46.1 for a distance of 300 ft.

E.2.2 Future Conditions: Short-Term Construction Activity

Table E.3 shows the screening levels for soil obtained from the Tier 1 look-up tables for the relevant routes of exposure from Appendix Q.3 and Q.5. The allowable groundwater concentration values are the same as for the current conditions because they are estimated using drinking water standards a the dilution attenuation factor for an exposure well at 300 feet from the source.

E.2.3 Future Conditions - Long Term

Table E.4 shows the screening levels for soil obtained from the Tier 1 look-up tables for the relevant routes of exposure from Appendix Q.1, Q.3, and Q.5.

The drinking water standards are the allowable groundwater concentration values because the compliance well is assumed to be located at the down-gradient edge of soil contamination.

E.3 SUMMARY TARGET LEVELS BASED ON TIER 1 EVALUATION

Based on the Tier 1 levels indicated in Tables E-1, E-3, and E-4, the lowest Tier 1 risk-based levels for soil for benzene, toluene, ethylbenzene, and xylene are 0.158 mg/kg, 0.595 mg/kg, 0.438 mg/kg, and 0.963 mg/kg respectively. Based on the Tier 1 levels indicated in Tables E.2 - E.5, the lowest Tier 1 risk-based levels for groundwater for benzene, toluene, ethylbenzene, and xylene are 0.0295 mg/l for each of the four chemicals, which is the level protective of the future off-site receptor drinking water well 100 ft. from the source. These values should be compared with the representative site concentrations. If the representative site concentrations are higher, implement a remedial action to achieve Tier 1 levels or consider evaluation under Tier 2. If the site concentrations are lower than Tier 1 levels, the NYSDEC may grant site closure.

TABLE E.1
TIER 1 LEVELS FOR SOIL FOR CURRENT CONDITIONS

Chemical	**On-Site Commercial Worker** Soil Concentrations for Indoor Inhalation* (mg/kg)	**Off-Site Resident** GW Exposure Well Located 300 ft. From Source** (mg/kg)	**Tier 1 Levels RBSLs** Minimum of all complete routes of exposure (mg/kg)
Benzene	0.0158	1.69	0.0158
Toluene	180	4.49	4.49
Ethylbenzene	474***	3.42	3.42
Xylenes (mixed)	141	7.53	7.53

Notes:

* From Appendix Q.3.
** Allowable soil concentration at the source to protect an exposure well 300 feet down-gradient (from Table 5-4).
*** This value exceeds the residual (saturated) soil concentration.

TABLE E.2
TIER 1 LEVELS FOR GROUNDWATER FOR CURRENT CONDITIONS

Chemical	Off-Site Receptor for Drinking Water Well 300 ft. from Source			On-Site Commercial Worker	Tier 1 Level RBSL$_w$
	Drinking Water (mg/l)	DAF at 300'	GW Conc.* = (0.005 * DAF @ 300'	GW Concentrations for Indoor Inhalation**	Minimum of all complete routes of exposure
Benzene	0.005	46.1	0.23	0.0739	0.0739
Toluene	0.005	46.1	0.23	81.8	0.23
Ethylbenzene	0.005	46.1	0.23	203***	0.23
Xylenes (mixed)	0.005	46.1	0.23	68.3	0.23

Notes:

* Allowable groundwater concentration at the source. The DAF is the dilution attenuation factor along the center line of the plume with no decay and presented in Table 5-5 for different distances.

** From Appendix Q.3.

*** This value exceeds the pure component water solubility.

TABLE E.3
TIER 1 LEVELS FOR SOIL FOR ON-SITE FUTURE CONSTRUCTION ACTIVITIES

Chemical	On-Site Construction Worker [Inhalation of vapors and particulates, dermal contact and ingestion of soil*] = surficial soil (mg/kg)	Tier 1 Level RBSLs Minimum of all complete routes of exposure (mg/kg)
Benzene	265	265
Toluene	35,200 **	35,200 **
Ethylbenzene	40,000 **	40,000 **
Xylenes (mixed)	38,400 **	38,400 **

Notes:

* Soil concentration for surficial soil which represents screening level for total exposure due to dermal contact accidental ingestion, and inhalation of particulates and vapors (from Appendix Q.4).

** This value exceeds the residual (saturated) soil concentration.

TABLE E.4
TIER 1 LEVELS FOR SOIL FOR FUTURE CONDITIONS

Chemical	**Off-Site Resident** GW Exposure Well at 100 ft from Source** (mg/kg)	**Tier 1 Level RBSLs** Minimum of all complete routes of exposure (mg/kg)
Benzene	0.216	0.216
Toluene	0.575	0.575
Ethylbenzene	0.438	0.438
Xylenes (mixed)	0.963	0.963

Notes:

* Soil concentration for indoor inhalation (from Appendix Q.1).

** Allowable soil concentration at 100 ft., i.e. at the property edge (from Appendix Q.5).

*** This value exceeds the residual (saturated) soil concentration.

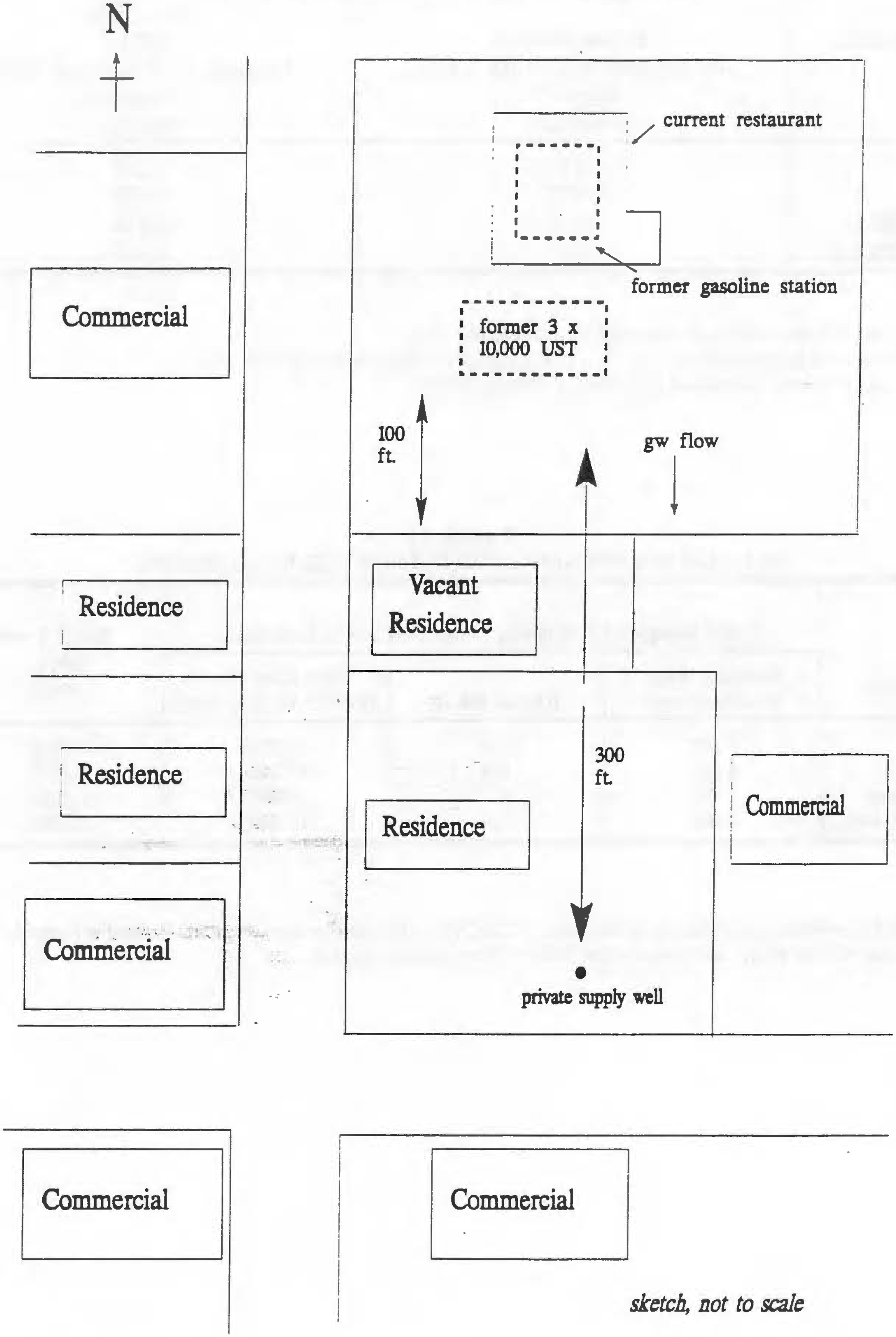
TABLE E.5
TIER 1 LEVELS FOR GROUNDWATER FOR FUTURE CONDITIONS

Chemical	**Off-Site Receptor for Drinking Water Well 100 ft. from Source**			**Tier 1 Level RBSL$_w$ (mg/l)**
	Drinking Water Standard (mg/l)	**DAF at 100 ft.**	**GW Conc.* = (0.005 * DAF @ 100')**	
Benzene	0.005	5.9	0.0295	0.0295
Toluene	0.005	5.9	0.0295	0.0295
Ethylbenzene	0.005	5.9	0.0295	0.0295
Xylenes (mixed)	0.005	5.9	0.0295	0.0295

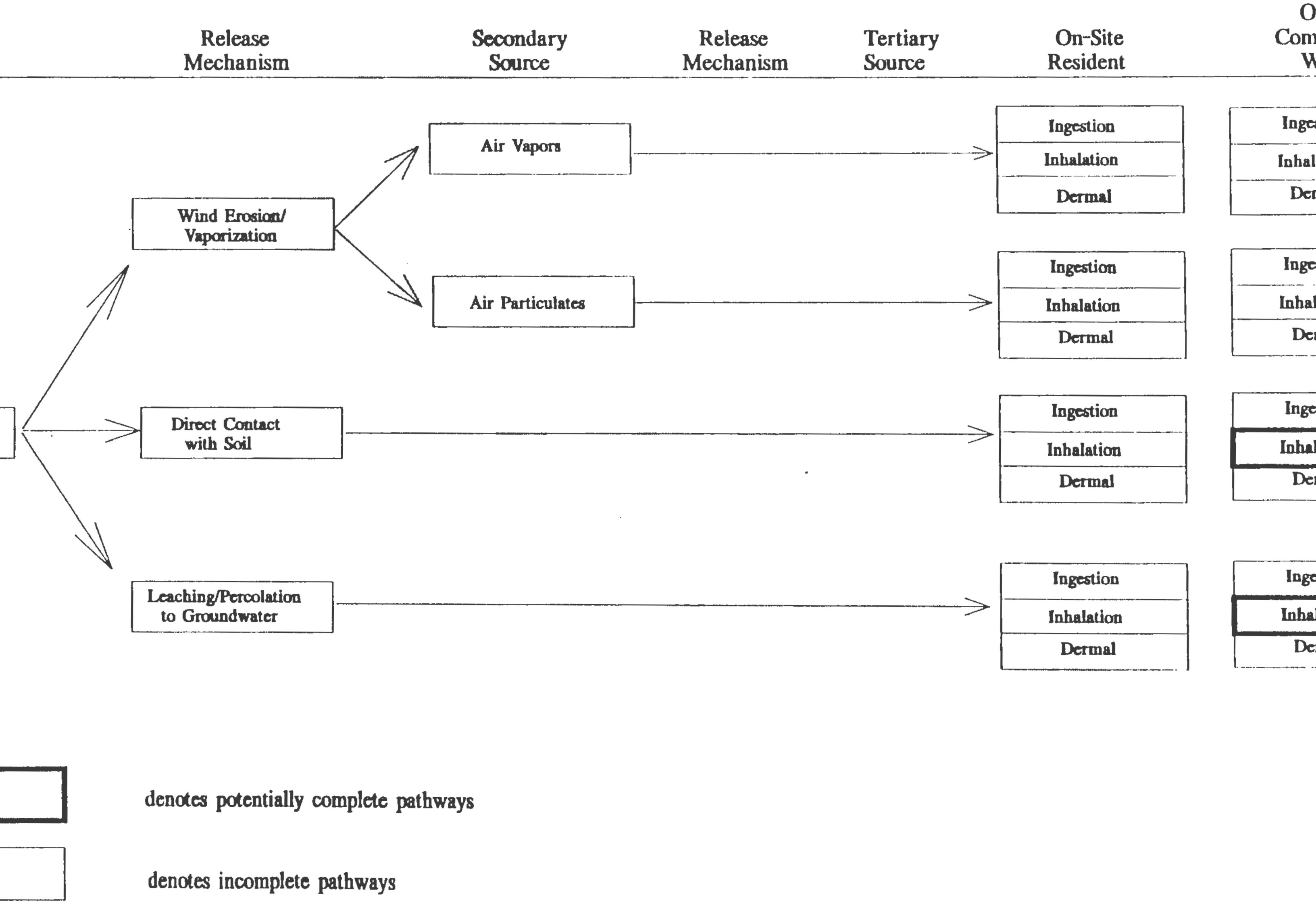
Note:

* Allowable groundwater concentrations at the source. The DAF is the dilution attenuation factor along the water line of the plume with no decay, and presented in Table 5-5 for different distances.

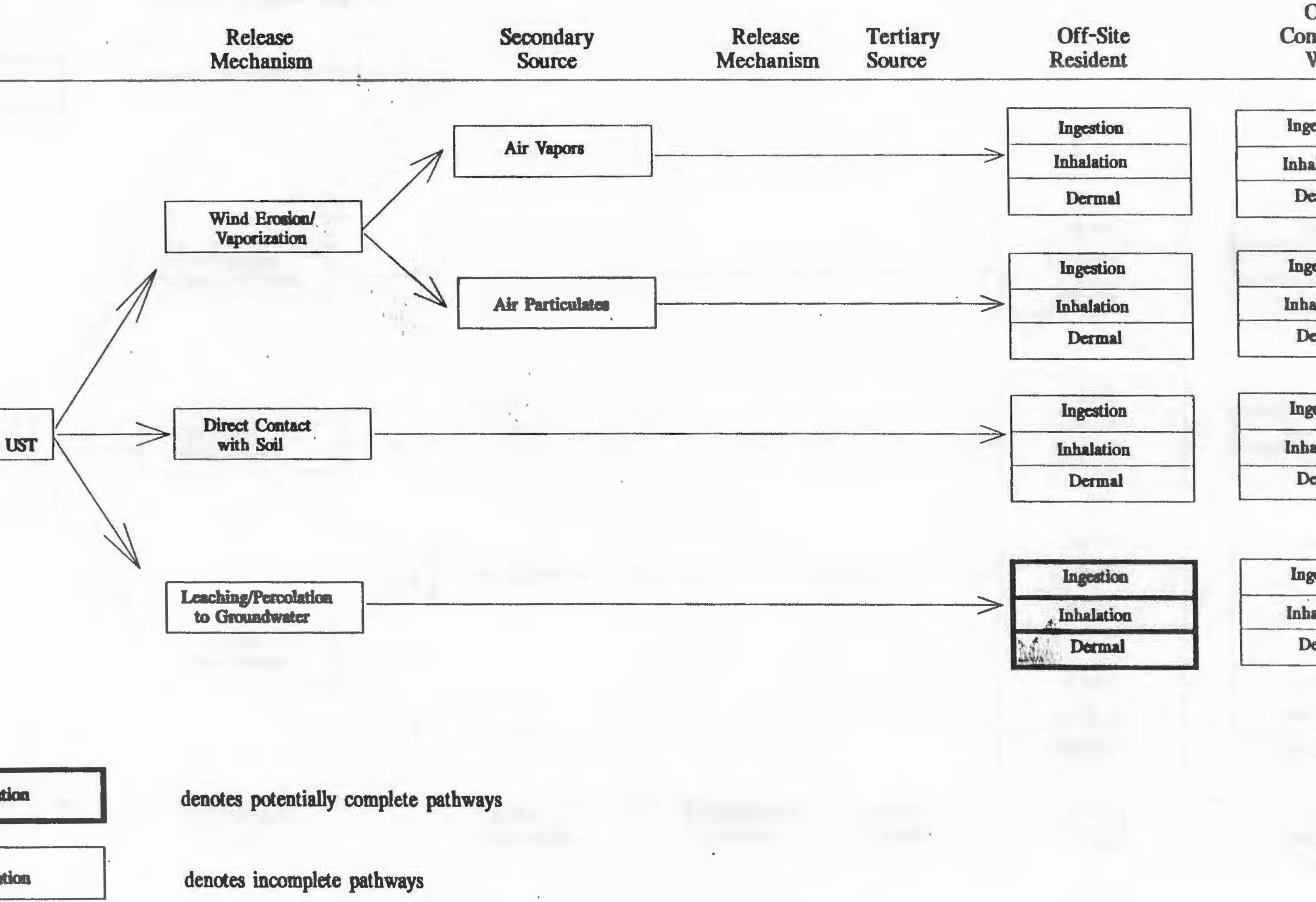
FIGURE E-1: Site Sketch for Example Site



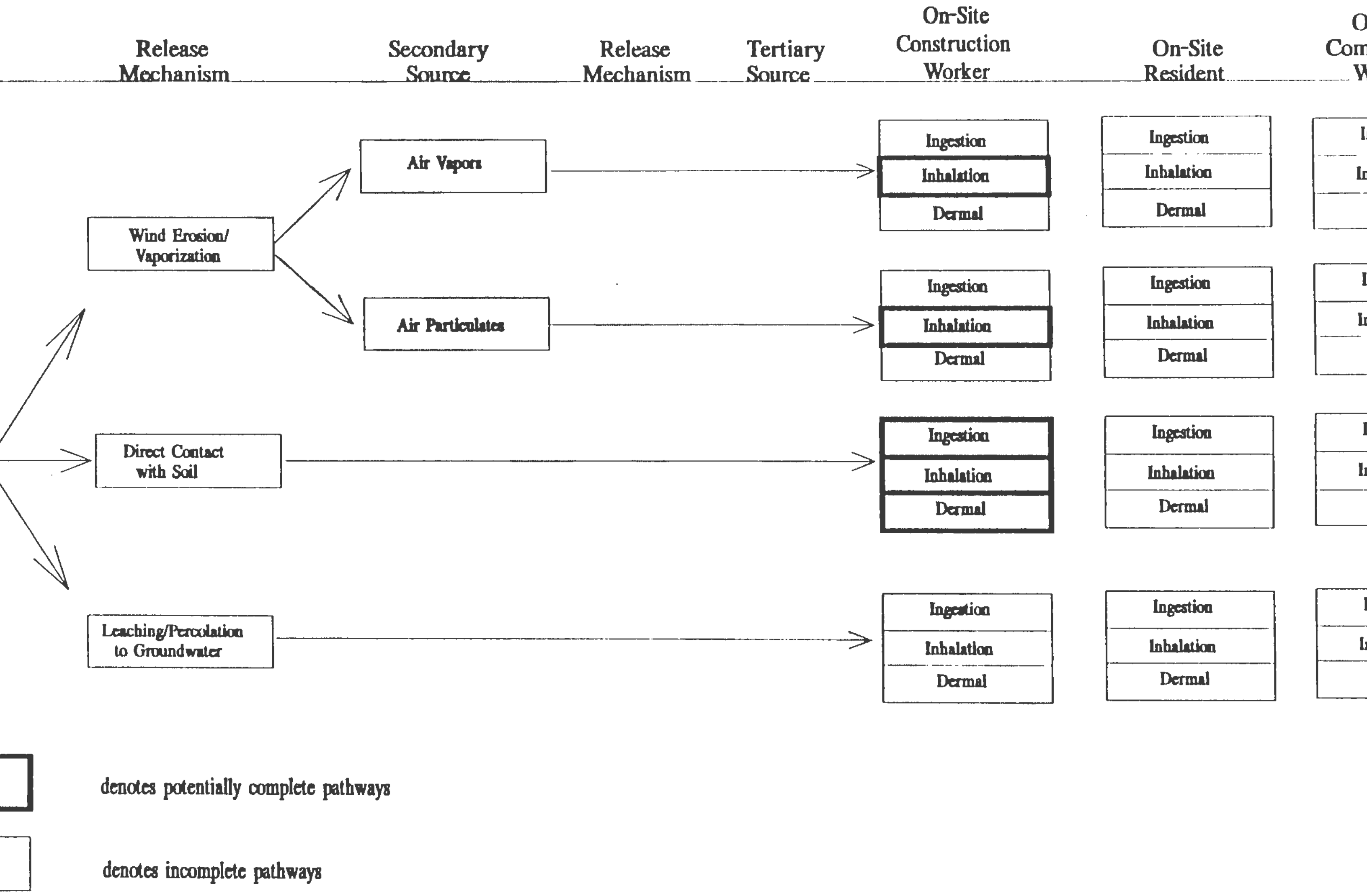
JRE E-2: Site Conceptual Exposure Scenario for Example Site for On-Site Current U



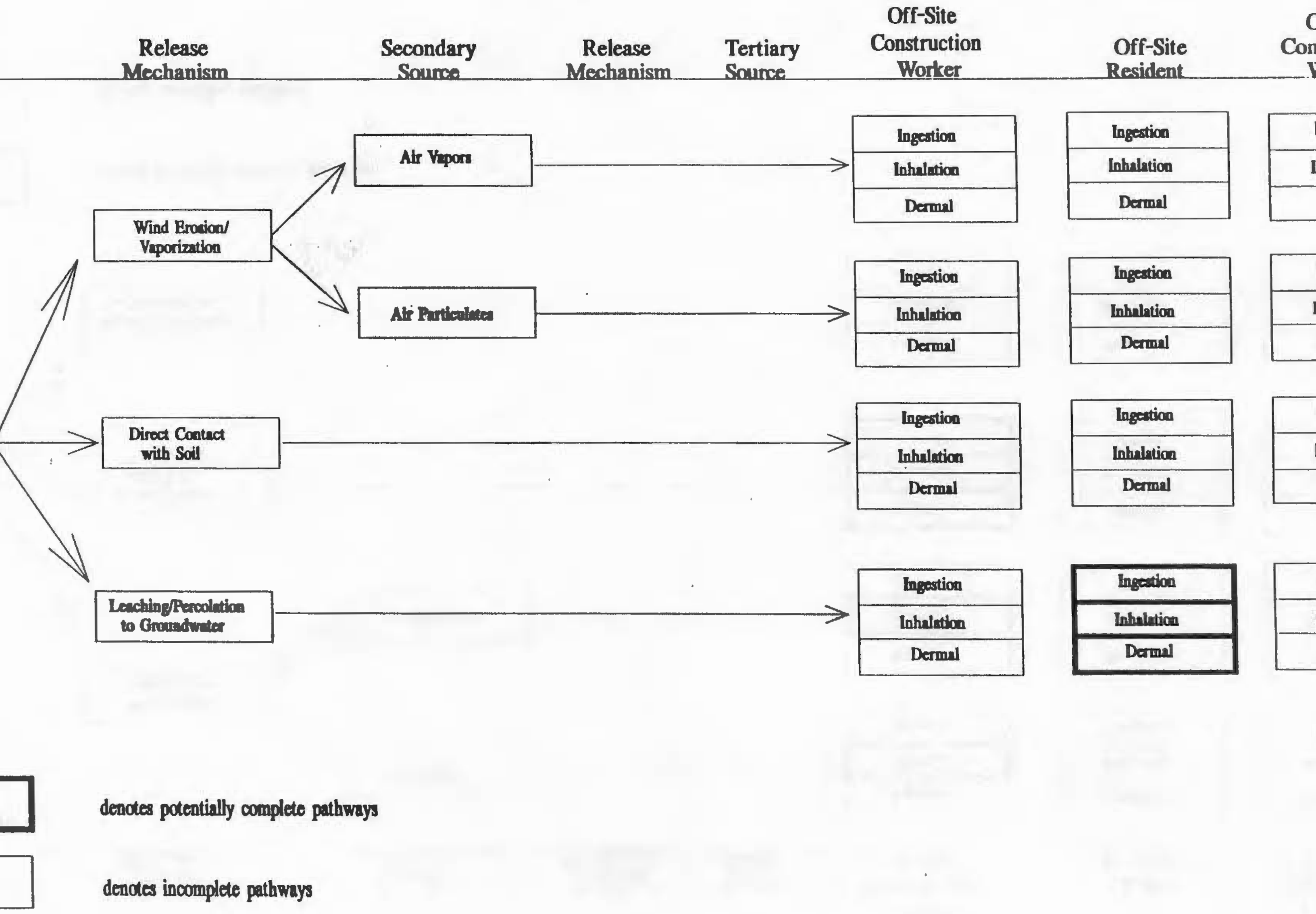
GURE E-3: Site Conceptual Exposure Scenario for Example Site for Off-Site Current



URE E-4: Site Conceptual Exposure Scenario for Example Site for On-Site Future Us



URE E-5: Site Conceptual Exposure Scenario for Example Site for Off-Site Future U



APPENDIX F
ESTIMATION OF AREA-WEIGHTED AVERAGE CALCULATIONS

Area-Weighted Average Calculations

A representative site concentration for each COC must be determined to convert multiple data points into one concentration. The one site concentration for each COC can then be compared to Tier 1 and/or Tier 2 risk-based screening levels.

The determination of a representative site concentration for each COC may be complicated by spatial variability and lack of sufficient data. The use of area-weighted averages is required for most Tier 1 exposure pathways and all Tier 2 exposure pathways. In addition, area-weighted averages are recommended for all Tier 3 exposure pathways.

The following detailed discussion on the Thiessen Polygon Method for calculating area-weighted averages is presented as a standard method for use in the NYSDEC RBCA Tier 1, Tier 2 and Tier 3 evaluations.

An area-weighted average concentration for a particular COC is calculated by:

- identifying discrete sections of the site around each data point location (soil boring, groundwater monitoring point, etc.
- determining the relative area of each discrete section;
- identifying the data point concentration for each discrete section;
- determining the total area of the source volume for the particular site (the sum of the individual discrete section with concentrations greater than "Non-Detect");
- multiplying each sections concentration by the section's relative area;
- adding each section concentration-area and dividing by the total area.

The Thiessen Polygon Method can be used to discretize the site into sections and calculating area-weighted soil and/or groundwater concentrations of each COC. The Polygon Method involves the following steps:

Step 1: Construct Site Map

A detailed plan-view site map must be constructed, identifying structures, roads, physical barriers, utilities, etc. See Figure 1 as an example.

Step 2: Compile Well Locations and Data

Identify the soil data point locations and the groundwater sampling point locations on the site map, and tabulate the data collected from the soil and groundwater sampling points. See Figure F-2, Table F.1 and Table F.2 as examples.

Step 3: Connect Wells/Data Points with Straight Lines

Each data point should be connected by a straight line to each immediately adjacent data point to form a web. See Figure F-3 as an example.

Step 4:

a. Construct Perpendicular Bisectors

Draw perpendicular bisectors for each straight line produced in Step 3 above.

b. Extend Perpendicular Bisectors to Interconnect, Forming Polygons. See Figure 4a as an example.

Extend the perpendicular bisectors drawn in Step F-4a. above until they intersect each other, forming polygons around each data point. See Figure F-4b as an example.

Step 5: Complete Polygon Map

Redraw the polygons and site map produced in Step 4 above by overlaying graph paper and tracing the polygon lines onto the graph paper. *See Figure F-5 as an example.

*Note: The perimeter data points, which should be "Non-Detect" if the site has been completely characterized, are usually not contained by completed polygons: Regardless, "Non-Detect" Polygons are not included in the area-weighted average calculations.

Step 6: Determine Area for Each Polygon

The area for each polygon is determined by counting the squares for each polygon and tabulating the polygon areas. See Figure F-6 as an example.

Step 7: Determine Polygons of Interest/Impact and Calculate Area-Weighted Average

Each COC will have a total area of interest/impact defined as those polygons which have a concentration greater than "Non-Detect." The area-weighted average for each COC is calculated based on the area of the individual polygons impacted with the COC, the concentration of that COC in each impacted polygon, and the total area of all polygons impacted by that COC. See Figures F-7a. - F-7d. as examples.

Step 8: Determine Soil Concentration for Each Well/Boring by Maximum, and Determine Soil "Plume" Area-Weighted Average

Using the maximum concentration value for each well/soil boring location, the impacted polygons for each COC can be identified, and the area-weighted average is calculated by the same method as in Step 7 above. See Figures F-8a.- F-8d. as examples.

The results of the Thiessen Polygon Method are "plume" sketches for groundwater or soil COCs. Each "plume" encompasses impacted polygons used in the area-weighted average calculation for each COC, and the "plume" concentration is the calculated area-weighted average concentration. See Figures
F-9a. - F-9d. as examples.

TABLE F.1

STEP 2: WELL COMPILATION DATA

Soil (ug/kg)

Well/Boring	Sample Depth	B	T	E	X
2	2 ft	ND	ND	ND	ND
	7 ft	6,000	17,500	16,000	33,000
DTW 8 ft	12 ft	800	3,000	1,200	6,200
17 ft ND's					
5	2 ft	ND	ND	ND	ND
	7 ft	2,100	6,700	2,900	9,000
DTW 8 ft	12 ft	100	ND	ND	450
17 ft ND's					
10	2 ft	ND	ND	ND	ND
	7 ft	200	350	50	500
DTW 8ft	12 ft	10	ND	ND	30
17 ft ND's					
11	2 ft	ND	ND	ND	ND
	7 ft	1	7	4	18
DTW 8 ft	12 ft	ND	ND	ND	ND

TABLE F.2

Groundwater (ug/l)

Well	B	T	E	X
1	ND	ND	ND	ND
2	2,700	19,000	750	11,400
3	ND	ND	ND	ND
4	ND	ND	ND	ND
5	1,300	13,000	1,200	17,200
6	ND	3	ND	12
7	ND	ND	ND	ND
8	ND	ND	ND	ND
9	ND	ND	4	25
10	458	488	153	481
11	22	2	49	17
12	ND	ND	ND	ND
13	ND	ND	ND	ND
14	ND	ND	ND	ND
15	ND	ND	ND	ND
16	ND	ND	ND	ND
17	ND	ND	ND	ND

FIGURE F-1: Step 1 Construct Site Map

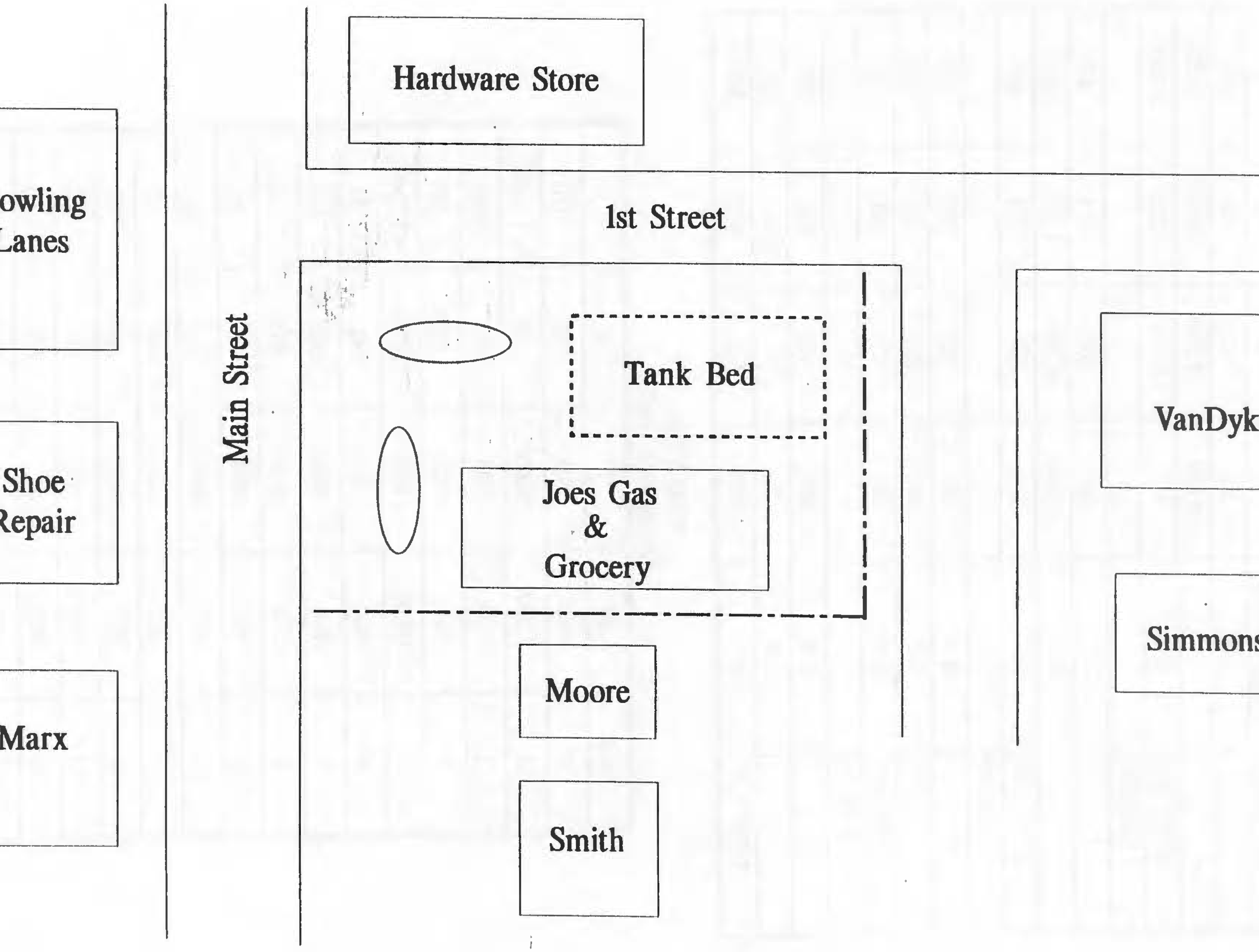


FIGURE F-2: Step 2 Compile Well Locations and Data

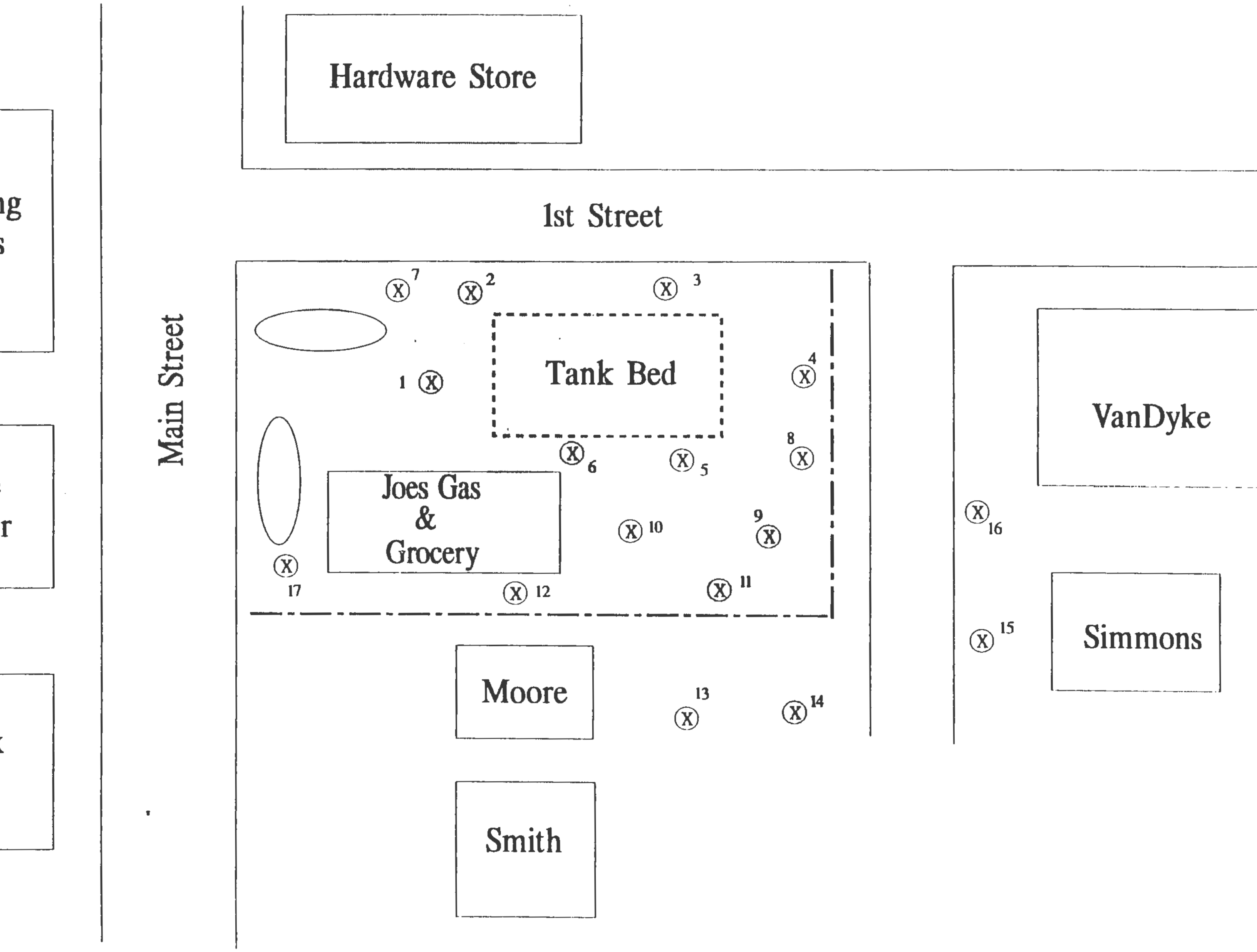


FIGURE F-3: Step 3 Connect Wells with Straight Lines

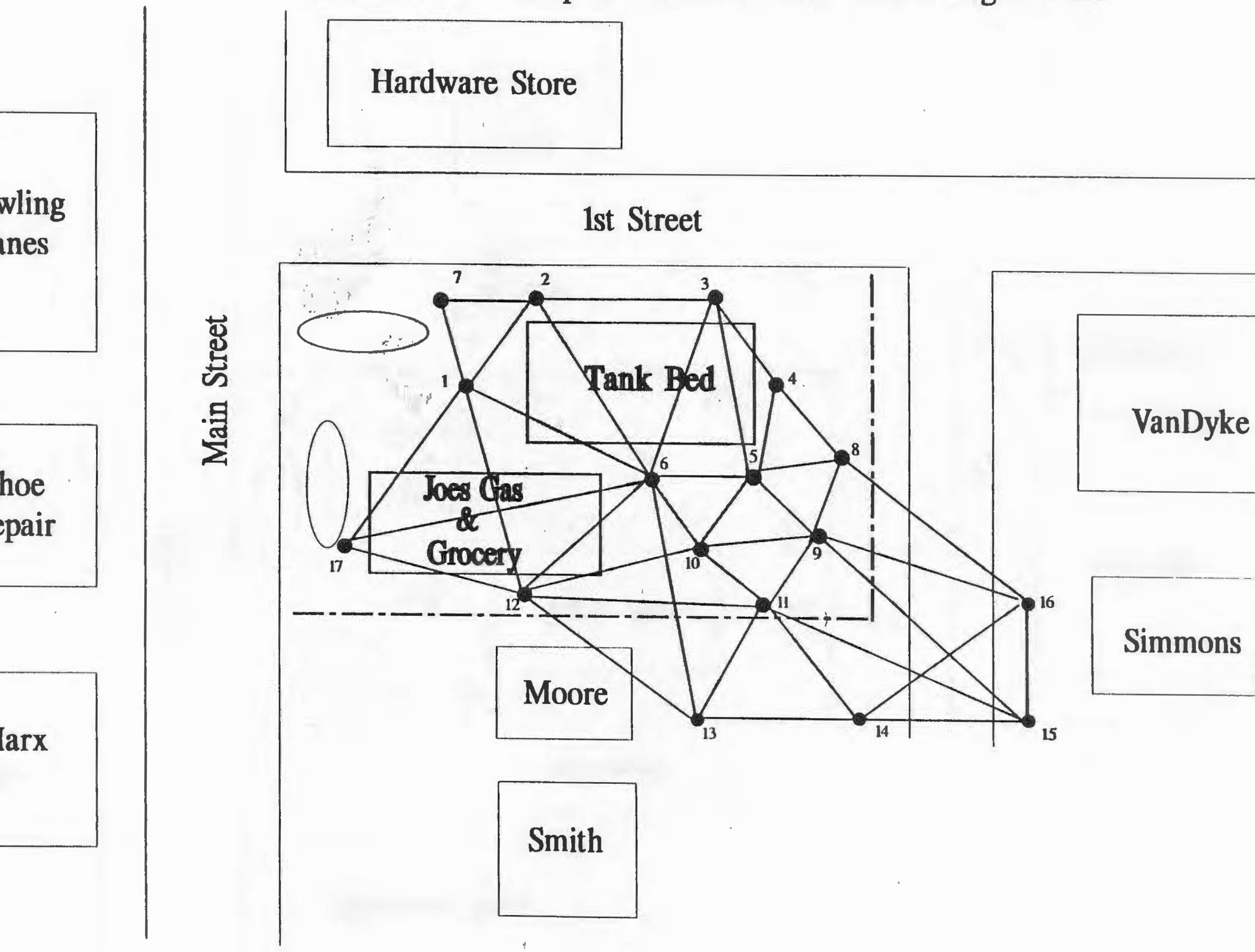


FIGURE F-4a: Step 4a Construct Perpendicular Bisection

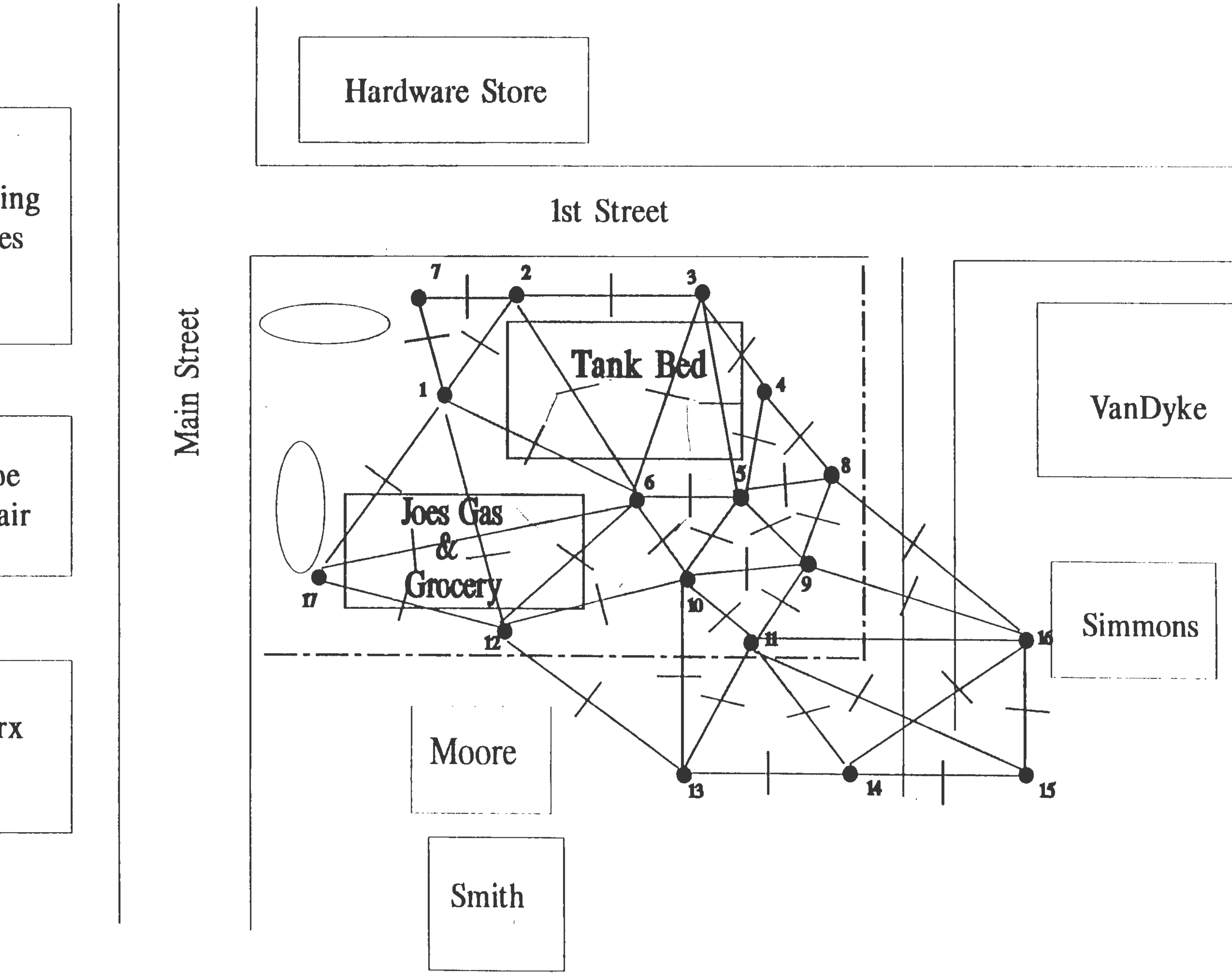


FIGURE F-4b: Step 4b Extend Biosectors to Inter-Connect Forming Polygon

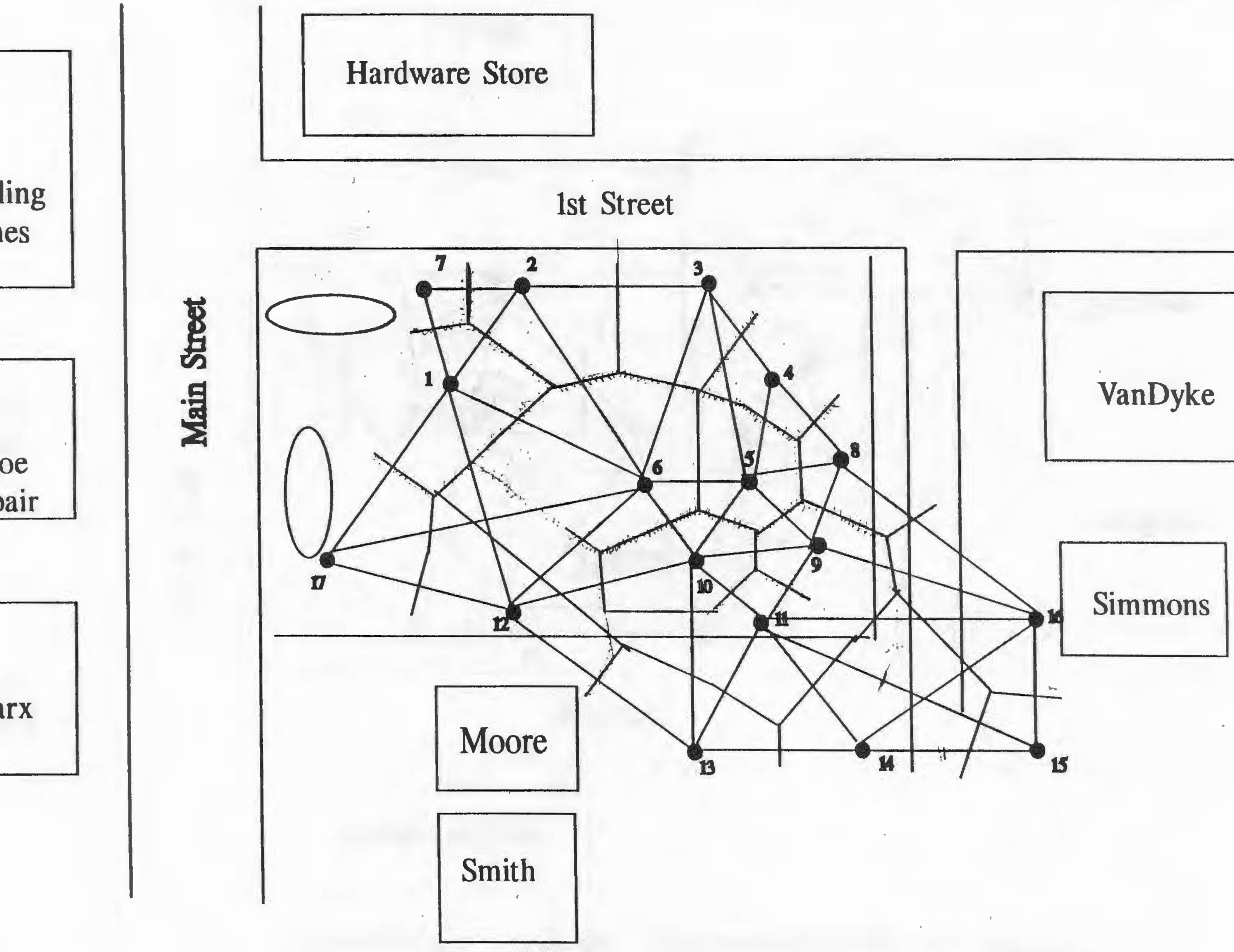


FIGURE F-5: Step 5 Complete Polygon Map

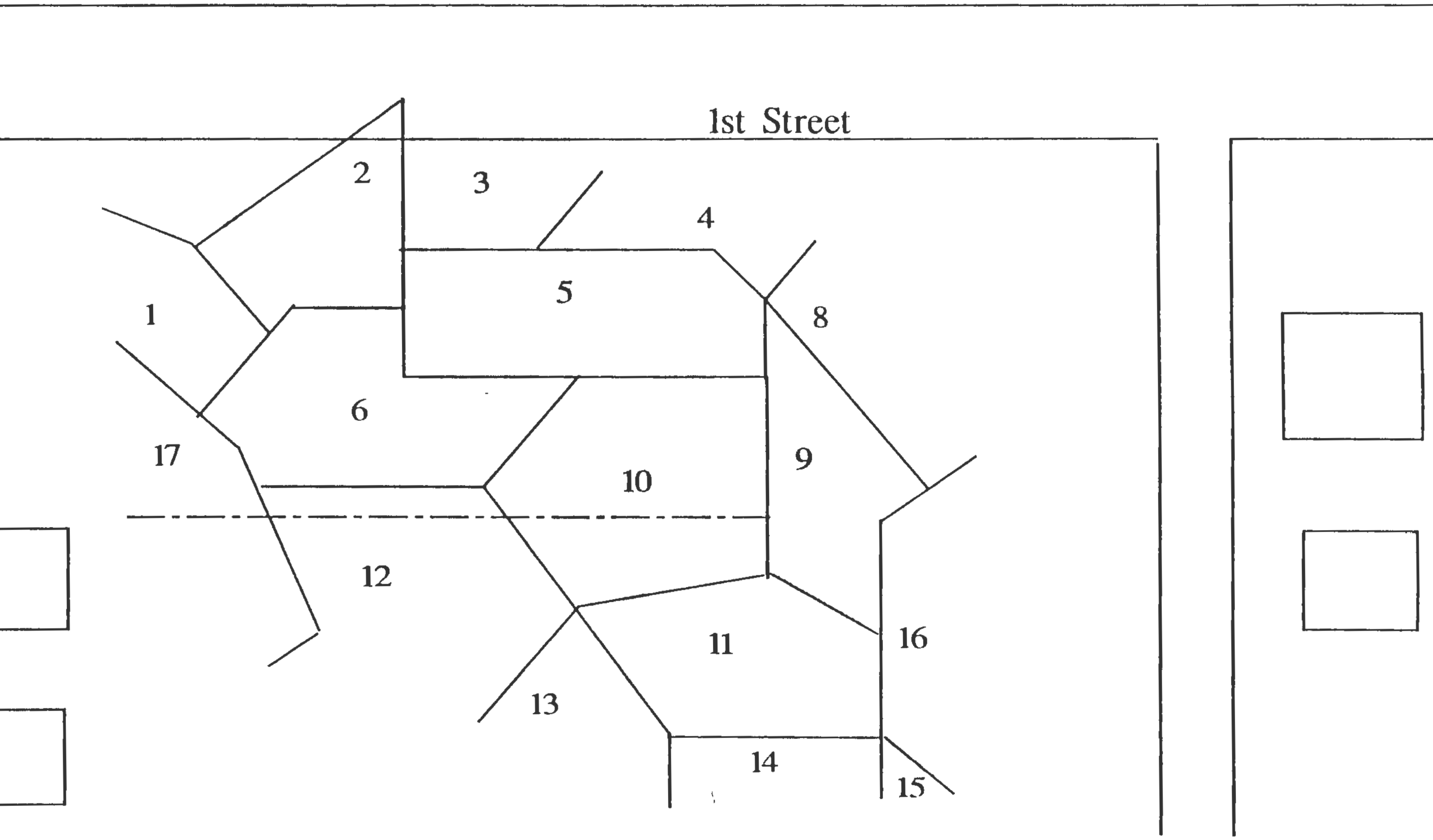
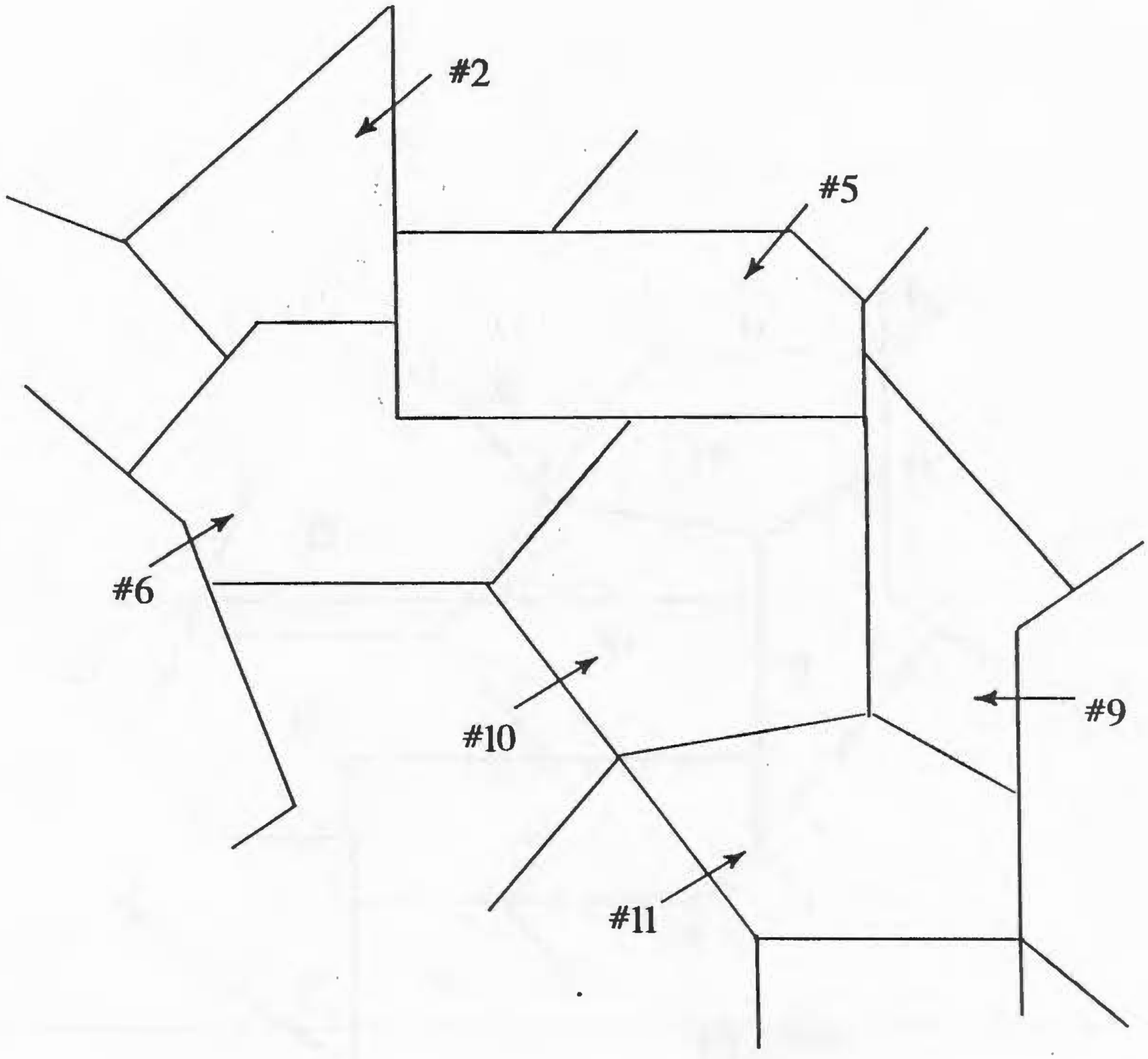
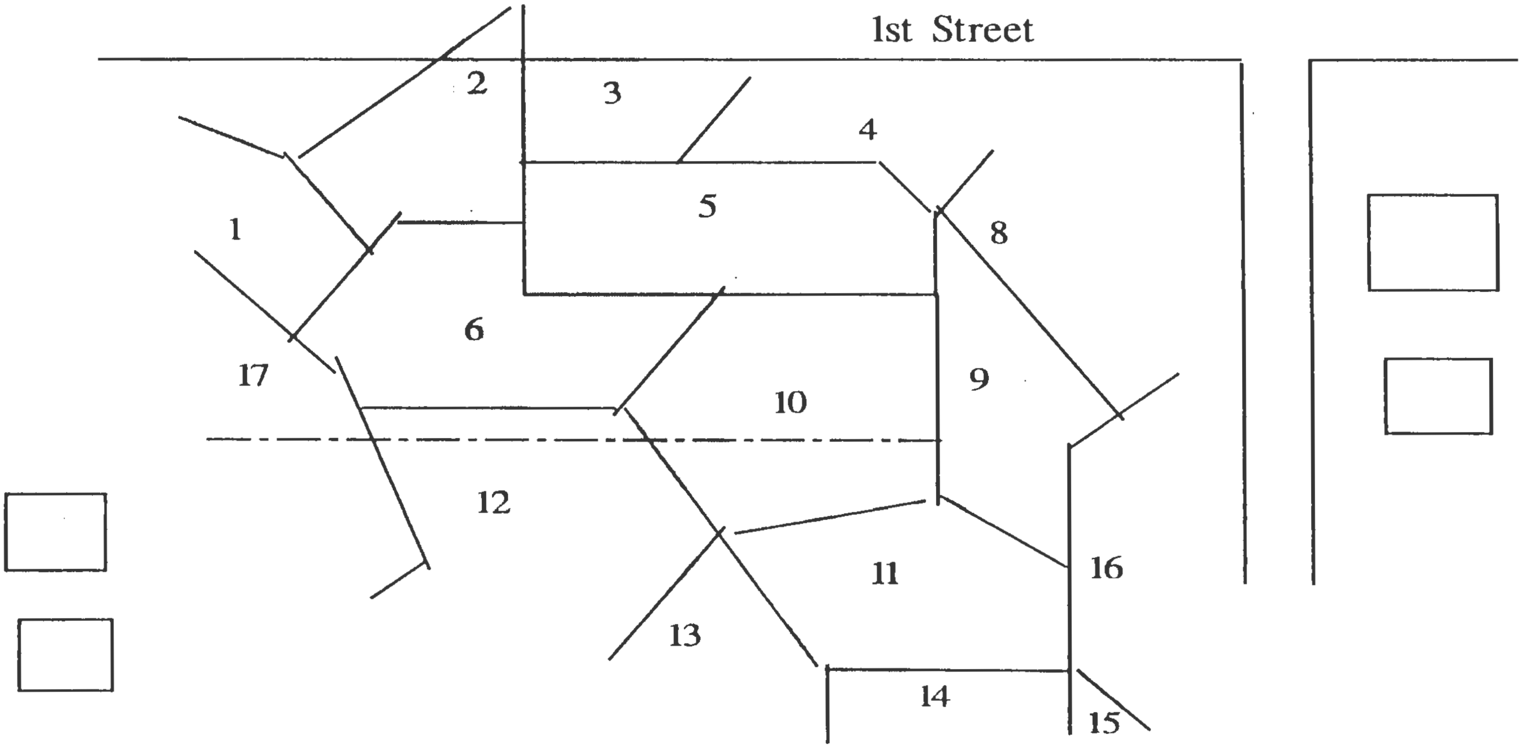


FIGURE F-6: Step 6 Determine Area for Each Polygon



Area #
2
5
6
9
10
11

FIGURE F-7a: Step 7 Determine Polygons of Interest/Impact & Area-Weighted Av
a: Benzene



Benzene Area-Weighted Average Concentration
GW Plume = Poly 2 + Poly 5 + Poly 10 + Poly 11

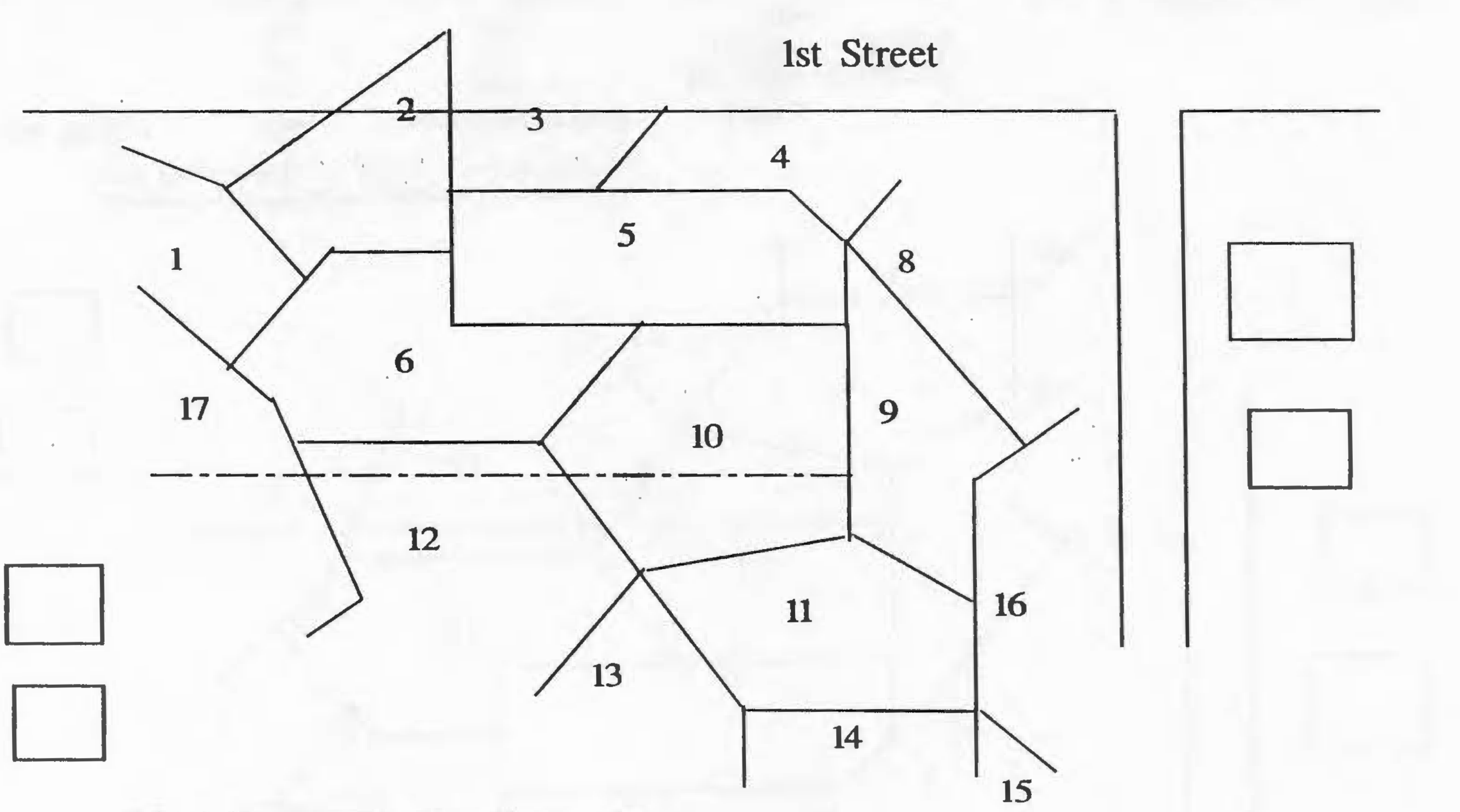
Well #/Poly #	Area	Concentration (ug/l)
2	95.5	2700
5	90.5	1300
10	79.5	458
11	122.5	22
Total Area	388	

Calc:

(95.5)(2700) + (90.5)(1300)
+ (79.5)(45.8) + (122.5)(22)
= 414,606

$$C_{ave} \text{ Benzene} = \frac{414,606}{388} = 1,069 \text{ ug/l}$$

FIGURE F-7b: Step 7
b: Toluene

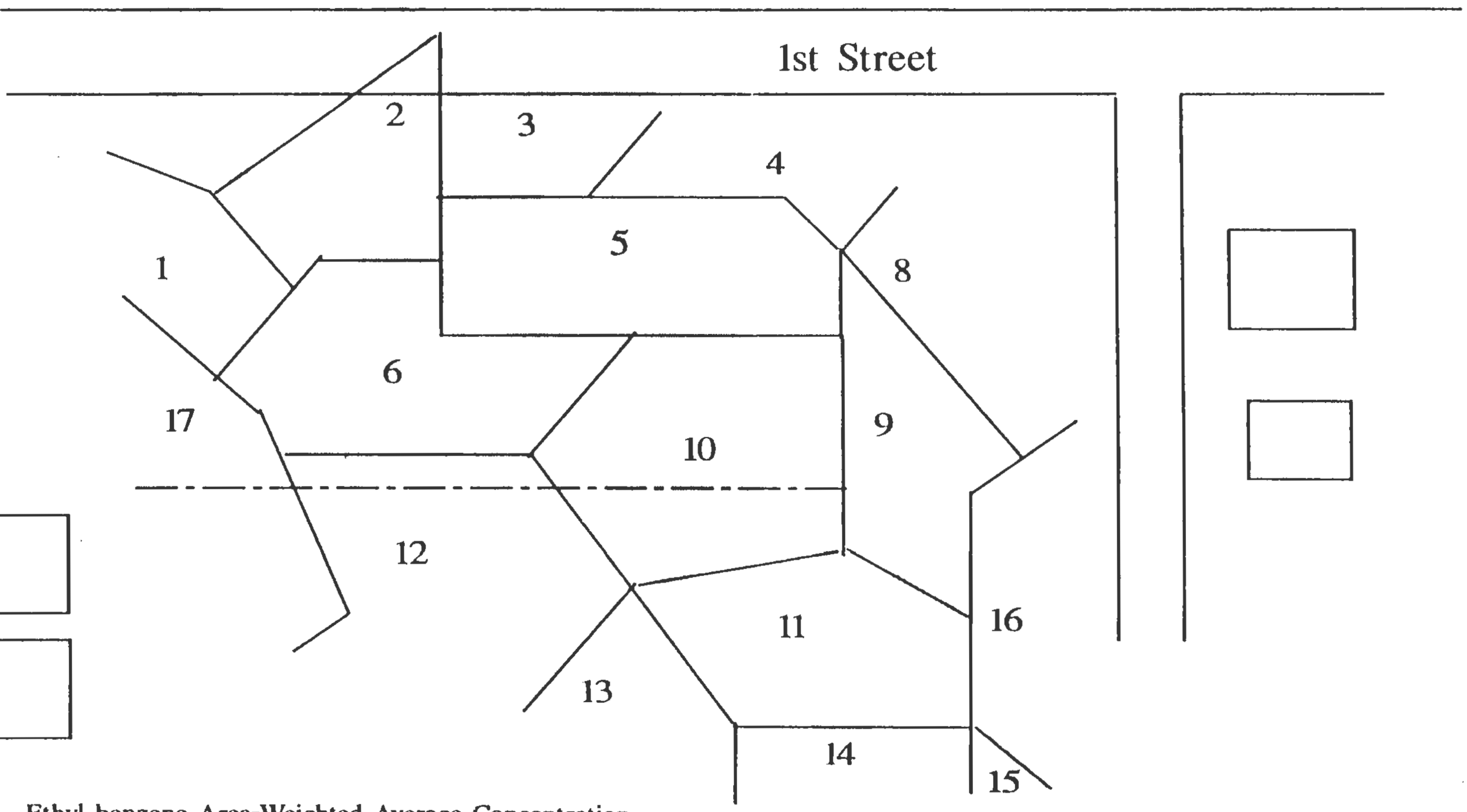


Toluene Area-Weighted Average Concentration
GW Plume = Poly 2 + Poly 5 + Poly 6 + Poly 10 + Poly 11

Well #/Poly #	Area	Concentration (ug/l)
2	95.5	19,000
5	90.5	13,000
6	131	3
11	122.5	2
Total Area	519	

$C_{ave\ \text{Toluene}}$ = 5,839 ug/l

FIGURE F-7c: Step 7
c: Ethyl benzene

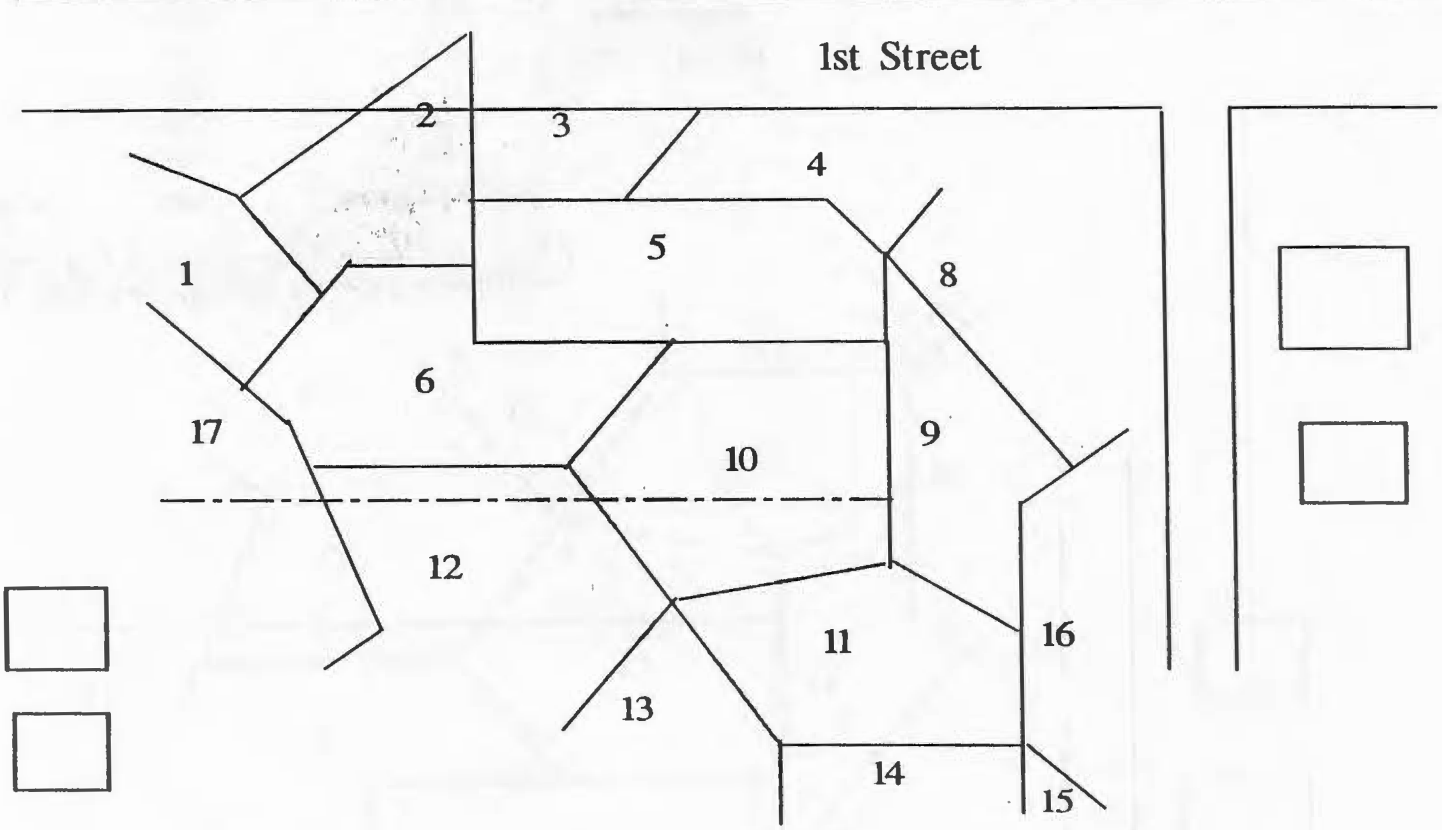


Ethyl benzene Area-Weighted Average Concentration
GW Plume = Poly 2 + Poly 5 + Poly 9 + Poly 10 + Poly 11

Vell #/Poly #	Area	Concentration (ug/l)
2	95.5	750
5	90.5	1,200
9	79.5	4
10	79.5	153
11	122.5	49
Total Area	467.5	

C_{ave} = 425 ug/l
Ethyl benzene

FIGURE F-7d: Step 7
d: Xylene



Xylene Area-Weighted Average Concentration
GW Plume = Poly 2 + Poly 5 + Poly 6 + Poly 9 + Poly 10 + Poly 11

Well #/Poly #	Area	Concentration (ug/l)
2	95.5	11,400
5	90.5	17,200
6	131	12
9	79.5	25
10	79.5	481
11	122.5	17
Total Area	598.5	

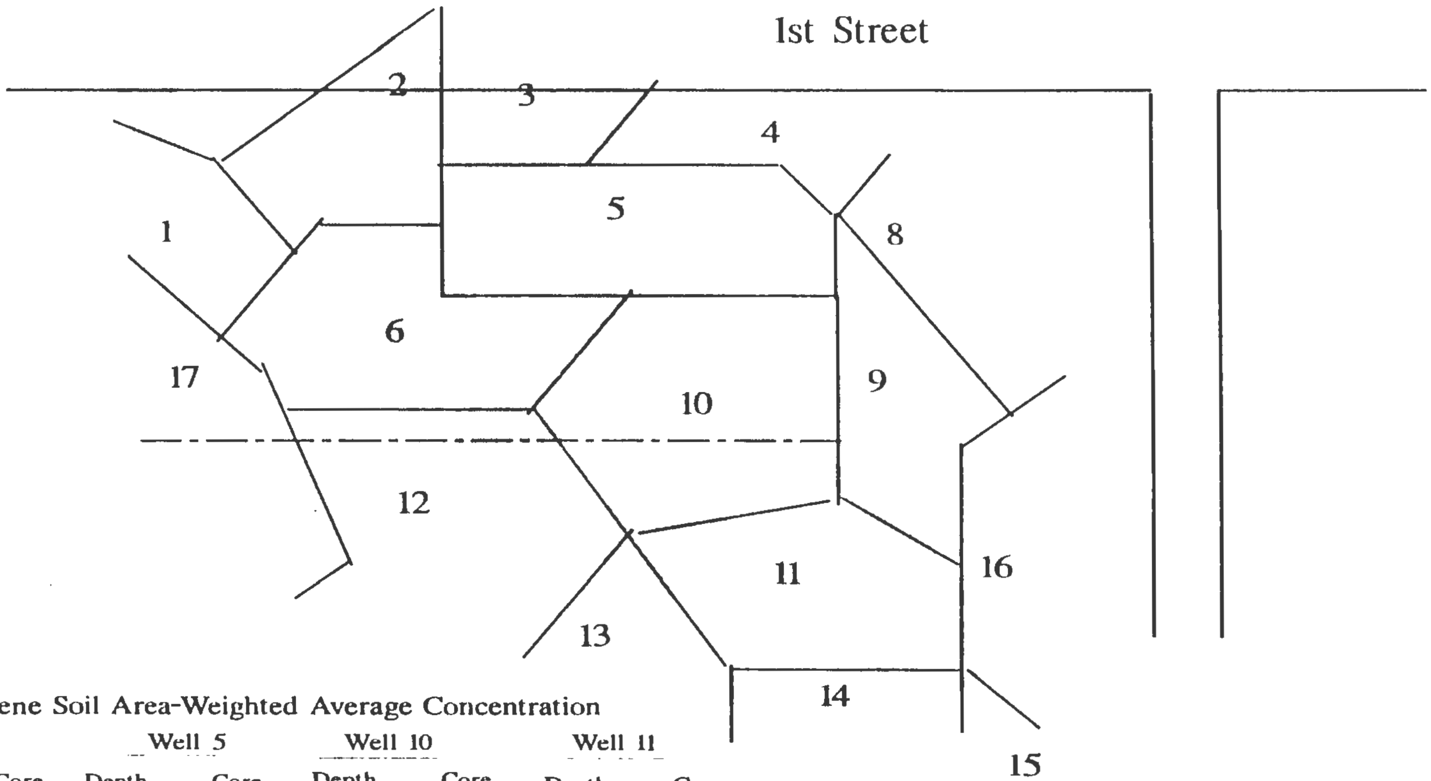
C_{ave} = 4,493 ug/l
Xylene

FIGURE F-8: Step 8

i. Benzene

a: Determine Soil Cone for Each Well by Maximum Co

b: Determine Soil Plume Area Weight Average



nzene Soil Area-Weighted Average Concentration

l 2	Well 5		Well 10		Well 11	
Core	Depth	Core	Depth	Core	Depth	Core
ND	2 ft	ND	2 ft	ND	2 ft	ND
6,000	7 ft	2,100	7 ft	200	7 ft	1
800	12 ft	100	12 ft	10	12 ft	ND
ND	17 ft	ND	17 ft	ND		

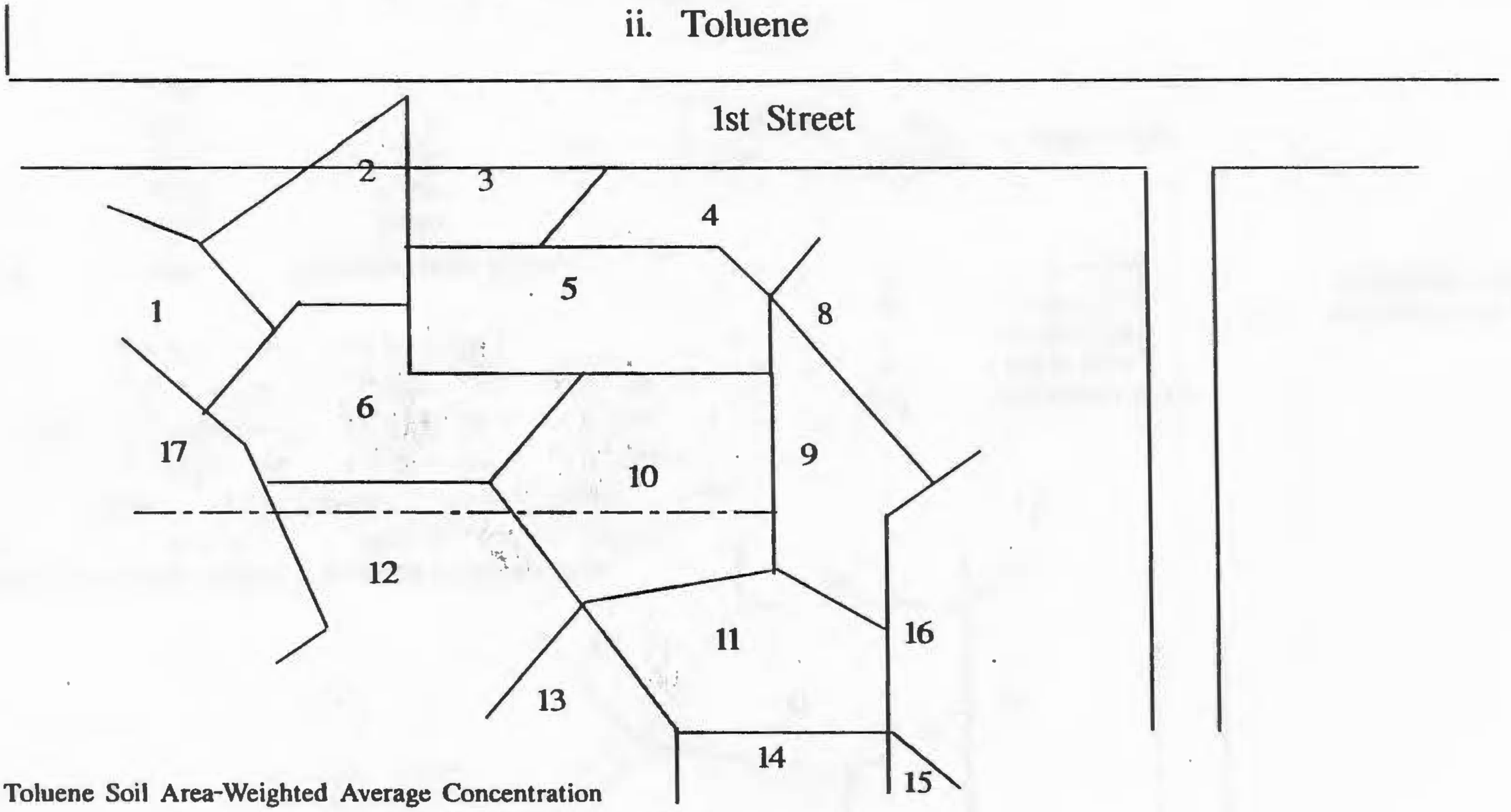
Well	Maximum Core
2	6,000 ug/kg
5	2,100 ug/kg
10	200 ug/kg
11	1 ug/kg

Calc = (95.5)(6,000) + (90.5)(
(79.5)(200) + (122.5)(1

ly #	Area	Concentration (ug/l)
	95.5	6,000
	90.5	2,100
	79.5	200
	122.5	1
ea	388	

$$C_{ave}\ \text{Benzene} = \frac{779{,}072.5}{388} = 2{,}008\ \text{ug/kg}$$

FIGURE F-8b: Step 8
ii. Toluene



Toluene Soil Area-Weighted Average Concentration

Well 2		Well 5		Well 10		Well 11	
h	Core	Depth	Core	Depth	Core	Depth	Core
	ND	2 ft	ND	2 ft	ND	2 ft	ND
	6,000	7 ft	2,100	7 ft	200	7 ft	1
	800	12 ft	100	12 ft	10	12 ft	ND
	ND	17 ft	ND	17 ft	ND		

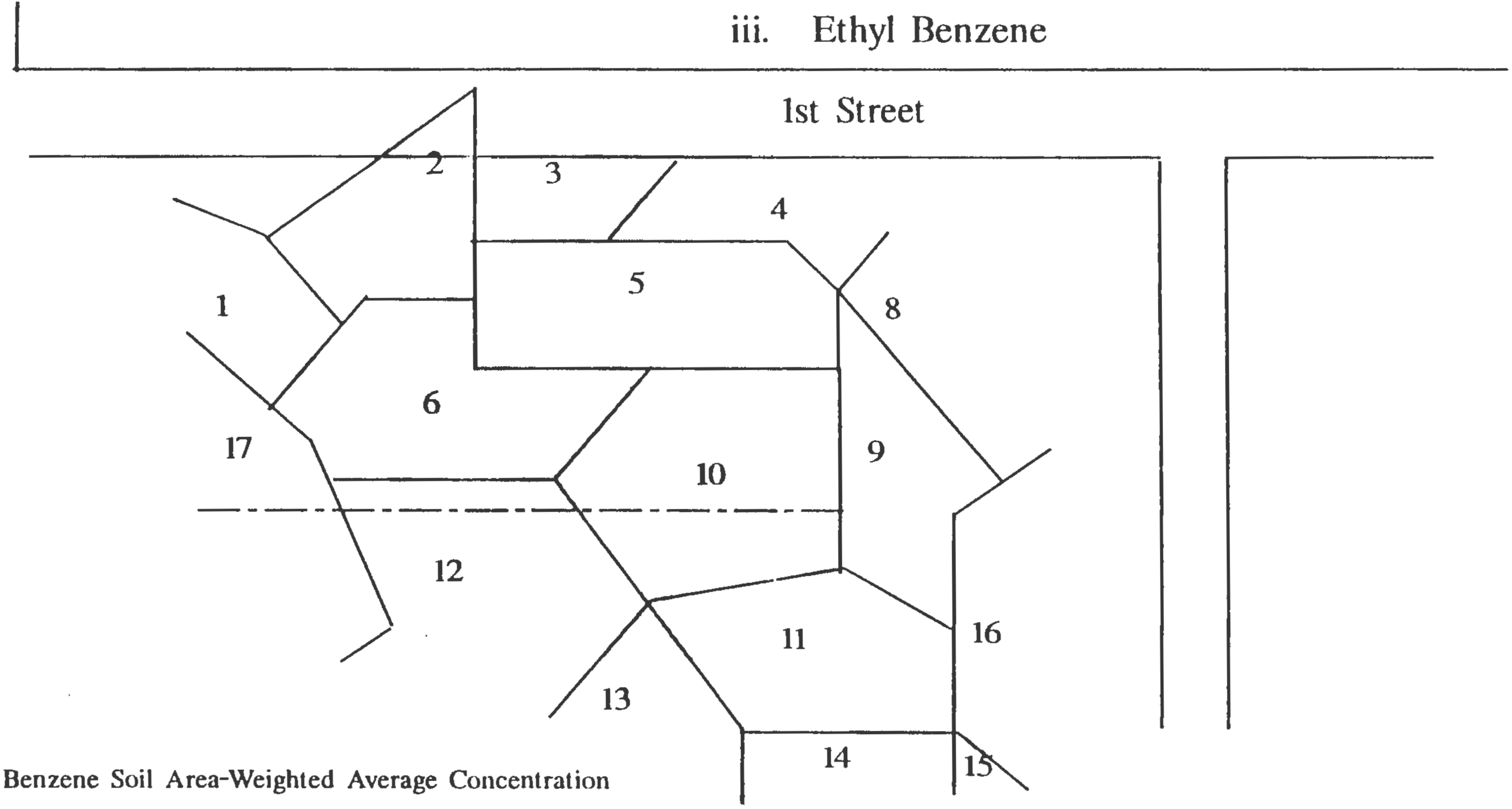
Well	Maximum Core
2	17,500 ug/kg
5	6,700 ug/kg
10	350 ug/kg
11	7 ug/kg

ell #/Poly #	Area	Concentration (ug/l)
2	95.5	17,500
5	90.5	6,700
10	79.5	350
11	122.5	7
otal Area	388	

C_{ave} Toluene = 5,944 ug/kg

FIGURE F-8c: Step

iii. Ethyl Benzene



l Benzene Soil Area-Weighted Average Concentration

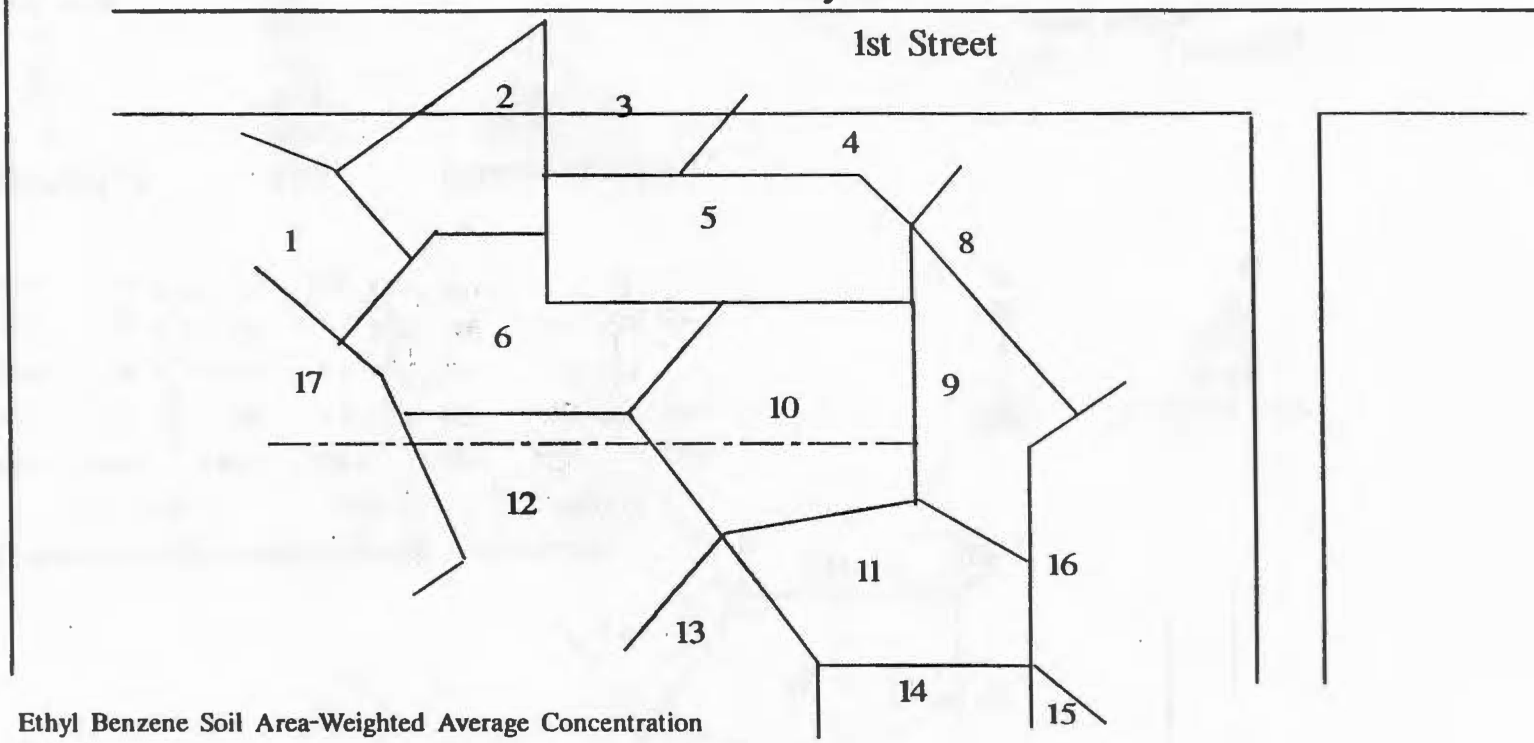
2	Well 5		Well 10		Well 11	
Core	Depth	Core	Depth	Core	Depth	Core
ND	2 ft	ND	2 ft	ND	2 ft	ND
6,000	7 ft	2,100	7 ft	200	7 ft	1
800	12 ft	100	12 ft	10	12 ft	ND
ND	17 ft	ND	17 ft	ND		

Well	Maximum Core
2	16,000
5	2,900
10	50
11	4

Well #/Poly #	Area	Concentration (ug/l)
2	95.5	16,000
5	90.5	2,900
10	79.5	50
11	122.5	4
Total Area	388	

C_{ave} = 4,626 ug/kg
Ethyl Benzene

FIGURE F-8d: Step 8
iv. Xylene



Ethyl Benzene Soil Area-Weighted Average Concentration

Well 2

pth	Core
ft	ND
ft	6,000
ft	800
ft	ND

Well 5

Depth	Core
2 ft	ND
7 ft	2,100
12 ft	100
17 ft	ND

Well 10

Depth	Core
2 ft	ND
7 ft	200
12 ft	10
17 ft	ND

Well 11

Depth	Core
2 ft	ND
7 ft	1
12 ft	ND

Well	Maximum Core
2	33,000
5	9,000
10	500
11	18

Well #/Poly #	Area	Concentration (ug/l)
2	95.5	33,000
5	90.5	9,000
10	79.5	500
11	122.5	18
Total Area	388	

C_{ave} Xylene = 10,330 ug/kg

Thiessen Polygon Example Summary

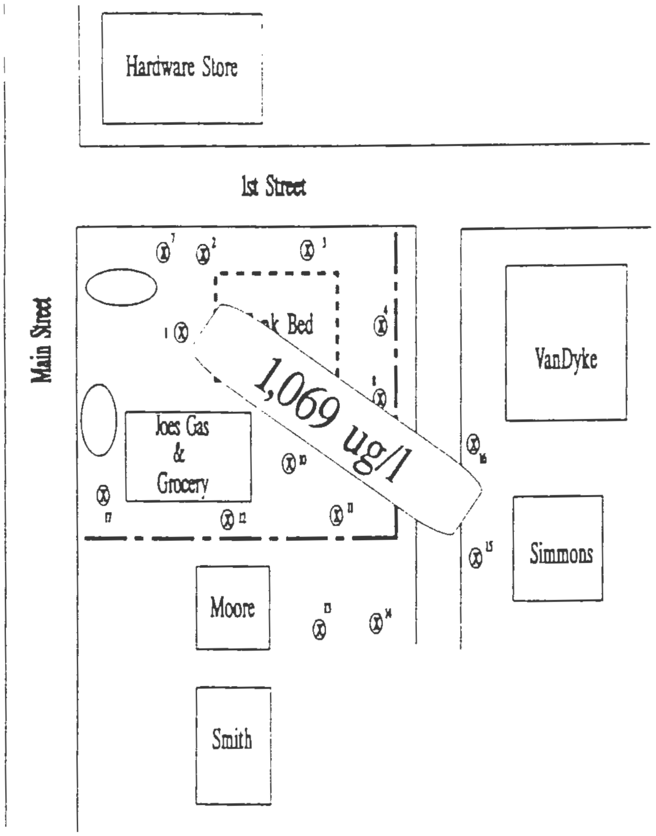


FIGURE 9a
Benzene GW Plume

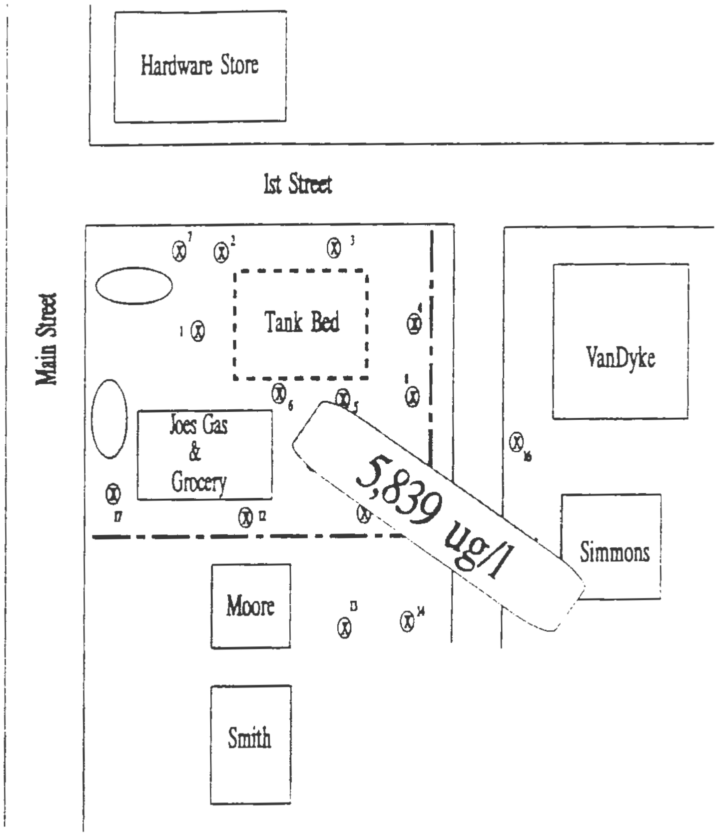


FIGURE 9b
Toluene GW Plume

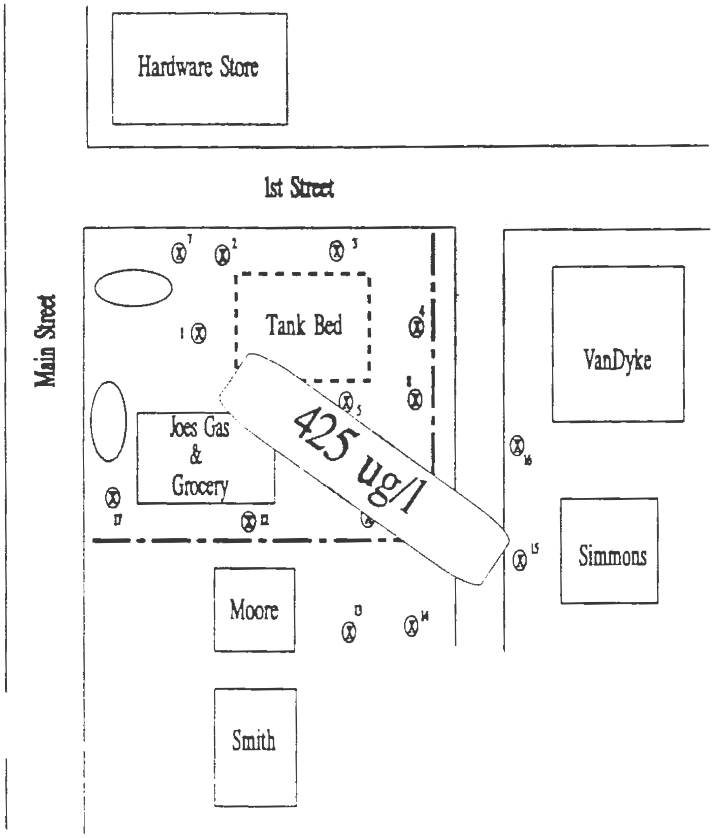


FIGURE 9c
Ethyl Benzene GW Plume

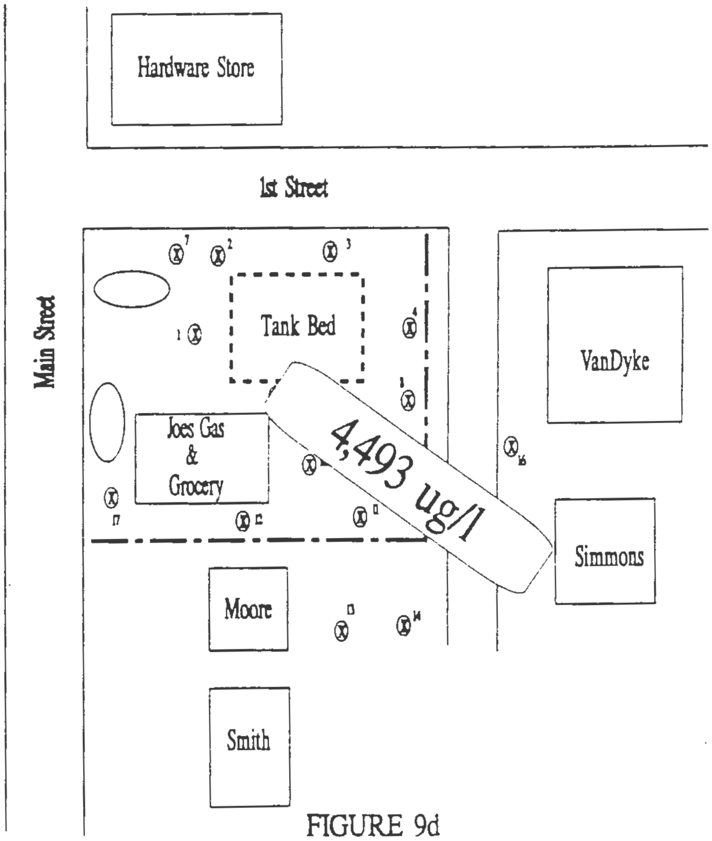


FIGURE 9d
Xylene GW Plume

APPENDIX G
SENSITIVITIES OF PARAMETERS ON TIER 1 LOOK-UP VALUES

rameter	Symbol	Units	NYS Default Value	Estimated Range	Comments on Sensitivity
es of Parameters Which Have Consistent Effect on Most of the Pathways:					
neters					Soil parameters, which are directly related t type, can not be varied independently. For t the greater the distance between the source a basement, the greater the effect soil paramet the Tier 1 look-up values.
sity	ρ_s	gm/cm^3	1.7	1.0 to 3.0	Bulk density ranges little for common soil ty from about 1.3 for clay to 1.7 for sand. The little effect on the RBSLs.
of organic	f_{oc}	gm-C/gm-soil	0.005	0.0001 (glacial sand) to 0.03 (river sediments)	Fractional organic carbon content has little e volatile chemicals for all of the pathways, e leaching to groundwater.
osity	θ_T	cm^3/cm^3-soil	0.38	0.25 to 0.40 (gravels) 0.25 to 0.50 (sands) 0.35 to 0.50 (silts) 0.40 to 0.70 (clays)	Porosity is correlated with volumetric air an contents; as porosity increases, so do water content, but not necessarily to the same exte
arameters					
source area o wind or ater flow	W	cm (ft)	1500 (49.2)	1 ft. to 10,000 ft.	The effect of this parameter increases as the increases. Due to the high range of variabil specific values are recommended.

APPENDIX G
SENSITIVITIES OF PARAMETERS ON TIER 1 LOOK-UP VALUES

rameter	Symbol	Units	NYS Default Value	Estimated Range	Comments on Sensitivity
ities of Parameters Used in Groundwater Enclosed-Space Vapor Inhalation Modeling:					
eters water content zone	θ_{ws}	cm^3/cm^3	0.12	0.05 to 0.40	Variation in this parameter directly effects air conte effect on this parameter increases as the source mo from the basement.
air content in ne	θ_{as}	cm^3/cm^3	0.26	0.05 to 0.40	Variation in this parameter directly effects water co effect on this parameter increases as the source mo from the basement.
of capillary	h_{cap}	cm	15 (5.9 inches)	0 to 72 inches	Thickness depends upon soil type (up to 72" for fi down to 0 for coarse gravels). This parameter has effect on the RBSLs for this pathway, since the ca (which serves as a barrier to vapor transport) is the predominant limiting feature.
c water content y fringe	θ_{wcap}	cm^3/cm^3	0.342	0.05 to 0.40	This value is correlated with the thickness of the ca fringe. Variation in this parameter directly effects
c air content in ringe	θ_{acap}	cm^3/cm^3	0.038	0.05 to 0.40	This value is correlated with the thickness of the ca fringe. Variation in this parameter directly effects content.
rameters groundwater	L_{gw}	cm (ft)	300 (9.8)	< 8 to > 50 feet	This parameter has a large effect on the RBSLs. D high range of variability, site-specific values are recommended.
Parameters					In most cases, building parameters have little effec pathway, due to the limiting effect the capillary fri vapor transport. Building parameters may significa RBSLs when the groundwater table lies close to th the basement.

APPENDIX G
SENSITIVITIES OF PARAMETERS ON TIER 1 LOOK-UP VALUES

arameter	Symbol	Units	NYS Default Value	Estimated Range	Comments on Sensitivity
space air rate					Air exchange rates play an increasingly significant rol enclosed-space volume/infiltration area ratio parameter smaller (i.e., smaller basements with a larger portion
l buildings	ER	1/sec (1/hour)	0.00014 (0.5)	0.25/hour to 3/hour	Residential air-exchange rates are lower (i.e., lower R better insulated homes. Typically, newer homes have exchange rates.
ial buildings	ER	1/sec (1/hour)	0.00023 (0.8)	4/hour [warehouses] to 60/hour [boiler rooms, bakeries, dry cleaners, foundries]	Building codes for several types of commercial buildi specify air exchange rates.
space foundation/ ness	L_{crack}	cm (inch)	15 (5.9)	4 inches to 12 inches	This parameter has little effect on the RBSLs for this
space volume/ n area ratio	L_B	cm	200	100 to 300 cm	This parameter relates to the volume of the basement of the basement below ground surface. This is the bui parameter with the largest effect on the RBSLs for thi
ction of cracks in n/walls	η	cm^2/cm^2	0.01	0.001 to 0.1	This parameter has a small effect on the RBSLs for th
ic air content in n/wall cracks	θ_{acrack}	cm^3/cm^3	0.26	0.05 to 0.40	This parameter has a small effect on the RBSLs for th and is dependent on air content.
ic water content tion/wall cracks	θ_{wcrack}	cm^3/cm^3	0.12	0.05 to 0.40	This parameter has a small effect on the RBSLs for th and is dependent on water content.

APPENDIX G
SENSITIVITIES OF PARAMETERS ON TIER 1 LOOK-UP VALUES

Parameter	Symbol	Units	NYS Default Value	Estimated Range	Comments on Sensitivity
vities of Parameters Used in Groundwater to Ambient Air Vapor Inhalation Modeling:					
Sensitivities of soil parameters for this pathway are similar to those presented in groundwater to enclosed-space vapor inhalation					
neters					Air parameters have little effect on this pathway, limiting effect the capillary fringe has on vapor tr parameters have increasing influence as the groun approaches the ground surface.
ed above ground ambient mixing zone	U_{air}	cm/sec (miles/hour)	225 (5.0)	0 to 50 miles/hour	The effect of this parameter increases as the value The typical average wind speed found in most sta (4.5 miles/hour).
air mixing zone	δ	cm (ft)	200 (6.6)	100 cm to 250 cm	This parameter, which represents the standard hei individual and does not vary greatly, has little eff RBSLs for this pathway.
ivities of Parameters in Subsurface Soil Enclosed-Space Vapor Inhalation Modeling:					
neters					
ic water content in one	θ_{ws}	cm^3/cm^3	0.12	0.05 to 0.40	This parameter has a large effect on RBSLs for th The effect of this parameter increases as the sourc away from the basement. Variation in this param effects air content.
ic air content in one	θ_{as}	cm^3/cm^3	0.26	0.05 to .40	This parameter has a large effect on RBSLs for th The effect of this parameter increases as the sourc away from the basement. Variation in this param effects water content.
arameters subsurface soil	L_s	cm (ft)	100 (3.3)	15 to 1000 cm (0.49 to 33 ft)	This parameter has a large effect on the RBSLs. high range of variability, site-specific values are recommended.

APPENDIX G
SENSITIVITIES OF PARAMETERS ON TIER 1 LOOK-UP VALUES

rameter	Symbol	Units	NYS Default Value	Estimated Range	Comments on Sensitivity
ameters ce air exchange					Building parameters have greater influence over this pa vapors do not have to pass through a capillary fringe. I parameters significantly effect RBSLs when the source bottom of the basement. Air exchange rates play an increasingly significant role space volume/infiltration area ratio parameter becomes smaller basements with a larger portion underground).
uildings	ER	1/sec (1/hour)	0.00014 (0.5)	0.25/hour to 3/hour	Residential air exchange rates are lower (i.e. lower RB insulated homes. Typically, newer homes have lower a
buildings	ER	1/sec (1/hour)	0.00023 (0.8)	4/hr [ware- houses] to 60/hr [boiler rooms, bakeries, dry cleaners, foundries]	Building codes for several types of commercial buildin air exchange rates.
ce foundation/wall	L_{crack}	cm (inch)	15 (5.9)	4 inches to 12 inches	This parameter has little effect on the RBSLs for this p
ce volume/ rea ratio	L_B	cm	200	100 to 300 cm	This parameter relates the volume of the basement to t basement below ground surface. This is the building pa largest effect on the RBSLs for this pathway.
n of cracks in valls	N	cm^2/cm^2	0.01	0.001 to 0.1	This parameter has a small effect on the RBSLs for thi
ir content in vall cracks	θ_{acrack}	cm^3/cm^3	0.26	0.05 to 0.40	This parameter has a small effect on the RBSLs for thi dependent on air content.
water content in vall cracks	θ_{wcrack}	cm^3/cm^3	0.12	0.05 to 0.40	This parameter has a small effect on the RBSLs for thi dependent on water content.
arameter ime for vapor flux worker)	τ	sec (yr)	1.8E+08 9.46E+08 7.98E+08	6 yrs 30 yrs 25 yrs	This parameter is used to determine the average vapor exposure period. It is equal to the exposure duration (While the parameter is important, site-specific values w significant effect on the outcome.

APPENDIX G
SENSITIVITIES OF PARAMETERS ON TIER 1 LOOK-UP VALUES

rameter	Symbol	Units	NYS Default Value	Estimated Range	Comments on Sensitivity
ies of Parameters in Subsurface Soil Ambient Air Vapor Inhalation:					
Sensitivities of soil parameters and source parameters are similar to those in subsurface soil to enclosed-space vapor inhalation path					
Sensitivities of air parameters are similar to those in groundwater to ambient air vapor inhalation pathway					
ies of Parameters in Subsurface Soil Leaching to Groundwater Modeling:					
ers					
organic carbon	f_{oc}	gm/C/gm-soil	0.01	0.0001 (glacial sand) to 0.03 (river sediments)	This parameter has a large effect on RBSLs for Due to the high range of variability, site-specific recommended.
water content in	θ_{ws}	cm³-cm³	0.12	0.05 to 0.40	This parameter has little effect on RBSLs for thi Variation in this parameter directly effects air co
air content in	θ_{as}	cm³-cm³	0.26	0.05 to 0.40	This parameter has little effect on RBSLs for thi Variation in this parameter directly effects water
r Parameters ate of water	I	cm/year (inch/year)	30 (12)	0.05 to 50 cm/year	This parameter has in increasingly large effect o the value increases. Due to the high range of va specific values are recommended.
r Darey velocity using hydraulic and hydraulic	U_{gw}	cm/year (ft/day)	2500 (0.22)	1 cm/year [clay] to 10,000 cm/year [sand]	This parameter has an increasingly large effect c the value decreases. Due to the high range of va specific values are recommended.
r mixing zone	P_{gw}	cm (ft)	200 (6.6)	0 to thickness of saturated zone	This parameter depends upon soil type, and typi vary greatly. Therefore, is has little effect on th this pathway.

APPENDIX G
SENSITIVITIES OF PARAMETERS ON TIER 1 LOOK-UP VALUES

arameter	Symbol	Units	NYS Default Value	Estimated Range	Comments on Sensitivity
neters urce area parallel ter flow	W	cm (ft)	1500 (49.2)	1 to 10,000 ft	This parameter has an increasingly large effect on the value increases. Due to the high range of vari specific values are recommended
ies of Parameters in Surficial Soil Vapor and Particulate Inhalation Modeling:					
ers water content in	θ_{ws}	cm^3-cm^3	0.12	0.05 - 0.40	Variation in this parameter directly effects air con
ir content in	θ_{as}	cm^3-cm^3	0.26	0.05 - 0.40	Variation in this parameter directly effects water
ers above ground nbient mixing zone	U_{air}	cm/sec (miles/hour)	225 (5.0)	0 to 50 miles/hour	The effect of this parameter increases as the value typical average wind speed found in most states is miles/hour).
mission rate nmercial worker	P_e	gc/cm^2-sec	6.9 x 10^{-14}	1 x 10^{-17} (rural air) to 1 x 10^{-6} gm/cm^2-sec (dusty construction site)	The single pathway particulate inhalation RBSL is proportional to this parameter.
n worker	P_e	gc/cm^2-sec	6.9 x 10^{-14}	--	
mixing zone	ρ_{air}	cm (ft)	200 (6.6)	100 cm to 250 cm	This parameter, which represents the standard hei individual and does not vary greatly, has little eff RBSLs for this pathway.

APPENDIX G
SENSITIVITIES OF PARAMETERS ON TIER 1 LOOK-UP VALUES

'arameter	Symbol	Units	NYS Default Value	Estimated Range	Comments on Sensitivity
neters of affected surficial	d	cm (ft)	100 (3.3)	15 to 100 cm	Surficial soils are often considered to represent of soils. (This parameter does not directly effec calculation. Instead, it is only used to identify t soils that will be evaluated for this pathway.
rameter ne for vapor flux n worker)	τ	sec (year)	31,400,000 (1)	2 weeks to 1 year	This parameter is used to determine the average during the exposure period. It is equal to the e duration (averaging time). It has little effect or this pathway.
ties of Parameters in Modeling Groundwater Dilution to the Point of Exposure					
Parameter Darcy velocity sing hydraulic & hydraulic gradient]	U_{gw}	cm/year (ft/day)	2500 (0.22)	1 cm/year [clay] to 10,000 cm/year [sand]	This parameter has an increasingly large effect as the value decreases. Due to the high range o site-specific values are recommended.
neters n perpendicular to the norizontal plane	S_w	ft	49.2	site-specific	This parameter has an increasing effect on the attenuation factor (DAF) as the value decreases specific parameter.
ness perpendicular to he vertical plane	S_d	ft	6.6	site-specific	This parameter has an increasing effect on the value decreases. It is a site-specific parameter.
point of exposure	X	ft	0 - 1000 feet	site-specific	This parameter has an increasingly large effect
s l dispersivity	α_x	ft	X/10	site-specific	This value increases as the distance to the poin increases.
dispersivity	α_y	ft	$A_x/3$ [X/30]	site-specific	This value increases as the distance to the poin increases.
persivity	α_z	ft	$A_x/20$ [X/200]	site-specific	This value increases as the distance to the poin increases.

ates value has a large effect on the pathway

APPENDIX H
ECOLOGICAL CRITERIA - ESTIMATING VEGETABLE INGESTION EXPOSURE

Estimating contaminant levels in vegetation from root uptake:

$$CV_{(l,p,e)} = RUF * Cs * DWF_{(l,p,e)}$$

where:

$CV_{(l,p,e)}$ = contaminant level in leafy, protected or exposed fruits/vegetables (mg/kg, wet wt.)
RUF = root uptake factor
Cs = contaminant level in soil (mg/kg, dry weight)
$DWF_{(l,p,e)}$ = dry-to-wet weight conversion factor for leafy, exposed or protected fruits/vegetables

<u>Estimating exposure from fruit/vegetable ingestion:</u>

$$DCV = \frac{[CV_1 * CON_1) + (CV_p * CON_p) + (CV_E * CON_e * CON_e)] * FR}{BW}$$

where:

DCV = dose from ingestion of contaminated vegetables
CV_l = contaminant level in leafy vegetables (mg/kg, west weight)
CV_p = contaminant levels in protected produce (mg/kg, wet weight)
CV_e = contaminant level in exposed produce (mg/kg, wet weight)
CON_l = leafy vegetable consumption rate (kg/d)
CON_e = protected produce consumption rate (kg/d)
CON_e = exposed produce consumption rate (kg/d)
FR = fraction homegrown
BW = body weight

<u>Parameter values:</u>

Parameter	**Child**			**Adult**		
	Central City[1]	Suburban[1]	Other[1]	Central City[1]	Suburban[1]	Other[1]
CON_l(kg/d)	0.0018	0.0030	0.0058	0.0100	0.0160	0.0307
CON_p (kg/d)	0.0068	0.0109	0.0210	0.0361	0.0580	0.1112
CON_e (kg/d)	0.0044	0.0070	0.0135	0.0232	0.0373	0.0715
DWF_l	0.066			0.066		
DWF_p	0.126			0.126		
DWF_e	0.222			0.222		
RUF (organics)	see below			see below		
RUF (inorganics)	Baes et al., 1984			Baes et al., 1984		
FR	0.4			0.4		

<u>Estimation of RUF for organic contaminants:</u>
RUF = 1.588 - 0.578 * log Kow (Travis and Arms, 1988)
<u>Estimation of log Kow if not known, but where Koc is known:</u>
log Kow = (log Koc - 1.377) / 0.544 (Dragun, 1988)
<u>Estimation of log kow if not known, but where solubility is known:</u>
log Kow = (4.186 - log solubility) / 0.922 (Lyman, et al., 1990)

REFERENCES:

Baes, C. F., Sharp, R.D., Sjoreen, A.L., Shor, R.W. 1984. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides Through Agriculture. Oak Ridge National Laboratory. ORNL-5786.

Dragun, J. 1988. The Soil Chemistry of Hazardous Materials. Silver Spring, MD: Hazardous Materials Control Research Institute.

Lyman, W.M., Reehl, W.F., Rosenblatt, D.H. 1990. Handbook of Chemical Property Estimation Methods. Washington, DC: American Chemical Society.

Travis, C.C., Arms, A.D. 1988. Bioconcentration of organics in beef, milk and vegetation. Environ. Science Technol. 22: 271-274.

APPENDIX I
CONTENTS OF AN ACCEPTABLE REMEDIAL ACTION PLAN

- RBCA EVALUATION REPORT

- REMEDIATION PROPOSAL

    1. Scaled site map, identifying all structures, storage tanks, dispensers, sampling and monitoring locations, etc. and proposed locations for remedial sampling, monitoring and equipment locations.

    2. Description of proposed activities to mitigate the release to the levels identified in the RBCA Evaluation Report.

    3. Description of proposed sampling techniques.

    4. Description of proposed analytical techniques.

    5. Scaled site maps identifying the extent of contaminant plumes, and the anticipated area of influence of remedial equipment.

    6. Description and schematic of proposed remedial systems.

    7. Description of proposed remedial equipment site-specific pilot testing.

    8. Proposed time schedule for specific remedial activities (pilot tests, installations, schedule maintenance, etc.).

    9. Anticipated time needed to complete the remedial efforts.

- MONITORING

    1. Scaled site map, identifying all structures, storage tanks, dispensers, sampling and monitoring and equipment locations, etc.

    2. List of parameters to be monitored.

    3. Regulatory/effluent limits for each parameter being monitored.

    4. Frequency of monitoring for each parameter.

    5. Analytical technique used for each parameter.

    6. Reporting schedule.

APPENDIX J
EXAMPLE SITE CLOSURE LETTER

Ref: (Insert Site Name and Location)

Dear (Insert Addressee's Name):

The Department is pleased to report that it is satisfied that the RBCA evaluation of and corrective actions (if applicable) at the parcel of real property located at ______________________________ County, New York, a map of which is attached hereto ("Site"), meets Department guidelines. So long as no information has been withheld from the Department or mistake made as to the hazard posed by, or the nature and extent of, the petroleum existing on, at or under the Site as of this date ("Existing Contamination"), the Department believes that no further investigation or response will be required at the Property to render the Site safe for use as a *[insert intended use e.g. commercial facility]*.

Assignable Release and Covenant Not to Sue:

The Department, therefore, hereby releases, covenants not to sue and forbears from bringing any action, proceeding, or suit against the current or future owners and operators of the Site or any interest in the Site including ______________________________ or its successors and assigns and their secured creditors, for the further investigation and remediation of the Site based upon the release or threatened release of any Existing Contamination; provided that, site owner(s) and/or its lessees, successors, and assigns promptly commence and diligently pursue to completion the Department-approved post-response operations and maintenance plan, if any.

Nevertheless, the Department hereby reserves all of its rights concerning, and such forbearance shall not extend to, any further investigation or remedial action the Department deems necessary:

i. due to the off-site migration of petroleum contaminants that was not addressed by the RBCA Evaluation and Remedial Action Plan (if applicable).

ii. due to environmental conditions related to the Site that were unknown to the Department at the time of its approval of the RBCA Evaluation Report and Remedial Action Plan (if applicable) or the last written Department-approved modification thereto; or

iii. due to information received, in whole or in part, after the Department's approval of the final RBCA Evaluation report and Remedial Action Plan (if applicable), which indicates that the RBCA evaluation and/or remedial action is not sufficiently protective of human health for the reasonably anticipated *[insert intended use]* of the Site.

iv. due to fraud by the responsible party in obtaining the release.

Additionally, the Department hereby reserves all of its rights concerning, and any such release and satisfaction shall not extend to, any person, including ________________________ or any of its lessees, successors, or assigns, who causes or suffers the release or threat of release at the Site of any hazardous substance or petroleum after [*insert the effective date of site closure*] with respect to such hazardous substance or petroleum; or who causes or suffers the use of the Site to change from the reasonably anticipated *[insert intended use*] of the Site to one requiring a lower level of residual contamination before that use can be implemented with sufficient protection of human health; or who is otherwise a responsible party for the existing contamination.

NEW YORK STATE DEPARTMENT OF
ENVIRONMENTAL CONSERVATION

By: ________________________________

Title: ________________________________

APPENDIX K
CONTENTS OF AN ACTIVITY USE LIMITATION

DEED RESTRICTION:

Within 30 days of receipt of the NYSDEC's notification approving the final RBCA Evaluation Report and certification, an instrument shall be recorded with the appropriate County Clerk. This instrument shall run with the land, and shall prohibit the Site from ever being used for purposes other than the contemplated use identified in the final RBCA Evaluation Report without the express written waiver of such prohibition by NYSDEC, or if at such time the NYSDEC does not exist, any New York State department, bureau, or other entity replacing the NYSDEC. Where applicable, such instrument also will include a provision prohibiting the use of the groundwater underlying the Site without treatment rendering it safe for drinking water or industrial purposes unless the user first obtains permission to do so from the NYSDEC, or if at such time the NYSDEC shall no longer exist, any New York State department, bureau, or other entity replacing the NYSDEC.

A copy of this instrument certified by the appropriate County Clerk to be a true and faithful copy of the instrument as recorded in the Office of the appropriate County Clerk shall be provided to the appropriate NYSDEC project manager prior to the issuance of the Site Closure letter.

APPENDIX L
NYSDEC's CRITERIA FOR DETERMINING GROUNDWATER USE

(UNDER DEVELOPMENT)

.1 THE ERROR FUNCTION

An error function is a mathematical function (similar to trigonometric or exponential function) and is defined as:

$$erf(x)=\frac{2}{\sqrt{\pi}}\int_{0}^{x} e^{-t^2}dt \tag{1-1}$$

The above integral cannot be evaluated analytically and has to be evaluated numerically. Table 1 gives the values of the error function for different values of ‘x’. For example, the erf of 0.2 is 0.222703.

The erf is used in Equation C-5 of the guidance document to estimate the dilution attenuation factor.

A related function is the complimentary error function written as “erfc”. This is defined as follows:

$$erfc(x)=1-erf(x) \tag{1-2}$$

For example, referring to Table 1 the erfc of 0.2 is 0.777297.

TABLE M.1
ERROR FUNCTION VALUES

x	erf(x)	erfc(x)
0	0	1
0.05	0.056372	0.943628
0.1	0.112463	0.887537
0.15	0.167996	0.832004
0.2	0.222703	0.777297
0.25	0.276326	0.723674
0.3	0.328627	0.671373
0.35	0.379382	0.620618
0.4	0.428392	0.571608
0.45	0.475482	0.524518
0.5	0.520500	0.479500
0.55	0.563323	0.436677
0.6	0.603856	0.396144
0.65	0.642029	0.357971
0.7	0.677801	0.322199
0.75	0.711155	0.288845
0.8	0.742101	0.257899
0.85	0.770668	0.229332
0.9	0.796908	0.203092
0.95	0.820891	0.179109
1	0.842701	0.157299
1.1	0.880205	0.119795
1.2	0.910314	0.089686
1.3	0.934008	0.065992
1.4	0.952285	0.047715
1.5	0.966105	0.033895
1.6	0.976348	0.023652
1.7	0.983790	0.016210
1.8	0.989091	0.010909
1.9	0.992790	0.007210
2	0.995322	0.004678
2.1	0.997021	0.002979
2.2	0.998137	0.001863
2.3	0.998857	0.001143
2.4	0.999311	0.000689
2.5	0.999593	0.000407
2.6	0.999764	0.000236
2.7	0.999866	0.000134
2.8	0.999925	0.000075
2.9	0.999959	0.000041
3	0.999978	0.000022

Reference:

Freeze, R.A., and Cherry, J.A. 1979. "Groundwater. Prentice-Hall, Inc.

M.2 DILUTION ATTENUATION FACTOR

The dilution attenuation factor (DAF) is the ratio of the concentration at an up-gradient location to the concentration at a downgradient location and is applicable in the saturated as well as the unsaturated zone. The DAF can be estimated using (i) generic factors, (ii) site-specific data, or (iii) models. The DAF depends on several factors such as the distance to the well, groundwater velocity, chemical properties, size of the source, etc. When a model is used to estimate the DAF, either default (Tier 1) or site-specific (Tier 2) values of these parameters are used in the model. Further, two or more coupled models may be required to estimate the DAF, such as, an unsaturated zone transport model, a saturated zone mixing model, and a saturated zone transport model.

The dilution factors used in the guidance document are (i) a mixing zone model as shown in Appendix C, Equation C-4 and (ii) an analytical saturated zone model as shown in Equation C-5.

The following two examples illustrate the use of DAF in estimating allowable concentrations.

Example 1:

From Figure M.2.1 the DAF in the unsaturated zone is:

$$DAF_{unsat} = \frac{C_{leachate}}{C_{watertable}} \tag{1-1}$$

where

DAF_{unsat} = dilution attenuation factor in the unsaturated zone [--]

$C_{leachate}$ = concentration in the leachate [mg/l]

$C_{water\ table}$ = concentration at the water table [mg/l]

Therefore, the DAF in the unsaturated zone is calculated as [5 mg/l ÷ 2.5 mg/l] = 2 mg/l.

Below the facility is a mixing zone in which the leachate mixes with the groundwater flow. The DAF in mixing zone is defined as:

$$DAF_{mixing} = \frac{C_{watertable}}{C_{mixing-edge}} \tag{1-2}$$

where

DAF_{mixing} = dilution attenuation factor in the mixing zone [--]

$C_{mixing\text{-}edge}$ = concentration in water at the downgradient edge of the impacted area in the subsurface [mg/l].

In Figure M.2.1 it is calculated as [2.5 mg/l ÷ 0.25 mg/l] = 10 mg/l.

The DAF in the saturated zone is defined as:

$$DAF_{sat} = \frac{C_{mixing-edge}}{C_{target}} \tag{1-3}$$

where

DAF_{sat} = dilution attenuation factor in the saturated zone [--]
C_{target} = concentration at the point of exposure [mg/l]

From Figure M.2.1 it is calculated as [0.25 mg/l ÷ 0.005 mg/l] = 50 mg/l.

The overall DAF is defined as:

$$DAF_{overall} = \frac{C_{leachate}}{C_{target}} = \frac{C_{leachate}}{C_{watertable}} \times \frac{C_{watertable}}{C_{mixing-edge}} \times \frac{C_{mixing-edge}}{C_{target}} \tag{1-4}$$

OR

$$DAF_{overall} = DAF_{unsat} \times DAF_{mixing} \times DAF_{sat} \tag{1-5}$$

In this example, three coupled models may be required to estimate the overall DAF (i) an unsaturated zone model, (ii) a mixing zone model, and (iii) a saturated zone model. Hence, the overall DAF from leachate to the point of exposure is calculated as [2 x 10 x 50] = 1,000

Based on the above discussion the allowable leachate concentration can be back-calculated as follows:

$$C_{leachate} = C_{target} \times DAF_{overall} \tag{1-6}$$

For example, the allowable leachate concentration in Figure M.2.1 is calculated as (0.005 mg/l x 1000) = 5 mg/l. The allowable leachate concentration can then be converted to an equivalent allowable soil concentration either by using the results of a site-specific leachate test or by assuming equilibrium partitioning between the soil concentration and the leachate concentration.

Example 2:

DAFs can be used to estimate the allowable concentration in a compliance well. Consider Figure M.2.2 which shows a hypothetical (or real) point of exposure well where the groundwater target concentration (risk-based or MCL) has to be met, and a compliance well. It is necessary to estimate the maximum allowable concentration in the compliance well such that the concentration in the point of exposure well does not exceed the target level. This can be estimated as follows:

$$C_{mixing-edge} = C_{comp} \times DAF_X \tag{1-7}$$

AND:

$$C_{mixing-edge} = C_{target} \times DAF_Y \tag{1-8}$$

where

$C_{mixing-edge}$ = concentration at the edge of mixing zone [mg/l]
C_{comp} = allowable concentration in the compliance well [mg/l]
C_{target} = concentration at the point of exposure [mg/l]
DAF_X = dilution attenuation factor to the compliance well located at "X" feet from the mixing edge [--]
DAF_Y = dilution attenuation factor to the point of exposure located at "Y" feet from the mixing edge [--]

Solving equations 1-7 and 1-8, dividing Equation 1-7 by Equation 1-8, the allowable concentration in a compliance well located at distance "X" feet from the mixing edge can be estimated as follows:

$$C_{comp} = C_{target} \times \frac{DAF_Y}{DAF_X} \tag{1-9}$$

Thus, if X = 300 feet, Y = 1000 feet and C_{target} = 0.005 mg/l at distance Y for benzene, the allowable concentration in the compliance well is calculated using the DAFs from Table 5-5 (Section 5.5.3) as [0.005 x 503/46.1] = 0.55 mg/l.

If X = 300 feet and Y = 500 feet, then the allowable concentration at the compliance well would be (.005 x 126/46.1) = .014 mg/l.

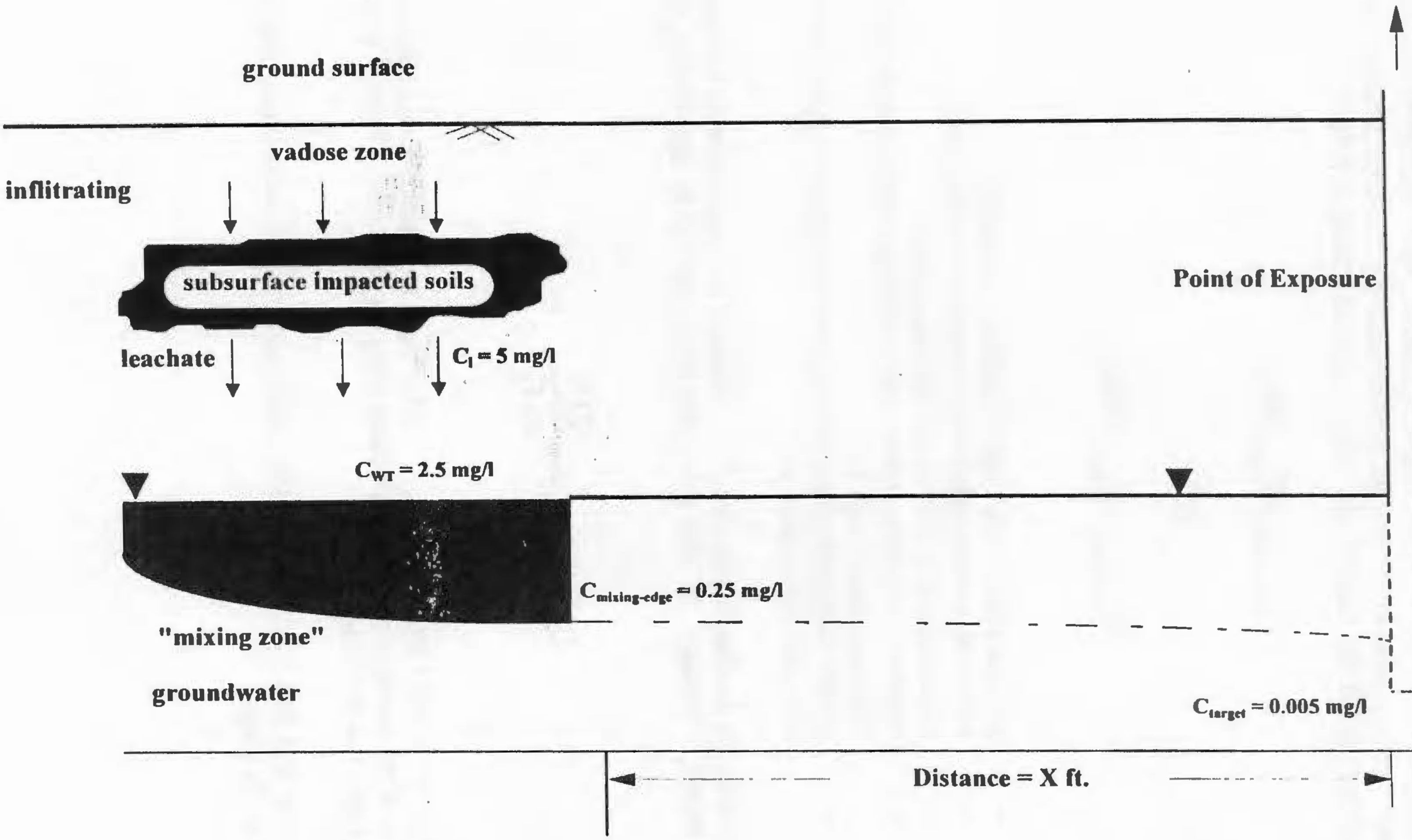


Figure M.2.1. Dilution Attenuation Factors (DAFs) in the Subsurface Zone

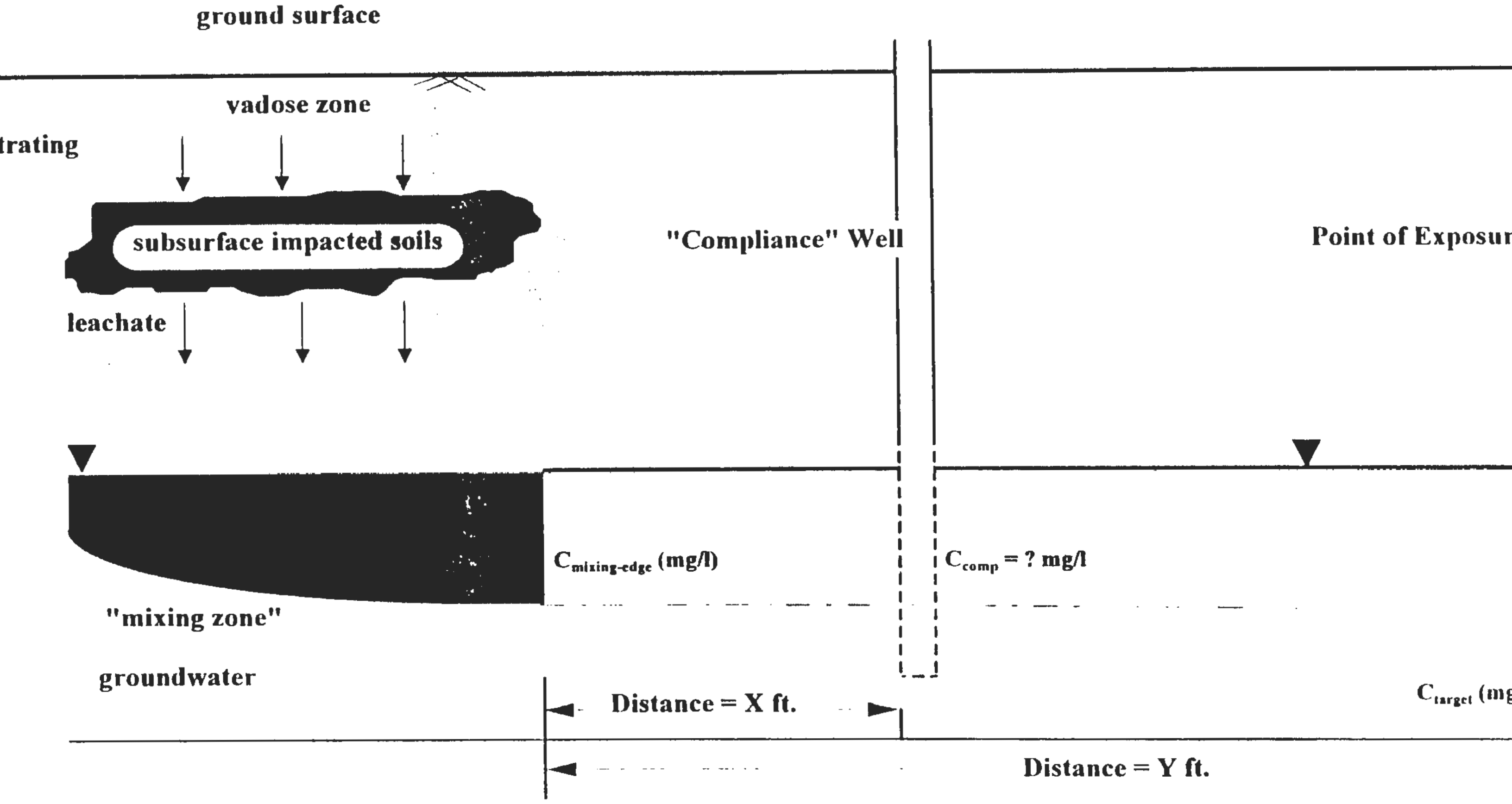


Figure M.2.2. Estimation of Concentration in a Compliance Well

FIGURE M.3.1
1,3,5 TRI-METHYLBENZENE
ESTIMATION OF HENRY'S LAW CONSTANT

Molecular Weight 120.2 *g/mol*

$$\text{Water Solubility} = 97\ g/m^3 = \frac{97\ g/m^3}{120.2\ g/mol} = 0.8070 mol/m^3$$

$$\text{Vapor Pressure} = 328\ \text{Pascal at } 25^\circ C = \frac{328\ Pa}{101315\ Pa/atm} = 0.0032\ atm$$

$$H = \frac{\text{Vapor Pressure}}{\text{Solubility}} = \frac{0.0032}{0.8070 mol/m^3} = 0.004\ atm\text{-}m^3/mol$$

$$H\ (\text{dimensionless}) = \frac{H}{RT} = \frac{0.004}{(.0000821)\ (298)} = 0.164$$

Where R = Universal Gas Constant = 8.21 E-5 Where T = Temperature in ° K = 273 + 25 = 298

FIGURE M.3.2
1,2,4 TRI-METHYLBENZENE
ESTIMATION OF HENRY'S LAW CONSTANT

Molecular Weight 120.2 *g/mol*

$$\text{Water Solubility} = 57\ g/m^3 = \frac{57\ g/m^3}{120.2\ g/mol} = 0.4742 mol/m3$$

$$\text{Vapor Pressure} = 271\ \text{Pascal at } 25^\circ C = \frac{271\ Pa}{101315\ Pa/atm} = 0.0027\ atm$$

$$H = \frac{\text{Vapor Pressure}}{\text{Solubility}} = \frac{0.0027 atm}{0.4742 mol/m^3} = 0.0057\ atm\text{-}m^3\ /mol$$

$$H\ (\text{dimensionless}) = \frac{H}{RT} = \frac{0.0057}{(.0000821)\ (298)} = 0.2327$$

Where R = Universal Gas Constant = 8.21 E-5 Where T = Temperature in ° K = 273 + 25 = 298

Information Extracted From:
Illustrated Handbook of Physical-Chemical Properties and Environmental Fate for Organic Chemicals, Volume 1 by Donald MacKay, Wan Ying Shiu and Kuo Ching Ma. Published by Lewis Publishers. ISRN 0-87371-573-6.

M.4 SOLUBILITY AND SATURATED SOIL CONCENTRATIONS

Solubility

Within the Tier 1 tables there are values which are identified as having exceeded the solubility limit. This implies that the estimated risk-based screening level exceeds the pure component water solubility. This, in fact, implies that even if free product were present at the site, the health risk would not exceed the target level.

Saturated Soil Concentrations

Within the Tier 1 tables there are values which are identified as having exceeded the saturation limit. This implies that estimated risk-based screening level for soil exceeds the residual (saturated) soil concentration. This, in fact, implies that even if free-phase product or precipitate is present in soil, the health risk would not exceed the target level. Note, the residual concentration using pure component water solubility and equilibrium equations.

M.5 VOLATILIZATION FACTOR FOR SUB-SURFACE SOIL TO INDOOR AIR

Explanation for the VF_{sesp} Factor:

Two approaches have been suggested to estimate the VF_{sesp} factor. Each of these are discussed below:

The VF_{sesp} expression in the example Table X2.5 of the ASTM RBCA E 1739-95 is based on the Johnson-Ettinger model and is generally believed to be very conservative, because this model is based on a constant chemical concentration in the sub-surface soils. That is, the contaminant source is assumed to be an infinite source for volatilization to an enclosed space (indoor air). As an alternative, a mass balance model (described below) assumes that the sub-surface soil contamination is depleted as contaminant volatilization occurs. **In this policy, both the Johnson-Ettinger model and the mass-balance are used to calculate the VF_{sesp}, and the smaller of the two is selected to calculate the $RBSL_s$.** No field data is available to verify this "claim". The claim is based on the realization that the application of this model yields very low RBSLs. For example, the RBSL for benzene for 1 x 10^{-6} residential scenario is 0.00537 mg/kg for soil assumed at a depth of about 100 cm. Empirical evidence and professional judgment suggests this to be too low.

The mass balance model can be derived as follows:

Assuming a contaminated soil zone (as shown in Figure M.2.1) of thickness d_s (cm), cross-sectional area A_s (cm^2), bulk density ρ_s (yngm/cm^3), and chemical concentration of C_s (mg/gm), the total mass of chemical in the contaminated zone is given by:

The total mass of chemical in the contaminated zone (mg) $= d_s A_s \rho_s C_s$ (1)

Assuming this mass volatilizes uniformly over a period of "T" seconds,

Emission per second (mg/sec) $= d_s A_s \rho_s C_s / T$ (2)

This uniformly emitted mass mixes with the air in the building resulting in a concentration of C_{air} (mg/cm^3).

Assuming air exchanges "n" times a second (note, "n" may be less than one), total air that passes through the building per second is given by,

Total air that passes through the building per second (cm^3/sec) = $n\ V$ (3)

Where V = indoor air volume of building

The mass of chemical that passes through with the air per second (mg/sec) = $n\ V\ C_{air}$ (4)

Equating Equations (2) and (4), i.e.

mass passing through the indoor air = mass emitted into the building/sec

$$n\ V\ C_{air} = d_s\ A_s\ \rho_s\ C_s\ /\ T$$

$$C_{air}\ /\ C_s = d_s\ A_s\ \rho_s\ /\ T\ n\ V$$

$$C_{air}\ /\ C_s = d_s\ \rho_s\ /\ T\ n\ (V/A_s)$$

Disadvantages:

This model is independent of the depth to sub-surface soil.
Does not account for any pavement or other barriers, etc.
The value of T has to be set arbitrarily. In this policy it is to set equal to the exposure duration.

M.6 SOURCES FOR PHYSICAL AND CHEMICAL PROPERTIES OF COC

The physical and chemical properties in Table 2-2(a) were obtained as follows:

The values in **bold** are from Tables X1.2 and X2.7 of the ASTM Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites E 1739 - 95.

The values in regular font are from Superfund Public Health Evaluation Manual (SPHEM) [EPA/540/1-86/060, October 1986], except the diffusivity in air for Acetone which is from Superfund Exposure Assessment Manual [EPA/540/1-88/001, April 1988].

Values in ***italics and bold*** are from EPA Region IX Preliminary Remediation Goals (PRGS) [Second Half, 1994].

The <u>underlined</u> values are from Lyman, W.J. et al. Handbook of Chemical Property Estimation Methods. McGraw-Hill, NY 1982.

Values in *italics* are from the spreadsheet software developed by GSI.

K_d values Statistics of Aquifer Materials Properties and Empirical pH-dependent Partitioning Relationships for As (III), As(V), Ba(II), BeII), Cd(II), Cr(VI), Cu(II), Hg(II), Ni(II), Pb(II), Sb(V), Se(IV), Se(VI), TI(I), and Zn(II), prepared by Environmental Research Laboratory, Athens, GA 30613 for USEPA Office of Solid Waste and Emergency Response, March, 1990.

The diffusion coefficient in air for the following chemicals:

1. Acenaphthene
2. Acenaphthylene
3. Anthracene
4. Benzo(a)anthracene
5. Benzo(b)fluoranthene
6. Benzo(g,h,i)perylene
7. Benzo(k)fluoranthene
8. Chrysene
9. Dibenzo(a,h)anthracene
10. Fluorene
11. Indeno(1,2,3-cd)pyrene
12. Phenanthrene
13. Pyrene
14. Cumene
15. MTBE
16. 1,2,4-Trimethylbenzene
17. 1,3,5-Trimethylbenzene

were calculated using the following equation:

$$D^{air}_{chem2} = D^{air}_{chem1}\ x\ \left(\frac{MW_{chem1}}{MW_{chem2}}\right)$$

where:

D^{air}_{chem2} = Diffusivity of chemical 2 in air
D^{air}_{chem1} = Diffusivity in air for Benzo(a)pyrene
MW_{chem1} = Molecular weight of Benzo(a)pyrene
MW_{chem2} = Molecular weight of chemical 2

The dermal relative absorption factor for metals was taken as 0.1% from EPA Dermal Exposure Assessment: Principles and Applications [EPA/600/8-91/011B, January 1992].

M.7 ESTIMATION OF ANNUAL AVERAGE DAILY SOIL INGESTION RATES

The annual average daily soil ingestion rate is computed by accounting for indoor as well as outdoor soil dust ingestion respectively. These rates for a child and an adult are discussed below.

SOIL INGESTION : CHILD

Outdoor - Child

NYSDOH assumes that a child ingests 80 mg/day for 5 days/week for 26 weeks in a year. Therefore, the amount of outdoor soil ingested in a year is

$$80 \text{ x } 5 \text{ x } 26 = 10{,}400 \text{ mg}$$

Indoor - Child

NYSDOH assumes that a child ingests 40 mg/day of indoor dust that originates as outdoor soil for 350 days in a year. Therefore, the amount of indoor dust ingested in a year is

$$40 \times 350 = 14,000 \text{ mg}$$

Thus, the total soil ingested is:

Total soil ingested = soil ingested (outdoor) + soil ingested (indoor)
Total ingested = 10,400 + 14,000 = 24,400 mg/year

The total soil ingested can be expressed as a rate spread over 350 days in a year as follows:

Annual average daily soil ingestion rate = 24,400 / 350 = 69.71 mg/day

Thus, the soil ingestion factors for a resident child for Tier 1 are:

ingestion rate = 69.71 mg/day
exposure frequency = 350 days/year

The above assumes that the indoor dust has the same characteristics as the outdoor soil.

SOIL INGESTION : ADULT

NYSDOH assumes that an adult ingests 82 mg/day of outdoor soil for 2 days/week for 5 months in a year. Therefore, the amount of outdoor soil ingested in a year is

$$82 \times 2 \times 5/12 \times 52 = 3,553.33 \text{ mg}$$

NOTE: NYSDOH assumes no indoor dust ingestion by an adult.

The total soil ingested can be expressed as a rate spread over 350 days in a year as follows:

Annual average daily soil ingestion rate = 3,553.33 / 350 = 10.15 mg/day

Thus, the soil ingestion factors for a resident adult for Tier 1 are:

ingestion rate = 10.15 mg/day
exposure frequency = 350 days/year

SOIL INGESTION : COMMERCIAL WORKER

DOH assumes that an adult ingests only outdoor soil 82 mg/day for 250 days. Therefore, the amount of outdoor soil ingested in a year is:

$$82 \times 250 = 20,500 \text{ mg}$$

NOTE: NYSDOH assumes no indoor dust ingestion by an adult.

The total soil ingested can be expressed as a rate spread over 350 days in a year as follows:

Annual average daily soil ingestion rate = 20,500/350 = 58.6 mg/day

Thus, the soil ingestion factors for a commercial worker for Tier 1 are:

ingestion rate = 58.6 mg/day
exposure frequency = 250 days/year

SOIL INGESTION: CONSTRUCTION WORKER

DOH assumes that an adult ingests only outdoor soil 82 mg/day.

Daily Ingestion Rate = 82 mg/day for 100 days is:

82 mg/day x 100 days = 8,200 mg

Annual average daily soil ingestion rate = 8,200 mg/350 day = 23.4 mg/day

REFERENCES:

Baes, C. F., Sharp, R.D., Sjoreen, A.L., Shor, R.W. 1984. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides Through Agriculture. Oak Ridge National Laboratory. ORNL-5786.

Dragun, J. 1988. The Soil Chemistry of Hazardous Materials. Silver Spring, MD: Hazardous Materials Control Research Institute.

Lyman, W.M., Reehl, W.F., Rosenblatt, D.H. 1990. Handbook of Chemical Property Estimation Methods. Washington, DC: American Chemical Society.

Travis, C.C., Arms, A.D. 1988. Bioconcentration of organics in beef, milk and vegetation. Environ. Science Technol. 22: 271-274.

RISK EVALUATION SUMMARY REPORT

PREPARED FOR:

____
(Site Name)

____
(Location)

____

____
(Prepared By)

____
(Date Issued)

Reviewed By:_________________________
Date:_________________________

Table of Contents

LIST OF FIGURES

APPENDICES

SECTION 1.0
EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

Spill #

PBS #

Date Form Completed:

Form Completed By:

FACILITY INFORMATION

Facility Name:

Facility Address:

Facility County:

Facility Owner/Phone:

Owner Address:

Facility Operator/Phone:

Facility Latitude/Longitude:

Legal Location:

List Previous Names of this Facility:

1.______________________________
2.______________________________
3.______________________________

List Previous Owner(s) of this Facility with Addresses

1.____
2.____
3.____

Has this site ever had an emergency response? ___ Yes ___ No
If yes, then was it: ____ State Lead ____ Owner/Operator Lead (discuss under additional notes, below)

Release Discovered During/By:

- ___ UST Removal
- ___ Release Detection Equipment
- ___ Inventory Control
- ___ Citizen Complaint
- ___ Unknown
- ___ Other (specify) ____
- ___ Closure in Place
- ___ Property Transaction
- ___ System Tightness Testing
- ___ Spill Incident

Pressure Mechanism:

___ Pressure ___ Suction ___ Unknown

Sources of Release(s):

___ Spills/Overfills ___ Piping ___ Dispenser ___ Tank Other (specify)________________________

Substance Released (check all that apply):

___ Gasoline ___ Diesel ___ Used Oil ___ AV Gas ___ Jet Fuel ___ Hydraulic Fluid
___ Other (specify)____

Has the source of release been identified? ___ Yes ___ No
Has the source been eliminated? ___ Yes ___ No
Is groundwater impacted? ___ On-Site ___ Off-Site ___ Unknown ___ No
Is surface water impacted? ___ On-Site ___ Off-Site ___ Unknown ___ No
Is soil impacted? ___ On-Site ___ Off-Site ___ Unknown ___ No
Dissolved phase extent: ___ Yes ___ No
Has NAPL been found at this site? ___ Yes ___ No
If YES, does NAPL extend off-site? ___ Yes ___ No
If YES, denote greatest thickness (to the nearest 1/100 foot): __________________
If YES, has Free Product removal been initiated? ___ Yes ___ No
If NO, cite reason:____

Details of the Release(s)

Date Discovered	Location	Quantity

Notes: ____
____
____

Land Use (circle use)

1. Current use: Commercial/Industrial Residential Agricultural Recreational Vacant
2. Adjacent property use: Commercial/Industrial Residential Agricultural Recreational Vacant
3. Future use of the site: Commercial/Industrial Residential Agricultural Recreational Vacant
4. Distance to nearest residential land use (feet): ____________________

Soil Conditions

5. Depth to top of contaminated soil (cm bgs[1]): ____________________
6. Depth to base of contaminated soil zone (cm bgs): ____________________
7. Thickness of contaminated soil zone (cm): ____________________
8. Areal extent of contaminated soil zone (square cm): ____________________
9. Minimum distance from contaminated soil zone to property boundary (cm) & nearest receptor: ____________________
10. Type of surface cover over affected soil ____________________
11. Date of most recent soil analysis[2]: ____________________
12. Has analysis included all relevant chemicals-of-concern for the product released: Yes No
13. Were the detection limits used in the analyses equal to or less than Tier 1 target concentrations? Yes No
14. Has the contaminant source been abated? Yes No
15. Have soil properties (water content, porosity, bulk density and fractional organic carbon content) been measured? Yes No

Groundwater Conditions

16. Depth to affected water-bearing stratum (cm bgs): ____________________
17. Approximate base of affected water-bearing stratum (cm bgs): ____________________
18. Approximate thickness of contaminated groundwater zone (cm): ____________________
19. Approximate areal extent of contaminated groundwater zone (square cm): ____________________
20. Total number of monitoring wells installed: ____________________
21. Total number of monitoring wells installed down the axis of the plume: ____________________
22. Have any monitoring wells been plugged? Yes No
    If yes, which ones and why? ____________________
23. Have static water levels ever been above the screened intervals for any of the monitoring wells? Yes No

---

[1] *bgs - below ground surface*

[2] *If greater than 1 year old, consideration should be given to the collection of verification samples unless you consider the contamination levels to be representative of current conditions.*

24. Have phase-separated hydrocarbons (PSH) ever been present in the sub-surface at site? Yes No

If yes, in which well(s)? Also indicate the date of the most recent PSH recovery. ______________________

25. If PSH is present, is the PSH plume stable? Yes No

If yes, how? - naturally or by containment: ______________________

26. Number of water wells within 0.25 miles of the site: ______________________

27. Has analysis included all relevant constituents for the product released: Yes No

28. Does analysis include all the chemicals-of-concern listed in Table 2-1 for the product(s) in question? Yes No

29. Has a receptor/survey been conducted? Yes No

30. Is the dissolved groundwater contaminant plume defined in the downgradient direction? Yes No

31. Direction of groundwater flow: ______________________

32. Does groundwater flow direction vary with time? Yes No

33. Is groundwater tidally influenced? Yes No

34. Does the plume extend beyond the property boundary? Yes No

If yes, distance beyond property boundary (feet): ______________________

If no, distance from property boundary (feet): ______________________

Remedial Actions

35. Have any remedial actions taken place?
If yes, provide a brief description ______________________

36. Is a remediation system still in operation? Yes No

37. Number of monitoring events after system shut down[3]: ______________________

---

[3] *The post-remediation monitoring period must be of sufficient length to clearly show that the groundwater plume is under steady state conditions (at no time will less than 4 quarterly sampling events be sufficient).*

TIER 2 - EXECUTIVE SUMMARY CHECKLIST

TIER 2 SSTL CALCULATION METHOD

SSTL Calculation Option

☐ Option 1: Site-Specific Screening Levels

☐ Option 2: Individual Constituent SSTL Values

☐ Option 3: Cumulative Constituent SSTL Values

Natural Attenuation Factor (NAF) Calculation Method

☐ Fate and Transport Modeling:

- ☐ RBCA Spreadsheet System
- ☐ Other Model(s)

☐ Empirical NAF Calculation

SITE DATA INVENTORY

Source Zone Investigation Complete

☐ Surface Soil (e.g. ≤ 6 in BGS)
☐ Subsurface Soil (e.g. > 6 in BGS)
☐ Groundwater

Exposure Pathway Information Compiled

☐ Air Pathway
☐ Surface Water Pathway
☐ Groundwater Pathway
☐ Land Use Classification (on-site and off-site)
☐ Soil Pathway

TIER 1 WORKSHEETS 1.3 - 4.2 and 5.6 Have Been Updated to Include New TIER 2 Information

TASKS COMPLETED

☐ Tier 1 Evaluation
☐ Tier 1 Interim
☐ Corrective Action
☐ Tier 2 Evaluation
☐ Tier 2 Interim Corrective Action
☐ Tier 2 Final Corrective Action
☐ Tier 3 Evaluation

TIER 2 CORRECTIVE ACTION CRITERIA

Affected Medium	Tier 2 SSTL Exceeded? YES	NO	Applicable Excess Risk Limits (specify value) Indiv. Risk	Hazard Index	Other Applicable Exposure Limit (specify, if any)
Surface Soil (≤ 6 in BGS)					
Subsurface Soil (> 6 in BGS)					
Groundwater					

PROPOSED ACTION

☐ No Action: Tier 2 SSTLs not exceeded. Apply for closure.

☐ Interim Corrective Action: Address principal, near-term risk sources.

☐ Final Corrective Action: Remediate/control size to meet Tier 2 criteria.

☐ Tier 3 Evaluation: Improve baseline risk and SSTL estimates.

ALL WORKSHEETS ENCLOSED IN THIS REPORT ARE IDENTIFIED ON THE TABLE OF CONTENTS FORM

SITE DESCRIPTION

Briefly discuss site chronology, operations, features of potential concern, and future plans for site use.

SITE ASSESSMENT INFORMATION

GEOLOGIC AND HYDROGEOLOGIC SUMMARY

Briefly describe regional site features, climate, vadose zone soils, and groundwater depth quality, and use.

BASELINE EXPOSURE ASSESSMENT

COMPLETE EXPOSURE PATHWAYS AND APPLICABLE RECEPTORS

Discuss current or potentially complete pathways for human or ecological exposure to site constituents.

ECOLOGICAL ASSESSMENT SUMMARY

Discuss potentially sensitive ecological receptors and habitat in the vicinity of site, if any.

TIER 1 RBSL OR TIER 2 SSTL EVALUATION

COMPARISON TO SOURCE MEDIA CONCENTRATIONS

For complete pathways, compare representative source concentrations to applicable RBSL or SSTL values.

QUALITATIVE UNCERTAINTY ASSESSMENT

Discuss uncertain/conservatism of the site data and calculation methods used in deriving RBSL or SSTL values.

PROPOSED CORRECTIVE ACTION

Describe rationale for proposed action (i.e. no action, interim action, final action, or tier upgrade), considering site classification and land use. Discuss for remedy selection, if applicable.

REFERENCE DOCUMENTS

- Appendices

List the document sources for the data cited in this report.

SECTION 2.0

SITE DESCRIPTION

SITE DESCRIPTION

LOCATION DESCRIPTION (See Figure 1)

Address: ______________________________

Cross-Street: ______________________________

City: ______________________________

County: ______________________________

State: ______________________________

Site Status

☐ Operating

☐ Permanently or Temporarily out-of-service. From __________ to __________

☐ Abandoned on: ____________________

Ground Surface Conditions:

☐ Paved % area paved: __________ Material: __________

Degree of cracking: ☐ Low ☐ Moderate ☐ High

☐ Unpaved

Utilities:

Types and Depths of Utilities:

☐ Conduit ☐ Potential Conduit

☐ Sanitary Sewer: Depth: __________ Flow Direction: ______________

☐ Storm Sewer: Depth: __________ Flow Direction: ______________

☐ Electric Line: Depth: __________ ☐ Telephone Line Depth: ______________

☐ Gas Line: Depth: __________ ☐ Water Line Depth: ______________

	Yes	No		Yes	No
Have the utilities been inspected	☐	☐	Were Readings Collected	☐	☐

Date of inspection ____________________ If Yes, Attach.

Immediate (within 1,000 feet) Land Use (at a minimum, state whether residential or non-residential)

Attach appropriate maps

North: ______________________________

Northeast: ______________________________

Northwest: ______________________________

South: ______________________________

Southeast: ______________________________

Southwest: ______________________________

West: ______________________________

East: ______________________________

Surface Drainage: Direction(s) ________________ Grade (ft/ft): ______________

Drainage Discharge: Stream ☐ YES ☐ NO If YES, name: ______________________________

Lake ☐ YES ☐ NO If YES, name: ______________________________

Controlled Inlet/Outlet ☐ YES ☐ NO If YES, name of waterbody: ____________________

Groundwater recharge/discharge area ☐ YES ☐ NO If YES, name of aquifer: ____________________

LAND USE SUMMARY

LOCAL LAND USE

On-Site Use	Current	Potential	Prior
Commercial	☐	☐	☐
Residential	☐	☐	☐
Industrial	☐	☐	☐
Sensitive Habitat	☐	☐	☐
Other:	☐	☐	☐

Other Comments

Discuss options for listed items (including anticipated future use)

TOPOGRAPHY (See Figures 1 and 3)

Terrain ☐ Flat ☐ Steep ☐ Variable

Site Elevation Interval (ft-MSL)

High Pt.________ Low Pt.________

Average Ground Surface Slope

Direction ________ Grade (ft/ft)________

Other Comments

LOCAL CLIMATE

Average Annual Rainfall (in):______

Annual Average Evapotranspiration (in):______

Within 100 Year Floodplain: ☐ Yes ☐ No

Average Temperature (°F): ______

Number of Frost-Free Days: ______

Other Comments

Distance and direction to the nearest residence (feet):________

Distance and direction to any environmentally sensitive area (feet) within 1/4 mile (define notes):________

Distance and direction to the nearest school, hospital, day care, retirement home, etc., (feet) (specify facility):________

Distance and direction to the nearest commercial/industrial site (feet) (specify):________

Notes:________

FUTURE LAND USE

	Potential
Residential	☐
Non-Residential	☐
Sensitive/special	☐
Other	☐

Comments

Notes:________

Check One: ☐ Tier 1 ☐ Tier 2 ☐ Tier 3

PAST RELEASES OR SOURCE AREA

TIME PERIOD		**Instructions:** *Describe potential sources and spill events, including spill number, location, type and estimated volume of materials stored or released, time and duration of release, and affected media (soil, groundwater, surface water, etc.). Discuss past corrective action efforts as appropriate.*
Begin	**End**	

OPTIONAL - PBS FACILITIES ONLY

UNDERGROUND STORAGE TANK TYPE **PBS I.D.**

ctive, check "YES" and if inactive, check "NO". Provide the installation date if the UST is active and the excavation date if the UST is
oting Tank Number(s) is required.

Product	Tank Registration I.D. Number	Capacity	Active		Installation Date	Tank Testing	Closure in-place Date	Tem of
			Yes	No				

tes:

SUMMARY OF CURRENT AND COMPLETED SITE ACTIVITIES

site activities to be recorded include: *- Preliminary Site Assessment/Site Inspection - Emergency Response - Review Hazard Ranking Sy*
- Risk/Exposure Assessment - Remedy Selection - Remedy Implementation
f sampling and testing include: *- Soil - Groundwater - Surface Water - Vapors*

Completed	Description of Task	Sampling and Testing Conducted	Goal/Result/Product/Impact

SUMMARY OF POTENTIAL NEAR-TERM SITE ACTIVITIES (1-2 YEARS)

vities to be recorded include: *- Preliminary Site Assessment/Site Inspection* *- Emergency Response* *- Review Hazard Ranking System*
- Risk/Exposure Assessment *- Remedy Selection* *- Remedy Implementation*
g and testing include: *- Soil* *- Groundwater* *- Surface Water* *- Vapors*

ted	Description of Task	Sampling and Testing Conducted	Gaol/Result/Product/

SECTION 3.0
SITE CHARACTERIZATION

SITE STRATEGY AND HYDROGEOLOGY

Groundwater impacted by release: ☐ YES ☐ NO ☐ Groundwater not encountered to depth of_____ feet BGS

Stratigraphy:

Depth	Unified Soil Classification	Type of Soil

Predominant Soil Type:

Depth	Type of Bedrock and Geologic Formation (Give rock properties and features - e.g., orientation of fractures)	
Predominant Type:		

Average depth at which groundwater was first encountered (ft): ________

Shallowest depth to water table/piezometer (ft): ____________________ ☐ Measured

Flow Direction (*attach contour map*): ____________________ ☐ Measured

Hydraulic Gradient (i)[ft/ft]:____________________ ☐ Measured

Estimated Porosity (0): ____________________ ☐ Estimated ☐ Measured

Water Content [cm^3/cm^3]: ____________________ ☐ Estimated ☐ Measured

Dry Bulk Density [g/cm^3]: ____________________ ☐ Estimated ☐ Measured

Hydraulic Conductivity (K) [ft/day]:____________________ ☐ Estimated ☐ Measured

Hydraulic Conductivity test method: ____________________ ☐ Estimated ☐ Measured

☐ grain size/sieve analysis ☐ slug test ☐ pump test, period (hours):___________

☐ other (specify) ____

Flow Velocity [ft/day] (Ki/0): ____________________

Is this a perched aquifer? ☐ YES ☐ NO

Is the first groundwater encountered confined? ☐ YES ☐ NO

Groundwater level fluctuations (± ft) (cite greatest known): ____________________

Aqufer Name:____

Aquifer length: __________ width: __________ thickness:__________ transmissivity:__________

Aquifer storativity: ☐ confined ☐ unconfined

Annual Precipitation, 30-yr avg (in/yr):____________________

Notes:____

____

____

SITE STRATIGRAPHY + HYDROGEOLOGY

Groundwater impacted by release: ☐ YES ☐ NO ☐ Groundwater not encountered to depth of ______ feet BGS

Stratigraphy:

Depth	Unified Soil Classification	Type of Soil

Predominant Soil Type:

Depth	Type of Bedrock and Geologic Formation (Give rock properties and features - e.g., orientation of fractures)	
Predominant Type:		

Average depth at which groundwater was first encountered (ft): ________ ☐ Estimated ☐ Measured

Shallowest depth to water table/piezometer (ft): ____________________ ☐ Estimated ☐ Measured

Flow Direction (*attach contour map*): ______________________________ ☐ Estimated ☐ Measured

Hydraulic Gradient (i)[ft/ft]: ______________________________ ☐ Estimated ☐ Measured

Estimated Porosity (0) [cm^3/cm^3]: ______________________________ ☐ Estimated ☐ Measured

Water Content [cm^3/cm^3]: ______________________________ ☐ Estimated ☐ Measured

Dry Bulk Density [g/cm^3]: ______________________________ ☐ Estimated ☐ Measured

Hydraulic Conductivity (K) [ft/day]: ______________________________ ☐ Estimated ☐ Measured

Hydraulic Conductivity test method: ______________________________ ☐ Estimated ☐ Measured

☐ grain size/sieve analysis ☐ slug test ☐ pump test, period (hours): ____________

☐ other (specify) ____

Flow Velocity [ft/day] (Ki/0): ____________________

Is this a perched aquifer? ☐ YES ☐ NO

Is the first groundwater encountered confined? ☐ YES ☐ NO

Groundwater level fluctuations (± ft) (cite greatest known): ____________________

Aquifer Name: ____

Estimated aquifer volume (if known) (cu. ft): ______________________________

Annual Precipitation, 30-yr avg (in/yr): ______________________________

Notes:

____

____

____

____

SITE CHARACTERISTICS

Groundwater Resources	Current	Potential	**Comments**
Domestic Supply	☐	☐	
Public/Municipal Supply	☐	☐	
Industrial Supply	☐	☐	
Agriculture	☐	☐	
Other (Define in Notes)	☐	☐	
Within Wellhead Protection Area	☐	☐	

Likelihood of use of groundwater for domestic supply in future
☐ Low ☐ Medium ☐ High ☐ None/Extremely Unlikely

Water Quality (if known, please specify units)
TDS: __________ Specific Conductance: __________ Chlorides: __________
Hardness: __________ Nitrates: __________ Iron: __________
Sulfates: __________ Pesticides (specify): __________
Other (specify):____

Notes:

____
____
____
____

Surface Water Resources **(if relevant)**	Current	Potential	**Comments**
Domestic Supply	☐	☐	
Public/Municipal Supply	☐	☐	
Recreational	☐	☐	
Other (wetlands, fish, propagation)	☐	☐	

Likelihood of use of surface water for domestic supply in future
☐ Low ☐ Medium ☐ High ☐ None/Extremely Unlikely

If a stream is, or may potentially be, impacted by COCs, does the stream have:
☐ Intermittent Water Flow ☐ Continuous Water Flow

DEC Stream Classification:
Name of Receiving Water:_________________________________
Latitude and Longitude of the Discharge:_______________________________

Notes:

____
____
____
____
____

WELL INVENTORY SURVEY

SUMMARY OF WELLS WITHIN 1/4 MILE RADIUS OF SITE

See Figure 1 for the well inventory survey within a 1/4 mile radius of the site.

	Radial Distance		**Downgradient Direction**		
Well Type	**Total #**	**Active #**	**Total #**	**Active #**	**# Screened in Potentially Impacted Aquifer**
Public/Municipal					
Industrial					
Domestic					
Agricultural					

POTENTIAL RECEPTOR POINTS

	Closest Downgradient Supply well(1)	Closes Downgradient Drinking Water Well(2)	Closest Down-Gradient Receptor(3)	Closes Reasonable Potential Well(4)
Well # or Designation				
Distance from Site (ft)				
Total Well Depth (ft)				
Current Use of Water				
Screened Interval below Ground Surface (ft)				
Seal Interval below Ground Surface (ft)				
Year Constructed				
Water Use Classification (see Worksheet 3.3)				

Notes:

1. *Supply Well; Any water supply well (drinking water, agricultural, industrial, etc.), which has not been abandoned and is completed through any lithologic unit that could be potentially impacted.*
2. *Drinking Water Well: Municipal or residential drinking water supply completed in any lithologic unit.*
3. *Actual Receptor: Municipal or residential drinking water supply well completed in same lithologic unit in which plume is migrating.*
4. *Potential Well: Closes reasonable placement for the future location of an off-site well.*

ECOLOGICAL ASSESSMENT SUMMARY

QUALITATIVE ECOLOGICAL IMPACT ASSESSMENT

Visual Site Inspection

Date Conducted:____________________ By:____

Observed Impacts Associated with Site

On-Site Vegetation	☐ None	☐ Limited	☐ Extensive
Off-Site Vegetation	☐ None	☐ Limited	☐ Extensive
On-Site Mammals, birds, fish, etc.	☐ None	☐ Suspected	☐ Observed
Off-Site Mammals, birds, fish, etc.	☐ None	☐ Suspected	☐ Observed
Other Impacts	☐ None	☐ Yes (explain below)	

Discussion:

HABITAT CHARACTERIZATION

Presence of Sensitive Habitat

Site located within or impacts a sensitive or protected habitat ☐ No ☐ Yes (explain below)

Description of Sensitive Habitat

Name:

Location:

Habitat Type:	☐ Aquatic	☐ Wetland	☐ Riparian	☐ Upland
Habitat Condition:	☐ Pristine	☐ Highly Altered	☐ Early Altered	☐ Late Recovery

Discussion: *Provide other information relative to habitat characterization including regulatory authority, basis for protection, etc.*

ECOLOGICAL RECEPTORS

Presence of Impacted Ecological Receptors

Site conditions have impacted sensitive ecological receptors, either on-site or off-site? ☐ No ☐ Yes (explain below)

List of Affected Receptors Threatened or Endangered Species	Economically/Sport Significant Species
____________________	____________________
____________________	____________________
____________________	____________________

ECOLOGICAL ASSESSMENT SUMMARY AND RECOMMENDED ACTION

Observed or Potential Impacts	-	**Recommended Action**
☐ None observed or anticipated	-	No action required
☐ Potential for significant impact	-	Further study required (describe below)
☐ Significant impact observed	-	Further study and/or remedial action required (describe below) SPDES point-source discharge evaluation
	-	

Recommended Work Program

Attached 1-2 page description of scope-of-work for more detailed ecological impact assessment, if needed. Address methods to be used, schedule, and cost.

SECTION 4.0
SITE EXPOSURE SCENARIO

SITE CONCEPTUAL EXPOSURE SCENARIO - CURRENT CONDITIONS

Potentially Exposed Receptor	**Exposure Route, Medium and Exposure Point**	C^1-NC^2	**Justification of Inclusion or Exclusion of Pathways**
Resident Child On-Site	Ingestion and dermal contact with surficial soil		
	Indoor inhalation of vapors from surficial soil		
	Indoor inhalation of vapors from sub-surface soil		
	Ingestion of shallow groundwater		
	Indoor inhalation of vapors from shallow groundwater		
	Ingestion of deep groundwater		
	Dermal contact with shallow groundwater		
	Indoor inhalation of vapors from deep groundwater		
	Dermal contact with deep groundwater		
Resident Adult On-Site	Ingestion and dermal contact with surficial soil		
	Indoor inhalation of vapors from surficial soil		
	Indoor inhalation of vapors from sub-surface soil		
	Ingestion of shallow groundwater		
	Indoor inhalation of vapors from shallow groundwater		
	Ingestion of deep groundwater		
	Dermal contact with shallow groundwater		
	Indoor inhalation of vapors from deep groundwater		
	Dermal contact with deep groundwater		

C^1 : Complete Pathway
NC^2: Incomplete Pathway

SITE CONCEPTUAL EXPOSURE SCENARIO - CURRENT CONDITIONS

Potentially Exposed Receptor	Exposure Route, Medium and Exposure Point	C^1-NC^2	Justification of Inclusion or Exclusion of Pathways
Commercial Worker Off-Site	Ingestion and dermal contact with surficial soil		
	Indoor inhalation of vapors from surficial soil		
	Indoor inhalation of vapors from sub-surface soil		
	Ingestion of shallow groundwater		
	Indoor inhalation of vapors from shallow groundwater		
	Ingestion of deep groundwater		
	Pathways not evaluated under Tier 1 as per OCC Guidance Document		
	Dermal contact with shallow groundwater		
	Indoor inhalation of vapors from deep groundwater		
	Dermal contact with deep groundwater		
Construction Worker Off-Site	Ingestion and dermal contact with surficial soil		
	Indoor inhalation of vapors from surficial soil		
	Indoor inhalation of vapors from sub-surface soil		
	Ingestion of shallow groundwater		
	Indoor inhalation of vapors from shallow groundwater		
	Ingestion of deep groundwater		
	Indoor inhalation of vapors from deep groundwater		
	Dermal contact with deep groundwater		

C^1 : Complete Pathway
NC^2: Incomplete Pathway

SITE CONCEPTUAL EXPOSURE SCENARIO - CURRENT CONDITIONS

Potentially Exposed Receptor	Exposure Route, Medium and Exposure Point	C^1-NC^2	Justification of Inclusion or Exclusion of Pathways
Resident Child Off-Site	Ingestion and dermal contact with surficial soil		
	Indoor inhalation of vapors from surficial soil		
	Indoor inhalation of vapors from sub-surface soil		
	Ingestion of shallow groundwater		
	Indoor inhalation of vapors from shallow groundwater		
	Ingestion of deep groundwater		
	Pathways not evaluated under Tier 1 as per OCG Guidance Document		
	Dermal contact with shallow groundwater		
	Indoor inhalation of vapors from deep groundwater		
	Dermal contact with deep groundwater		
Resident Adult Off-Site	Ingestion and dermal contact with surficial soil		
	Indoor inhalation of vapors from surficial soil		
	Indoor inhalation of vapors from sub-surface soil		
	Ingestion of shallow groundwater		
	Indoor inhalation of vapors from shallow groundwater		
	Ingestion of deep groundwater		
	Indoor inhalation of vapors from deep groundwater		
	Dermal contact with deep groundwater		

C^1 : Complete Pathway
NC^2: Incomplete Pathway

SITE CONCEPTUAL EXPOSURE SCENARIO - CURRENT CONDITIONS

Potentially Exposed Receptor	**Exposure Route, Medium and Exposure Point**	**C^1-NC^2**	**Justification of Inclusion or Exclusion of Pathways**
Commercial Worker On-Site	Ingestion and dermal contact with surficial soil		
	Indoor inhalation of vapors from surficial soil		
	Indoor inhalation of vapors from sub-surface soil		
	Ingestion of shallow groundwater		
	Indoor inhalation of vapors from shallow groundwater		
	Ingestion of deep groundwater		
	Dermal contact with shallow groundwater		
	Indoor inhalation of vapors from deep groundwater		
	Dermal contact with deep groundwater		
Construction Worker On-Site	Ingestion and dermal contact with surficial soil		
	Indoor inhalation of vapors from surficial soil		
	Indoor inhalation of vapors from sub-surface soil		
	Ingestion of shallow groundwater		
	Indoor inhalation of vapors from shallow groundwater		
	Ingestion of deep groundwater		
	Indoor inhalation of vapors from deep groundwater		
	Dermal contact with deep groundwater		

C^1 : Complete Pathway
NC^2: Incomplete Pathway

SITE CONCEPTUAL EXPOSURE SCENARIO - FUTURE CONDITIONS

Potentially Exposed Receptor	Exposure Route, Medium and Exposure Point	C^1-NC^2	Justification of Inclusion or Exclusion of Pathways
Resident Child On-Site	Ingestion and dermal contact with surficial soil		
	Indoor inhalation of vapors from surficial soil		
	Indoor inhalation of vapors from sub-surface soil		
	Ingestion of shallow groundwater		
	Indoor inhalation of vapors from shallow groundwater		
	Ingestion of deep groundwater		
	Dermal contact with shallow groundwater		
	Indoor inhalation of vapors from deep groundwater		
	Dermal contact with deep groundwater		
Resident Adult On-Site	Ingestion and dermal contact with surficial soil		
	Indoor inhalation of vapors from surficial soil		
	Indoor inhalation of vapors from sub-surface soil		
	Ingestion of shallow groundwater		
	Indoor inhalation of vapors from shallow groundwater		
	Ingestion of deep groundwater		
	Dermal contact with shallow groundwater		
	Indoor inhalation of vapors from deep groundwater		
	Dermal contact with deep groundwater		

C^1 : Complete Pathway

NC^2: Incomplete Pathway

SITE CONCEPTUAL EXPOSURE SCENARIO - FUTURE CONDITIONS

Potentially Exposed Receptor	**Exposure Route, Medium and Exposure Point**	**C^1-NC^2**	**Justification of Inclusion or Exclusion of Pathways**
Commercial Worker Off-Site	Ingestion and dermal contact with surficial soil		
	Indoor inhalation of vapors from surficial soil		
	Indoor inhalation of vapors from sub-surface soil		
	Ingestion of shallow groundwater		
	Indoor inhalation of vapors from shallow groundwater		
	Ingestion of deep groundwater		
	Pathways not evaluated under Tier 1 as per OCC Guidance Document		
	Dermal contact with shallow groundwater		
	Indoor inhalation of vapors from deep groundwater		
	Dermal contact with deep groundwater		
Construction Worker Off-Site	Ingestion and dermal contact with surficial soil		
	Indoor inhalation of vapors from surficial soil		
	Indoor inhalation of vapors from sub-surface soil		
	Ingestion of shallow groundwater		
	Indoor inhalation of vapors from shallow groundwater		
	Ingestion of deep groundwater		
	Indoor inhalation of vapors from deep groundwater		
	Dermal contact with deep groundwater		

C^1 : Complete Pathway
NC^2: Incomplete Pathway

SITE CONCEPTUAL EXPOSURE SCENARIO - FUTURE CONDITIONS

Potentially Exposed Receptor	Exposure Route, Medium and Exposure Point	C^1-NC^2	Justification of Inclusion or Exclusion of Pathways
Resident Child Off-Site	Ingestion and dermal contact with surficial soil		
	Indoor inhalation of vapors from surficial soil		
	Indoor inhalation of vapors from sub-surface soil		
	Ingestion of shallow groundwater		
	Indoor inhalation of vapors from shallow groundwater		
	Ingestion of deep groundwater		
	Pathways not evaluated under Tier 1 as per OCG Guidance Document		
	Dermal contact with shallow groundwater		
	Indoor inhalation of vapors from deep groundwater		
	Dermal contact with deep groundwater		
Resident Adult Off-Site	Ingestion and dermal contact with surficial soil		
	Indoor inhalation of vapors from surficial soil		
	Indoor inhalation of vapors from sub-surface soil		
	Ingestion of shallow groundwater		
	Indoor inhalation of vapors from shallow groundwater		
	Ingestion of deep groundwater		
	Indoor inhalation of vapors from deep groundwater		
	Dermal contact with deep groundwater		

C^1 : Complete Pathway

NC^2: Incomplete Pathway

SITE CONCEPTUAL EXPOSURE SCENARIO - FUTURE CONDITIONS

Potentially Exposed Receptor	Exposure Route, Medium and Exposure Point	C^1-NC^2	Justification of Inclusion or Exclusion of Pathways
Commercial Worker On-Site	Ingestion and dermal contact with surficial soil		
	Indoor inhalation of vapors from surficial soil		
	Indoor inhalation of vapors from sub-surface soil		
	Ingestion of shallow groundwater		
	Indoor inhalation of vapors from shallow groundwater		
	Ingestion of deep groundwater		
	Dermal contact with shallow groundwater		
	Indoor inhalation of vapors from deep groundwater		
	Dermal contact with deep groundwater		
Construction Worker On-Site	Ingestion and dermal contact with surficial soil		
	Indoor inhalation of vapors from surficial soil		
	Indoor inhalation of vapors from sub-surface soil		
	Ingestion of shallow groundwater		
	Indoor inhalation of vapors from shallow groundwater		
	Ingestion of deep groundwater		
	Indoor inhalation of vapors from deep groundwater		
	Dermal contact with deep groundwater		

C^1 : Complete Pathway
NC^2: Incomplete Pathway

SECTION 5.0
DEFAULT EXPOSURE FACTORS

TABLE P.1
TIER 1 DEFAULT EXPOSURE FACTORS

Exposure Parameter	Units	Symbol	NYS Default Value	Reference
Averaging Time - Carcinogen	yr	AT	70	1
Averaging Time - Non-carcinogen (equals exposure duration):				
On-Site Commercial Worker	yr	AT	25	2
On/Off-Site Resident (adult)	yr	AT	30	2
On/Off-Site Resident (child)	yr	AT	6	2
Construction Worker	yr	AT	1	3
Body Weight:				
Adult Receptors	kg	BW	70	1
Child Receptors	kg	BW	15	1
Exposure Duration:				
On-Site Commercial Worker	yr	ED	25	2
On/Off-Site Resident (adult)	yr	ED	30	2
On/Off-Site Resident (child)	yr	ED	6	2
Construction Worker	yr	ED	1	3
Exposure Frequency:				
On/Off-Site Residents	days/yr	EF	350	1
On-Site Commercial Worker	days/yr	EF	250	1
Construction Worker	days/yr	EF	100	3
Soil Ingestion Rate[1]**:**				
On/Off-Site Resident (adult)	ann. avg. mg/day	IR_S	10.15	5
On/Off-Site Resident (child)	ann. avg. mg/day	IR_S	69.7	5
On-Site Commercial Worker	ann.avg. mg/day	IR_S	58.6	5
Construction Worker	ann. avg. mg/day	IR_S	23.4	5
Daily Indoor Inhalation Rate:				
On/Off-Site Resident (child)	m^3/day	IR	9.1	4,6
On/Off-Site Resident (adult)	m^3/day	IR	19.2	4,6
Commercial and Construction Workers	m^3/day	IR	20	1
Daily Outdoor Inhalation Rate:				
On/Off-Site Resident (child)	m^3/day	IR	.9	4,6
On/Off-Site Resident (adult)	m^3/day	IR	.8	4,6
Commercial and Construction Workers	m^3/day	IR	20	6
Soil Skin Adherence Factor	mg/cm^2	M	0.5	6
Oral Relative Absorption Factor	—	RAF_O	1	6
Dermal Relative Absorption Factor (volatiles)	—	RAF_d	0.5	6
Dermal Relative Absorption Factor (PAHs)	—	RAF_d	0.005	6
Dermal Relative Absorption Factor (metals)	—	RAF_d	0.001	8
Skin Surface Area For Dermal Contact with Soil:				
Adult Receptors	cm^2	SA	1700	4
Child Receptors	cm^2	SA	2100	4
Target Hazard Quotient for Individual Constituents	---	THI	1	2
Target Excess Individual Lifetime Cancer Risk	---	TR	$1x10^{-6}$	2

TABLE F.2
TIER 1 DEFAULT FATE AND TRANSPORT PARAMETERS

Parameter	Symbol	Units	Value	Reference
Thickness of Surficial Soil Zone	d	cm	15.24	7
Enclosed Space Air Exchange Rate: Resident	ER	l/s	0.00014	7
Commercial/Construction Worker	ER	l/s	0.00023	7
Fractional Organic Carbon Content in Soil	f_{oc}	g-C/g-soil	0.005	7
Thickness of Capillary Fringe	h_{cap}	cm	5	7
Thickness of Vadose Zone	h_v	cm	295	7
Infiltration Rate of Water Through Soil	I	cm/yr	13.97	7
Enclosed Space Volume/Infiltration Ratio: Residents	L_B	cm	200	7
Commercial/Construction Workers	L_B	cm	300	7
Enclosed Space Foundation Area/Wall Thickness	L_{crack}	cm	15	7
Depth to Groundwater	L_{GW}	cm	300	7
Thickness of Subsurface Impacted Soil	d_s	cm	100	7
Depth to Subsurface Impacted Soil	L_S	cm	100	7
Particulate Emission Rate: Residents/Commercial Worker	P_e	g/cm^2-s	6.90E-14	7
Construction Worker	P_e	g/cm^2-s	6.90E-09	7
Wind Speed Above Ground Surface in Ambient Mixing Zone	U_{air}	cm/s	225	7
Groundwater Darcy Velocity	U_{gw}	cm/yr	2500	7
Width of Source Area Parallel to Wind or gw Flow	W	cm	1500	7
Ambient Air Mixing Zone Height	δ_{air}	cm	200	7
Groundwater Mixing Zone Thickness	δ_{gw}	cm	200	7
Areal Fraction of Foundation/Wall Cracks	η	cm^2-cm^2	0.01	7
Volumetric Air Content in Capillary Fringe Soils	θ_{acap}	cc/cc	0.038	7
Volumetric Air Content of Foundation Wall Cracks	θ_{acrack}	cc/cc	0.26	7
Volumetric Air Content of Vadose Zone Soils	θ_{as}	cc/cc	0.26	7
Total Soil Porosity	θ_T	cc/cc-soil	0.38	7
Volumetric Water Content in Capillary Fringe Soils	θ_{wcap}	cc/cc	0.342	7
Volumetric Water Content in Foundation/Wall Cracks	θ_{wcrack}	cc/cc	0.12	7
Volumetric Water Content in Vadose Zone Soils	θ_{ws}	cc/cc	0.12	7
Soil Bulk Density	ρ_s	g/cc	1.70E+00	7
Averaging Time for Vapor Flux: On/Off-Site Resident (child)	τ	sec	1.89E+08	7
On/Off-Site Resident (adult)	τ	sec	9.46E+08	7
Commercial Worker	τ	sec	7.88E+08	7
Construction Worker	τ	sec	3.15E+07	7
Distance from the Source to the Exposure Well (variable)	X	ft	X(0-1000)	7
Longitudinal Dispersivity	α_x	ft	X/10	7
Transverse Dispersivity	α_y	ft	$\alpha_x/3$	7
Vertical Dispersivity	α_z	ft	$\alpha_x/20$	7
Source Width Perpendicular to flow in the Horizontal Plume	S_w	ft	49.2	7
Source Thickness Perpendicular to flow in the Vertical Plume	S_d	ft	6.6	7
Soil/Water pH	pH	su	6.5	

SITE PARAMETER CHECKLIST FOR RISK-BASED SCREENING LEVELS

Soil Parameters		**Default Value Used**	**Site-Specific Value Used**
	Soil Type	☐ sandy soil	☐ ______
Θ_r	Soil Porosity	☐ 0.38 (dim)	☐ ______
Θ_{ws}	Water Content - Vadose Zone	☐ 0.12 (dim)	☐ ______
Θ_{as}	Air Content - Vadose Zone ($= \Theta_r - \Theta_{ws}$)	☐ 0.26 (dim)	☐ ______
Θ_{wcap}	Water Content - Capillary Fringe	☐ 0.342 (dim)	☐ ______
Θ_{acap}	Air Content - Capillary Fringe ($= \Theta_r - \Theta_{wcap}$)	☐ 0.038 (dim)	☐ ______
ρ_s	Soil Density	☐ 1.7 g/cm^3	☐ ______
foc	Mass Fraction of Organic Carbon in Soil	☐ 0.005 (dim)	☐ ______
L_s	Depth to Contaminated Soil	☐ 100 cm	☐ ______
L_{gw}	Depth to Groundwater	☐ 300 cm	☐ ______
h_{cap}	Capillary Zone Thickness	☐ 5 cm	☐ ______
hv	Vadose Zone Thickness ($= L_{gw}$ - hc)	☐ 295 cm	☐ ______
pH	Soil/Water pH	☐ 6.5	☐ ______
Groundwater Parameters			
I	Water Infiltration Rate	☐ 13.97 cm/yr	☐ ______
V_{gw}	Groundwater Velocity	☐ 6579 cm/yr	☐ ______
ρ_{gw}	Groundwater Mixing Zone Depth	☐ 200 cm	☐ ______
Surface Parameters			
U_{air}	Ambient Air Velocity in Mixing Zone	☐ 225 cm/s	☐ ______
δ_{air}	Mixing Zone Height	☐ 200 cm	☐ ______
W	Width of Contaminated Area	☐ 1500 cm	☐ ______
d	Thickness of Surficial Soils	☐ 15.24 cm	☐ ______
P_e	Particulate Areal Emission Rate Res/Comm	☐ 6.90E-14 g/cm^2-s	☐ ______
P_e	Particulate Areal Emission Rate Construction Worker	☐ 6.90E- 9 g/cm^2-s	☐ ______
Building Parameters			
L_{crack}	Foundation Crack Thickness	☐ 15 cm	☐ ______
η	Foundation Crack Fraction	☐ 0.01 (dim)	☐ ______
L_B	Building Volume/Foundation Area Ratio (res.)	☐ 200 cm	☐ ______
L_B	Building Volume/Foundation Area Ratio (com./ind.)	☐ 300 cm	☐ ______
ER	Building Vapor Volume Exchange Rate (res.)	☐ 1.4E-4 l/s	☐ ______
ER	Building Vapor Volume Exchange Rate (com./ind.)	☐ 2.3E-4 l/s	☐ ______

Discussion: *Provide rationale for default parameter revision: discuss additional site-specific features of note*

(continue on next page if needed)

SECTION 6.0

SUMMARY OF CONTAMINATION CONCENTRATIONS

SUMMARY OF SOURCE ZONE CHARACTERISTICS

AFFECTED SURFACE SOILS (0 - 15.24 cm)

☐ Present
☐ Not Present
☐ Not Measured

If present, complete the following:

Maximum area extent (m^2): ____________________
Width of affected zone (m): ____________________
Length of affected zone (m): ____________________
Depth interval (cm): ____________________

AFFECTED SUBSURFACE SOILS (15.24 cm - 300 cm)

☐ Present
☐ Not Present
☐ Not Measured

If present, complete the following:

Depth to top of affected soil (cm) (min. 15.24 cm): ____________________

Depth to base of affected soil (cm, BGS): ____________________

Maximum area extent (m^2): ____________________

AFFECTED GROUNDWATER

☐ Present
☐ Not Present
☐ Not Measured

If present, complete the following:

Maximum areal extent (m^2): ____________________
Length of Plume (m): ____________________
Width of Plume (m): ____________________
Depth to top of affected water-bearing unit (cm BGS): ____________________
Depth to base of plume (cm, BGS) ____________________

OTHER SOURCE MEDIUM

☐ Present
☐ Not Present

If present, describe nature of material and dimensions:

____
____
____
____
____

SURFACE SOIL CONCENTRATION DATA SUMMARY (<0 - 15.24 cm)

Name	Analytical Method		Sample Population		Selected Represen Concentration (m
	Method #	Detection Limit (mg/kg)	# of Samples	# of Detects	

SUB-SURFACE SOIL CONCENTRATION DATA SUMMARY (>15.24 cm - 300 cm)

Name	Analytical Method		Sample Population		Selected Represen Concentration (m
	Method #	Detection Limit (mg/kg)	# of Samples	# of Detects	

GROUNDWATER CONCENTRATION DATA SUMMARY

Name	Analytical Method		Sample Population		Selected Represen Concentration (m
	Method #	Detection Limit (mg/kg)	# of Samples	# of Detects	

SECTION 7.0
TIER 1 RESULTS

COMPARISON OF TIER 1 RBSLs WITH MAXIMUM ON-SITE CONCENTRATIONS - CURRENT CONDITIONS

Media	Route of Exposure	C¹NC²	Tier 1 Levels								
			Benzene		Toluene		Ethylbenzene		Xylenes		Naphth
Surficial Soil	Ingestion + Dermal	NC	--	--	--	--	--	--	--	--	--
	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	--
Sub-Surface Soil	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	--
Allowable Soil Concentration (mg/kg)			NA	NA	NA	NA	NA	NA	NA	NA	NA
Maximum On-Site Soil Concentration (mg/kg)			--		--		--				--
Shallow Groundwater	Ingestion + Dermal	NC	--	--	--	--	--	--	--	--	--
	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	--
Deep Groundwater	Ingestion of Water	NC	--	--	--	--	--	--	--	--	--
Allowable Groundwater Concentration (mg/l)			NA	NA	NA	NA	NA	NA	NA	NA	NA
Maximum On-Site Groundwater Concentration (mg/l)			--		--		--		--		--
Surficial Soil	Ingestion + Dermal	NC	--	--	--	--	--	--	--	--	--
	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	--
Sub-Surface Soil	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	--
Allowable Soil Concentration (mg/kg)			NA	NA	NA	NA	NA	NA	NA	NA	NA
Maximum On-Site Soil Concentration (mg/kg)			--		--		--		--		--
Shallow Groundwater	Ingestion of Water	NC	--	--	--	--	--	--	--	--	--
	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	--
Deep Groundwater	Ingestion of Water	NC	--	--	--	--	--	--	--	--	--
Allowable Groundwater Concentration (mg/l)			NA	NA	NA	NA	NA	NA	NA	NA	NA
Maximum On-Site Groundwater Concentration (mg/l)			--		--		--		--		--

NA: Not Applicable
¹: Complete Pathway
²: Incomplete Pathway
E: Maximum On-Site Concentration Exceeds Tier 1 RBSL
NE: Maximum On-Site Concentration Does Not Exceed Tier 1 RBSL

COMPARISON OF TIER 1 RBSLs WITH MAXIMUM ON-SITE CONCENTRATIONS - CURRENT CONDITIONS

Media	Route of Exposure	C^1NC^2	Tier 1 Levels								
			Benzene		Toluene		Ethylbenzene		Xylenes		Naphtl
Surficial Soil	Ingestion + Dermal	NC	--	--	--	--	--	--	--	--	--
	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	--
Sub-Surface Soil	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	--
Allowable Soil Concentration (mg/kg)			NA	NA	NA	NA	NA	NA	NA	NA	NA
Maximum On-Site Soil Concentration (mg/kg)			--		--		--				-
Shallow Groundwater	Ingestion + Dermal	NC	--	--	--	--	--	--	--	--	--
	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	--
Deep Groundwater	Ingestion of Water	NC	--	--	--	--	--	--	--	--	--
Allowable Groundwater Concentration (mg/l)			NA	NA	NA	NA	NA	NA	NA	NA	NA
Maximum On-Site Groundwater Concentration (mg/l)			--		--		--		--		-
Surficial Soil	Ingestion + Dermal	NC	--	--	--	--	--	--	--	--	--
	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	--
Sub-Surface Soil	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	--
Allowable Soil Concentration (mg/kg)			NA	NA	NA	NA	NA	NA	NA	NA	NA
Maximum On-Site Soil Concentration (mg/kg)			--		--		--		--		-
Shallow Groundwater	Ingestion of Water	NC	--	--	--	--	--	--	--	--	--
	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	--
Deep Groundwater	Ingestion of Water	NC	--	--	--	--	--	--	--	--	--
Allowable Groundwater Concentration (mg/l)			NA	NA	NA	NA	NA	NA	NA	NA	NA
Maximum On-Site Groundwater Concentration (mg/l)			--		--		--		--		-

NA: Not Applicable

[1]: Complete Pathway

[2]: Incomplete Pathway

E: Maximum On-Site Concentration Exceeds Tier 1 RBSL

E: Maximum On-Site Concentration Does Not Exceed Tier 1 RBSL

COMPARISON OF TIER 1 RBSLs WITH MAXIMUM ON-SITE CONCENTRATIONS - CURRENT CONDITIONS

Media	Route of Exposure	C^{1}NC^2	Tier 1 Levels								
			Benzene		Toluene		Ethylbenzene		Xylenes		Naphtha
Surficial Soil	Ingestion + Dermal	NC	--	--	--	--	--	--	--	--	--
	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	--
Sub-Surface Soil	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	--
Allowable Soil Concentration (mg/kg)			NA	NA	NA	NA	NA	NA	NA	NA	NA
Maximum On-Site Soil Concentration (mg/kg)			--		--		--				--
Shallow Groundwater	Ingestion + Dermal	NC	--	--	--	--	--	--	--	--	--
	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	--
Deep Groundwater	Ingestion of Water	NC	--	--	--	--	--	--	--	--	--
Allowable Groundwater Concentration (mg/l)			NA	NA	NA	NA	NA	NA	NA	NA	NA
Maximum On-Site Groundwater Concentration (mg/l)			--		--		--		--		--
Surficial Soil	Ingestion + Dermal	NC	--	--	--	--	--	--	--	--	--
	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	--
Sub-Surface Soil	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	--
Allowable Soil Concentration (mg/kg)			NA	NA	NA	NA	NA	NA	NA	NA	NA
Maximum On-Site Soil Concentration (mg/kg)			--		--		--		--		--
Shallow Groundwater	Ingestion of Water	NC	--	--	--	--	--	--	--	--	--
	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	--
Deep Groundwater	Ingestion of Water	NC	--	--	--	--	--	--	--	--	--
Allowable Groundwater Concentration (mg/l)			NA	NA	NA	NA	NA	NA	NA	NA	NA
Maximum On-Site Groundwater Concentration (mg/l)			--		--		--		--		--

NA: Not Applicable
[1]: Complete Pathway
[2]: Incomplete Pathway
E: Maximum On-Site Concentration Exceeds Tier 1 RBSL
NE: Maximum On-Site Concentration Does Not Exceed Tier 1 RBSL

COMPARISON OF TIER 1 RBSLs WITH MAXIMUM ON-SITE CONCENTRATIONS - CURRENT CONDITIONS

Media	Route of Exposure	C[1]NC[2]	Tier 1 Levels								
			Benzene		Toluene		Ethylbenzene		Xylenes		Naphtha
Surficial Soil	Ingestion + Dermal	NC	--	--	--	--	--	--	--	--	--
	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	--
Sub-Surface Soil	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	--
Allowable Soil Concentration (mg/kg)			NA	NA	NA	NA	NA	NA	NA	NA	NA
Maximum On-Site Soil Concentration (mg/kg)			--		--		--				--
Shallow Groundwater	Ingestion + Dermal	NC	--	--	--	--	--	--	--	--	--
	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	--
Deep Groundwater	Ingestion of Water	NC	--	--	--	--	--	--	--	--	--
Allowable Groundwater Concentration (mg/l)			NA	NA	NA	NA	NA	NA	NA	NA	NA
Maximum On-Site Groundwater Concentration (mg/l)			--		--		--		--		--
Surficial Soil	Ingestion + Dermal	NC	--	--	--	--	--	--	--	--	--
	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	--
Sub-Surface Soil	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	--
Allowable Soil Concentration (mg/kg)			NA	NA	NA	NA	NA	NA	NA	NA	NA
Maximum On-Site Soil Concentration (mg/kg)			--		--		--		--		--
Shallow Groundwater	Ingestion of Water	NC	--	--	--	--	--	--	--	--	--
	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	--
Deep Groundwater	Ingestion of Water	NC	--	--	--	--	--	--	--	--	--
Allowable Groundwater Concentration (mg/l)			NA	NA	NA	NA	NA	NA	NA	NA	NA
Maximum On-Site Groundwater Concentration (mg/l)			--		--		--		--		--

NA: Not Applicable
[1]: Complete Pathway
[2]: Incomplete Pathway
E: Maximum On-Site Concentration Exceeds Tier 1 RBSL
NE: Maximum On-Site Concentration Does Not Exceed Tier .SL

COMPARISON OF TIER 1 RBSLs WITH MAXIMUM ON-SITE CONCENTRATIONS - CURRENT CONDITIONS

Media	Route of Exposure	C[1] NC[2]	Tier 1 Levels								
			Benzene		Toluene		Ethylbenzene		Xylenes		Na
Surficial Soil	Ingestion + Dermal	NC	--	--	--	--	--	--	--	--	-
	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	-
Sub-Surface Soil	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	-
Allowable Soil Concentration (mg/kg)			NA	NA	NA	NA	NA	NA	NA	NA	N
Maximum On-Site Soil Concentration (mg/kg)			--		--		--				
Shallow Groundwater	Ingestion + Dermal	NC	--	--	--	--	--	--	--	--	-
	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	-
Deep Groundwater	Ingestion of Water	NC	--	--	--	--	--	--	--	--	-
Allowable Groundwater Concentration (mg/l)			NA	NA	NA	NA	NA	NA	NA	NA	N
Maximum On-Site Groundwater Concentration (mg/l)			--		--		--		--		
Surficial Soil	Ingestion + Dermal + Inhalation of Vapor & Particulates	NC	--	--	--	--	--	--	--	--	-
Maximum On-Site Soil Concentration (mg/kg)			NA	NA	NA	NA	NA	NA	NA	NA	N
Groundwater	Dermal Contact	NC	--	--	--	--	--	--	--	--	-
Maximum On-Site Groundwater Concentration (mg/l)			--		--		--		--		
l Concentration of All Routes of Exposure (mg/kg)			0.000		0.000		0.000		0.000		
oundwater Concentration of All Routes of Exposure (mg/l)			0.000		0.000		0.000		0.000		

oint of Exposure for Groundwater [Refer Tables 5-6(a) through 5-8(c) of the Guidance Document]: ___*Distance*___ **ft** **County:** ___

NA: Not Applicable

[1]: Complete Pathway

[2]: Incomplete Pathway

E: Maximum On-Site Concentration Exceeds Tier 1 RBSL

NE: Maximum On-Site Concentration Does Not Exceed Tier 1 RBSL

COMPARISON OF TIER 1 RBSLs WITH MAXIMUM ON-SITE CONCENTRATIONS - CURRENT CONDITIONS

Media	Route of Exposure	C[1] NC[2]	Tier 1 Levels								
			Benzene		Toluene		Ethylbenzene		Xylenes		Na
Surficial Soil	Ingestion + Dermal	NC	--	--	--	--	--	--	--	--	-
	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	-
Sub-Surface Soil	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	-
Allowable Soil Concentration (mg/kg)			NA	NA	NA	NA	NA	NA	NA	NA	N
Maximum On-Site Soil Concentration (mg/kg)			--		--		--				
Shallow Groundwater	Ingestion + Dermal	NC	--	--	--	--	--	--	--	--	-
	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	-
Deep Groundwater	Ingestion of Water	NC	--	--	--	--	--	--	--	--	-
Allowable Groundwater Concentration (mg/l)			NA	NA	NA	NA	NA	NA	NA	NA	N
Maximum On-Site Groundwater Concentration (mg/l)			--		--		--		--		
Surficial Soil	Ingestion + Dermal + Inhalation of Vapor & Particulates	NC	--	--	--	--	--	--	--	--	-
Maximum On-Site Soil Concentration (mg/kg)			NA	NA	NA	NA	NA	NA	NA	NA	N
Groundwater	Dermal Contact	NC	--	--	--	--	--	--	--	--	-
Maximum On-Site Groundwater Concentration (mg/l)			--		--		--		--		
il Concentration of All Routes of Exposure (mg/kg)			0.000		0.000		0.000		0.000		
oundwater Concentration of All Routes of Exposure (mg/l)			0.000		0.000		0.000		0.000		

Exposure for Groundwater [Refer Tables 5-6(a) through 5-8(c) of the Guidance Document]: *Distance* **ft** **County:** *Co*

NA: Not Applicable

[1]: Complete Pathway

[2]: Incomplete Pathway

E: Maximum On-Site Concentration Exceeds Tier 1 RBSL

NE: Maximum On-Site Concentration Does Not Exceed Tier 1 L

COMPARISON OF TIER 1 RBSLs WITH MAXIMUM ON-SITE CONCENTRATIONS - FUTURE CONDITIONS

Media	Route of Exposure	C^1 NC^2	Tier 1 Levels								
			Benzene		Toluene		Ethylbenzene		Xylenes		N
Surficial Soil	Ingestion + Dermal	NC	--	--	--	--	--	--	--	--	
	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	
Sub-Surface Soil	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	
Allowable Soil Concentration (mg/kg)			NA	NA	NA	NA	NA	NA	NA	NA	N
Maximum On-Site Soil Concentration (mg/kg)			--		--		--				
Shallow Groundwater	Ingestion + Dermal	NC	--	--	--	--	--	--	--	--	
	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	
Deep Groundwater	Ingestion of Water	NC	--	--	--	--	--	--	--	--	
Allowable Groundwater Concentration (mg/l)			NA	NA	NA	NA	NA	NA	NA	NA	N
Maximum On-Site Groundwater Concentration (mg/l)			--		--		--		--		
Surficial Soil	Ingestion + Dermal + Inhalation of Vapor & Particulates	NC	--	--	--	--	--	--	--	--	
Maximum On-Site Soil Concentration (mg/kg)			NA	NA	NA	NA	NA	NA	NA	NA	N
Groundwater	Dermal Contact	NC	--	--	--	--	--	--	--	--	
Maximum On-Site Groundwater Concentration (mg/l)			--		--		--		--		
il Concentration of All Routes of Exposure (mg/kg)			0.000		0.000		0.000		0.000		
roundwater Concentration of All Routes of Exposure (mg/l)			0.000		0.000		0.000		0.000		

Exposure for Groundwater [Refer Tables 5-6(a) through 5-8(c) of the Guidance Document]: _*Distance*_ ft **County: _*Co*_**

NA: Not Applicable

[1]: Complete Pathway

[2]: Incomplete Pathway

E: Maximum On-Site Concentration Exceeds Tier 1 RBSL

NE: Maximum On-Site Concentration Does Not Exceed Tier 1 RBSL

COMPARISON OF TIER 1 RBSLs WITH MAXIMUM ON-SITE CONCENTRATIONS - FUTURE CONDITIONS

Media	Route of Exposure	C[1] NC[2]	Tier 1 Levels								
			Benzene		Toluene		Ethylbenzene		Xylenes		Na
Surficial Soil	Ingestion + Dermal	NC	--	--	--	--	--	--	--	--	-
	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	-
Sub-Surface Soil	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	-
Allowable Soil Concentration (mg/kg)			NA	NA	NA	NA	NA	NA	NA	NA	N
Maximum On-Site Soil Concentration (mg/kg)			--		--		--				
Shallow Groundwater	Ingestion + Dermal	NC	--	--	--	--	--	--	--	--	-
	Indoor Inhalation	NC	--	--	--	--	--	--	--	--	-
Deep Groundwater	Ingestion of Water	NC	--	--	--	--	--	--	--	--	-
Allowable Groundwater Concentration (mg/l)			NA	NA	NA	NA	NA	NA	NA	NA	N
Maximum On-Site Groundwater Concentration (mg/l)			--		--		--		--		
Surficial Soil	Ingestion + Dermal + Inhalation of Vapor & Particulates	NC	--	--	--	--	--	--	--	--	-
Maximum On-Site Soil Concentration (mg/kg)			NA	NA	NA	NA	NA	NA	NA	NA	N
Groundwater	Dermal Contact	NC	--	--	--	--	--	--	--	--	-
Maximum On-Site Groundwater Concentration (mg/l)			--		--		--		--		
l Concentration of All Routes of Exposure (mg/kg)			0.000		0.000		0.000		0.000		
oundwater Concentration of All Routes of Exposure (mg/l)			0.000		0.000		0.000		0.000		

Exposure for Groundwater [Refer Tables 5-6(a) through 5-8(c) of the Guidance Document]: *Distance* ft **County: *Co***

A: Not Applicable

[1]: Complete Pathway

[2]: Incomplete Pathway

Maximum On-Site Concentration Exceeds Tier 1 RBSL

Maximum On-Site Concentration Does Not Exceed Tier 1 RBSL

ORBCA SUMMARY REPORT
CONCLUSIONS AND RECOMMENDATIONS OF TIER 1

SECTION 8.0

TIER 2/3 RESULTS

JUSTIFICATION FOR TIER 2/TIER 3 EXPOSURE FACTORS

Tier 2/Tier 3 Factor: ____________________

Justification:

Tier 2/Tier 3 Factor: ____________________

Justification:

Tier 2/Tier 3 Factor: ____________________

Justification:

Tier 2/Tier 3 Factor: ____________________

Justification:

Tier 2/Tier 3 Factor: ____________________

Justification:

TIER 2/TIER 3 FATE AND TRANSPORT PARAMETERS

PARAMETER	UNITS	TIER 1	TIER 2/TIER 3	SOURCE
Other parameter(s) specifically for Tier 2/Tier 3				

REFERENCES AND PROTOCOLS

APPENDIX O
CHEMICALS OF CONCERN LISTING

TABLE O.1
CHEMICALS OF CONCERN FOR EVALUATION AT RBCA SITES[a]

CHEMICAL	PETROLEUM PRODUCT					
	Gasoline	Diesel	Jet Fuel	Kerosene	Fuel Oil	Used Oil*
ORGANICS						
Benzene	X	X	X	X	X	X
Cumene	X	X	X	X	X	X
1,2-dibromoethane	X					X
Ethylbenzene	X	X	X	X	X	X
Methyl-t-butyl (MTBE)	X					X
Toluene	X	X	X	X	X	X
1,2,4-trimethylbenzene	X	X	X	X	X	X
1,3,5-trimethylbenzene	X	X	X	X	X	X
M-xylene	X	X	X	X	X	X
O-xylene	X	X	X	X	X	X
P-xylene	X	X	X	X	X	X
Xylenes (mixed)	X	X	X	X	X	X
PAHs[c]						
Acenaphthene						X
Acenaphthylene						X
Anthracene						X
Benz(a)anthracene						X
Benzo(a)pyrene						X
Benzo(b)fluoranthene						X
Benzo(g,h,i)perylene						X
Benzo(k)fluoranthene						X
Chrysene						X
Dibenz(a,h)anthracene						X
Fluorene	X			X	X	X
Indeno(1,2,3-cd)pyrene						X
Naphthalene	X	X	X	X	X	X
Phenanthrene		X		X	X	X
Pyrene		X		X	X	X
METALS						
Chromium (III)						X
Chromium (VI)						X
Copper						X
Lead	X					X
Manganese						X
Nickel						X
Tin						X

X = Chemical selected for evaluation.

[a] Based on available information on petroleum product composition, analytical capability and toxicological properties.

[b] A variety of other contaminants (e.g. chlorinated organic solvents, polychlorinated biphenyls (PCBs)) may be found in "Used Oil" depending on practices at service stations and the source of the oil.

[c] Polynuclear aromatic hydrocarbons.

[d] Leaded gasoline.

TABLE O.2
PHYSICAL AND CHEMICAL PROPERTIES OF CHEMICALS OF CONCERN

ICAL	Mol. Wt. [g/mole]	Koc [ml/g]	Henry's Constant [Dimensionless]	Diffusion coefficient in air [cm^2/s]	Diffusion coefficient in water [cm^2/s]	Pure Product Solubility [mg/L]	Saturated Soil Concentration [mg/kg]	LE [pp
	78	**3.80E+01**	**2.20E-01**	**0.093**	**1.10E-05**	**1.75E+03**	5.15E+02	130
	120	*1.00E+00*	6.20E-01	0.072	*7.10E-06*	5.00E+01	8.52E+00	-
ne	*190*	*2.80E+01*	*1.33E-02*	*0.073*	*6.35E-06*	*3.40E+03*	7.23E+02	-
	106	**9.55E+01**	**3.20E-01**	**0.076**	**8.50E-06**	**1.52E+02**	9.07E+01	100
-Ether (MTBE)	88.15	*1.15E+01*	4.16E-02	0.086	*8.71E-06*	**4.80E+04**	6.45E+03	-
	92	**1.35E+02**	**2.60E-01**	**0.085**	**9.40E-06**	**5.35E+02**	4.20E+02	12
nzene	120.2	*2.59E+03*	2.33E-01	0.0724	*8.40E-06*	5.70E+01	7.45E+02	-
nzene	120.2	*6.61E+02*	[illegible]	0.0724	*8.40E-06*	9.70E+01	3.30E+02	-
	106.2	*1.29E+02*	*2.19E-01*	*0.087*	*1.00E-05*	1.75E+02	1.31E+02	-
	106.16	*1.66E+02*	*2.16E-01*	*0.07*	*7.80E-06*	1.30E+02	1.21E+02	-
	106.17	*2.40E+02*	*2.98E-01*	*0.072*	*8.50E-06*	1.98E+02	2.61E+02	-
	106	**2.40E+02**	**2.90E-01**	**0.072**	**8.50E-06**	**1.98E+02**	2.60E+02	11
	154	4.60E+03	3.80E-03	0.064	*7.69E-06*	3.42E+00	7.89E+01	
	152	2.50E+03	6.10E-02	0.064	*7.53E-06*	3.93E+00	4.94E+01	
	178	**1.41E+04**	4.23E-02	0.059	*7.74E-06*	**4.50E-02**	3.18E+00	60
ene	228	**1.38E+06**	4.81E-05	0.053	*9.00E-06*	**6.70E-03**	4.62E+01	
	252	**3.89E+05**	**5.80E-08**	**0.050**	**5.80E-06**	**1.20E-03**	2.33E+00	
hene	252	**5.50E+05**	5.00E-04	0.050	*5.56E-06*	**1.40E-02**	3.85E+01	
lene	276	**1.58E+06**	2.21E-06	0.048	*5.65E-06*	**7.00E-04**	5.55E+00	
hene	252	**5.50E+05**	1.60E-03	0.050	*5.56E-06*	**4.30E-01**	1.18E+03	
	228	**2.00E+05**	4.36E-05	0.053	*6.21E-06*	**1.80E-03**	1.80E+00	
racene	278	3.30E+06	3.04E-06	0.048	*5.24E-06*	5.00E-04	8.25E+00	
	116	**7.24E+03**	2.70E-03	0.074	*7.88E-06*	**1.69E+00**	6.13E+01	
pyrene	276	1.60E+06	2.85E-06	0.048	*4.41E-06*	5.30E-04	4.24E+00	
	128	**1.28E+02**	**4.90E-02**	**0.072**	**9.40E-06**	**3.10E+01**	2.23E+01	9
	178	**1.41E+04**	6.60E-03	0.059	*7.47E-06*	**1.00E+00**	7.07E+01	
	202	**3.80E+04**	2.00E-04	0.056	*7.24E-06*	**1.32E-01**	2.51E+01	
	52	$K_d = 20$	na	*na*	*na*	na	na	
	52	$K_d = 20$	na	*na*	*na*	na	na	
	63.54	$K_d = 316$	na	*na*	*na*	na	na	
	207.2	$K_d = 126$	na	*na*	*na*	na	na	
	54.94	$K_d = 20$	na	*na*	*na*	na	na	
	58.69	$K_d = 79$	na	*na*	*na*	na	na	
	47.88	$K_d = 20$	na	*na*	*na*	na	na	

NOTE: Bold faced, shaded italicized values refer to parameter derviation. See Appendix O.4 for complete reference

TABLE O.3
TOXICITY PARAMETERS OF CHEMICALS OF CONCERN

CHEMICAL	Slope Factor [kg-d/mg]				Reference Dose [mg/kg-d]			
	Oral	REF	Inhalation	REF	Oral	REF	Inhalation	REF
Benzene	0.029	1	0.029	1	0.0007	2	0.0017	3
Cumene	na	--	na	--	0.04	1	0.0026	4
1,2-Dibromoethane	85	1	0.77	1	0.00025	5	0.000057	4
Ethylbenzene	na	--	na	--	0.1	1	0.29	1
Methyl-tert butyl ether (MTBE)	na*	--	na*	--	0.03	5	0.86	1
Toluene	na	--	na	--	0.2	1	0.11	1
1,2,4-trimethylbenzene	na	--	na	--	0.0005	3	0.0005	3
1,3,5-trimethylbenzene	na	--	na	--	0.0004	3	0.0004	3
o-xylene	na	--	na	--	2	4	0.2	3
m-xylene	na	--	na	--	2	4	0.2	3
p-xylene	na	--	na	--	na	--	0.086	3
Xylenes (mixed)	na	--	na	--	2	1	0.086	6
Acenaphthene	na	--	na	--	0.06	1	0.06	1[a]
Acenaphthylene	na	--	na	--	0.03	**	0.03	**
Anthracene	na	--	na	--	0.3	1	0.3	1[a]
Benzo(a)anthracene	1.47	***	na	--	0.03	**	0.03	**
Benzo(a)pyrene	14.7	7	2.1****	8	0.03	**	0.03	**
Benzo(b)fluoranthene	1.47	***	na	--	0.03	**	0.03	**
Benzo(g,h,i)perylene	na	--	na	--	0.03	**	0.03	**
Benzo(k)fluoranthene	0.147	***	na	--	0.03	**	0.03	**
Chrysene	0.0147	***	na	--	0.03	**	0.03	**
Dibenzo(a,h)anthracene	14.7	***	na	--	0.03	**	0.03	**
Fluorene	na	--	na	--	0.04	1	0.04	1[a]
Indeno(1,2,3-cd)pyrene	1.47	***	na	--	0.03	**	0.03	**
Naphthalene	na	--	na	--	0.04	9	0.003	10
Phenanthrene	na	--	na	--	0.03	**	0.03	**
Pyrene	na	--	na	--	0.03	1	0.03	1[a]
Chromium (III)	na	--	na	--	1	1	2.90E-05	11
Chromium (VI)	na	--	175	11	0.005	1	2.90E-05	11
Copper	na	--	na	--	0.038	4	0.038	4[a]
Manganese	na	--	na	--	0.005	1	8.60E-05	12
Nickel	na	--	0.84	1	0.02	1	5.70E-06	13
Tin	na	--	na	--	0.6	4	0.6	4[a]

Notes:

na = Not Applicable

Oral slope factor and oral reference doses were used in dermal exposure calculations.

* Under review

** Based on pyrene surrogate RfD

*** Based on US EPA relative potency factors for PAHs (14). Guidance specifies use only for evaluating oral carcinogenic risks.

**** The US EPA inhalation slope factor for benzo(a)pyrene is 6.1$(mg/kg\text{-}day)^{-1}$ and is currently under review. The NYS DOH is reviewing both inhalation cancer slope factors for their applicability to RBCA process.

References to Table O.3

1. United States Environmental Protection Agency. 1996. Integrated Risk Information System (IRIS). July.

2. United State Environmental Protection Agency. 1986. Volatile Organic Chemicals. Washington, DC: Criteria and Standards Division and Technical Support Division, Office of Drinking Water (as cited in Agency for Toxic Substances and Disease Registry Toxicological Profile for Benzene. Draft. December 1987).

3. United States Environmental Protection Agency. 1996. Risk-Based Concentration Table. Region III Technical Support Section. Provisional value from EPA Office of Environmental Criteria and Assessment.

4. United States Environmental Protection Agency. 1995. Health Effects Assessment Summary Tables (HEAST). Washington, DC: Office of Solid Waste and Emergency Response. EPA 540/R-94-020.

5. New York State Department of Health. 1994. New York State Human Health Fact Sheet for Ethylene Dibromide (EDB). Ambient Water Quality Value for Protection of Human Health and Source of Potable Water. Albany, NY: Bureau of Toxic Substance Assessment.

6. United States Environmental Protection Agency. 1992. Drinking Water Health Advisory for Methyl-t-Butyl Ether. Draft. Washington, DC: Office of Science and Technology, Office of Water.

7. United States Environmental Protection Agency. 1991. Health Effects Assessment Summary Tables (HEAST). Washington, DC: Office of Solid Waste and Emergency Response. NTIS PB91-921100.

8. New York State Department of Health. 1984. Recommended Ambient Surface Water Quality Criteria Fact Sheet for Benzo(a)pyrene. Albany, NY: Bureau of Toxic Substance Assessment.

9. New York State Department of Health. 1989. Ambient Air Quality Criteria Document for Polynuclear Aromatic Hydrocarbons. Albany, NY: Bureau of Toxic Substance Assessment.

10. United States Environmental Protection Agency. 1992. Health Effects Assessment Summary Tables (HEAST). Washington, DC: Office of Solid Waste and Emergency Response. OHEA ECAO-CIN-821.

11. Agency for Toxic Substances and Disease Registry. 1994. Toxicological Profile for Naphthalene. Draft Update. Public Health Service. US Department of Health and Human Services.

12. New York State Department of Health. 1990. Ambient Air Criteria Document for Chromium. Albany, NY: Bureau of Toxic Substance Assessment.

13. New York State Department of Health. 1989. Ambient Air Criteria Document for Manganese. Albany, NY: Bureau of Toxic Substance Assessment.

14. New York State Department of Health. 1989. Ambient Air Criteria Document for Nickel. Albany, NY: Bureau of Toxic Substance Assessment.

15. United States Environmental Protection Agency. 1992. Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons. Washington, DC: Office of Research and Development. EPA/600/R-93-089.

APPENDIX P
DEFAULT EXPOUSRE FACTORS

TABLE P.1 TIER 1 DEFAULT EXPOSURE FACTORS
TABLE P.2 TIER 1 DEFAULT FATE AND TRANSPORT PARAMETERS
TABLE P.3 REFERENCES

TABLE P.1
TIER 1 DEFAULT EXPOSURE FACTORS

Exposure Parameter	Units	Symbol	NYS Default Value	Reference
Averaging Time - Carcinogen	yr	AT	70	1
Averaging Time - Non-carcinogen (equals exposure duration):				
On-Site Commercial Worker	yr	AT	25	2
On/Off-Site Resident (adult)	yr	AT	30	2
On/Off-Site Resident (child)	yr	AT	6	2
Construction Worker	yr	AT	1	3
Body Weight:				
Adult Receptors	kg	BW	70	1
Child Receptors	kg	BW	15	1
Exposure Duration:				
On-Site Commercial Worker	yr	ED	25	2
On/Off-Site Resident (adult)	yr	ED	30	2
On/Off-Site Resident (child)	yr	ED	6	2
Construction Worker	yr	ED	1	3
Exposure Frequency:				
On/Off-Site Residents	days/yr	EF	350	1
On-Site Commercial Worker	days/yr	EF	250	1
Construction Worker	days/yr	EF	100	3
Soil Ingestion Rate[1]:				
On/Off-Site Resident (adult)	ann. avg. mg/day	IR_S	10.15	5
On/Off-Site Resident (child)	ann. avg. mg/day	IR_S	69.7	5
On-Site Commercial Worker	ann.avg.mg/day	IR_S	58.6	5
Construction Worker	ann. avg. mg/day	IR_S	23.4	5
Daily Indoor Inhalation Rate:				
On/Off-Site Resident (child)	m^3/day	IR	9.1	4,6
On/Off-Site Resident (adult)	m^3/day	IR	19.2	4,6
Commercial and Construction Workers	m^3/day	IR	20	1
Daily Outdoor Inhalation Rate:				
On/Off-Site Resident (child)	m^3/day	IR	.9	4,6
On/Off-Site Resident (adult)	m^3/day	IR	.8	4,6
Commercial and Construction Workers	m^3/day	IR	20	6
Soil Skin Adherence Factor	mg/cm^2	M	0.5	6
Oral Relative Absorption Factor	---	RAF_O	1	6
Dermal Relative Absorption Factor (volatiles)	---	RAF_d	0.5	6
Dermal Relative Absorption Factor (PAHs)	---	RAF_d	0.005	6
Dermal Relative Absorption Factor (metals)	---	RAF_d	0.001	8
Skin Surface Area For Dermal Contact with Soil:				
Adult Receptors	cm^2	SA	1700	4
Child Receptors	cm^2	SA	2100	4
Target Hazard Quotient for Individual Constituents	---	THI	1	2
Target Excess Individual Lifetime Cancer Risk	---	TR	1×10^{-6}	2

TABLE P.2
TIER 1 DEFAULT FATE AND TRANSPORT PARAMETERS

Parameter	Symbol	Units	Value	Reference
Thickness of Surficial Soil Zone	d	cm	15.24	7
Enclosed Space Air Exchange Rate: Resident	ER	l/s	0.00014	7
Commercial/Construction Worker	ER	l/s	0.00023	7
Fractional Organic Carbon Content in Soil	f_{oc}	g-C/g-soil	0.005	7
Thickness of Capillary Fringe	h_{cap}	cm	5	7
Thickness of Vadose Zone	h_v	cm	295	7
Infiltration Rate of Water Through Soil	I	cm/yr	13.97	7
Enclosed Space Volume/Infiltration Ratio: Residents	L_B	cm	200	7
Commercial/Construction Workers	L_B	cm	300	7
Enclosed Space Foundation Area/Wall Thickness	L_{crack}	cm	15	7
Depth to Groundwater	L_{GW}	cm	300	7
Thickness of Subsurface Impacted Soil	d_s	cm	100	7
Depth to Subsurface Impacted Soil	L_S	cm	100	7
Particulate Emission Rate: Residents/Commercial Worker	P_e	g/cm²-s	6.90E-14	7
Construction Worker	P_e	g/cm²-s	6.90E-09	7
Wind Speed Above Ground Surface in Ambient Mixing Zone	U_{air}	cm/s	225	7
Groundwater Darcy Velocity	U_{gw}	cm/yr	2500	7
Width of Source Area Parallel to Wind or gw Flow	W	cm	1500	7
Ambient Air Mixing Zone Height	δ_{air}	cm	200	7
Groundwater Mixing Zone Thickness	δ_{gw}	cm	200	7
Areal Fraction of Foundation/Wall Cracks	η	cm²-cm²	0.01	7
Volumetric Air Content in Capillary Fringe Soils	θ_{acap}	cc/cc	0.038	7
Volumetric Air Content of Foundation Wall Cracks	θ_{acrack}	cc/cc	0.26	7
Volumetric Air Content of Vadose Zone Soils	θ_{as}	cc/cc	0.26	7
Total Soil Porosity	θ_T	cc/cc-soil	0.38	7
Volumetric Water Content in Capillary Fringe Soils	θ_{wcap}	cc/cc	0.342	7
Volumetric Water Content in Foundation/Wall Cracks	θ_{wcrack}	cc/cc	0.12	7
Volumetric Water Content in Vadose Zone Soils	θ_{ws}	cc/cc	0.12	7
Soil Bulk Density	ρ_s	g/cc	1.70E+00	7
Averaging Time for Vapor Flux: On/Off-Site Resident (child)	τ	sec	1.89E+08	7
On/Off-Site Resident (adult)	τ	sec	9.46E+08	7
Commercial Worker	τ	sec	7.88E+08	7
Construction Worker	τ	sec	3.15E+07	7
Distance from the Source to the Exposure Well (variable)	X	ft	X(0-1000)	7
Longitudinal Dispersivity	α_x	ft	X/10	7
Transverse Dispersivity	α_y	ft	$\alpha_x/3$	7
Vertical Dispersivity	α_z	ft	$\alpha_x/20$	7
Source Width Perpendicular to flow in the Horizontal Plume	S_w	ft	49.2	7
Source Thickness Perpendicular to flow in the Vertical Plume	S_d	ft	6.6	7
Soil/Water pH	pH	su	6.5	

References:

1. *Risk Assessment Guidance for Superfund, Vol. 1, Human Health Evaluation Manual, Part A*, EPA/540/1-89/002, Environmental Protection Agency.

2. It is the practice of the NYSDOH Bureau of Toxic Substance Assessment that a value of 30 years is appropriate for circumstances involving localized exposure potentials, when it is unlikely that an exposed individual could move into another house and have the same type of exposure potential. A value of 70 years is appropriate for statewide standard-setting and when it is likely that an individual could move from one house to another and still be exposed to petroleum site contamination. This document will use 30 years as a non-carcinogenic exposure duration.

3. Where no single value could be identified, the Division of Environmental Remediation has selected a value based upon literature searches, best judgement, and experience.

4. J.K. Hawley, "Assessment of Health Risk from Exposure to Contaminated Soil", Risk Analysis, Vol. 5, No. 4, 1985.

5. See M.7 (Time Weighting Factors Recommended by NYSDOH).

6. Exposure Factors Handbook, EPA 600/8-89/043, Environmental Protection Agency, Washington, DC, July 1989.

7. Standard Guide for Risk Based Corrective Action at Petroleum Release Sites, ASTM Designation E1739-95.

8. EPA Dermal Exposure Assessment: Principles and Applications [EPA/600/8-91/011B, January 1992].

APPENDIX Q
TIER 1 DEFAULT RISK-BASED SCREENING LEVELS (RBSL)

Q.1 TIER 1 RBSL for ADULT
Q.2 TIER 1 RBSL for CHILD
Q.3 TIER 1 RBSL for COMMERCIAL WORKER
Q.4 TIER 1 RBSL for CONSTRUCTION WORKER
Q.5 SOIL CONCENTRATIONS PROTECTIVE OF DRINKING WATER

TABLE Q.1

RESIDENT - ADULT
TIER 1 RISK-BASED SCREENING LEVELS

Chemical	Water Concentration		Soil Concentration			Air Concentration	
	Inhalation Indoor-Water [mg/l]	Inhalation Outdoor-Water [mg/l]	Inhalation Indoor-Soil [mg/kg]	Inhalation Outdoor-Soil [mg/kg]	Surficial Soil [mg/kg]	Inhalation Indoor Air [µg/m³]	Inh Outd [µ
	1.86E-02	2.71E+02	4.77E-02	4.06E+00	1.35E+01	3.06E-01	7.3
	3.36E-01	5.58E+03 •	1.54E+00	3.48E+01 †	6.54E+03 †	9.89E+00	2.3
ne	8.83E-03	6.28E+01	1.80E-03	2.33E+00	3.81E-02	1.15E-02	2.7
	6.14E+01	9.51E+05 •	1.72E+02 †	2.50E+04 †	1.68E+04 †	1.10E+03	2.6
l-ether (MTBE)	8.01E+02	7.95E+06 •	5.10E+02	1.13E+05 †	5.03E+03	3.27E+03	7.8
	2.47E+01	3.73E+05 •	6.52E+01	1.37E+04 †	3.34E+04 †	4.18E+02	1.0
nzene	1.42E-01	2.10E+03 •	8.45E-01	1.36E+03 †	8.37E+01	1.90E+00	4 5
nzene	1.50E-01	2.08E+03 •	2.50E-01	4.02E+02 †	6.70E+01	1.52E+00	3.6
	4.99E+01	7.30E+05 •	1.18E+02	2.75E+04 †	3.30E+05 †	7.60E+02	1 8
	6.31E+01	9.26E+05 •	1.18E+02	4.33E+04 †	3.30E+05 †	7.60E+02	1 8
	2.02E+01	3.08E+05 •	5.10E+01	1.85E+04 †	8.60E+06 †	3.27E+02	7 8
	2.06E+01	3.13E+05 •	5.10E+01	1.90E+04 †	3.23E+05 †	3.27E+02	7 8
	6.24E+02 •	3.08E+06 •	1.24E+04 †	1.99E+07 †	8.21E+04 †	2.28E+02	5.4
	2.69E+01 •	2.88E+05 •	2.11E+02 †	3.39E+05 †	4.10E+04 †	1.14E+02	2.7
	3.82E+02 •	3.49E+06 •	1.85E+04 †	2.98E+07 †	4.10E+05 †	1.14E+03	2 7
ene	2.27E+04 •	9.62E+07 •	1.40E+08 †	2.25E+11 †	2.20E+00	1.14E+02	2.7
	6.19E+00 •	2.59E+04 •	1.08E+04 †	1.71E+07 †	2.20E-01	4.22E-03	1 0
hene	2.90E+03 •	1.26E+07 •	7.08E+06 †	1.14E+10 †	2.20E+00	1.14E+02	2.7
lene	1.37E+05 •	5.79E+08 •	9.68E+08 †	1.55E+12 †	4.16E+04 †	1.14E+02	2.7
hene	9.28E+02 •	4.24E+06 •	2.24E+06 †	3.60E+09 †	2.20E+01	1.14E+02	2.7
	2.64E+04 •	1.12E+08 •	2.35E+07 †	3.77E+10 †	2.20E+02 †	1.14E+02	2.7

TABLE Q.1

RESIDENT - ADULT
TIER 1 RISK-BASED SCREENING LEVELS

Chemical	Water Concentration		Soil Concentration			Air Concentration	
	Inhalation Indoor-Water [mg/l]	Inhalation Outdoor-Water [mg/l]	Inhalation Indoor-Soil [mg/kg]	Inhalation Outdoor-Soil [mg/kg]	Surficial Soil [mg/kg]	Inhalation Indoor Air [µg/m³]	Inhal Outdo [µg
racene	1.35E+05 •	5.70E+08 •	1.98E+09 †	3.19E+12 †	2.20E-01	1.14E+02	2.74
	5.04E+02 •	2.42E+06 •	1.59E+04 †	2.55E+07 †	5.47E+04 †	1.52E+02	3.65
yrene	1.55E+05 •	6.57E+08 •	1.11E+09 †	1.78E+12 †	2.20E+00	1.14E+02	2.74
	2.78E+00	2.68E+04 •	1.78E+00	2.15E+03 †	4.68E+04 †	1.14E+01	2.74
	1.99E+02 •	1.07E+06 •	1.19E+04 †	1.91E+07 †	4.10E+04 †	1.14E+02	2.74
	6.26E+03 •	2.67E+07 •	1.06E+06 †	1.70E+09 †	4.15E+04 †	1.14E+02	2.74
	na	na	na	na	2.90E+03	na	
	na	na	na	na	1.33E+00	na	
	na	na	na	na	2.36E+05	na	
	na	na	na	na	4.00E+02 †**	1.5 **	1.
	na	na	na	na	6.83E+03	na	
	na	na	na	na	2.78E+02	na	
	na	na	na	na	3.73E+06 †	na	

= These values exceed the pure component water solubilities.

= These values exceed the residual (saturated) soil concentrations.

= USEPA Section 403 Interim Lead Guidance, "Agency Guidance on Residual Lead-Based Paint, Lead-Contaminated Dust, and Lead-Contaminated Soil", July 14, 1994.

TABLE Q.2

RESIDENT - CHILD
TIER 1 RISK-BASED SCREENING LEVELS

Chemical	Water Concentration		Soil Concentration			Air Concentration	
	Inhalation Indoor-Water [mg/l]	Inhalation Outdoor-Water [mg/l]	Inhalation Indoor-Soil [mg/kg]	Inhalation Outdoor-Soil [mg/kg]	Surficial Soil [mg/kg]	Inhalation Indoor Air [$\mu g/m^3$]	Inh Outd [µ
	4.20E-02	2.58E+02	2.16E-02	3.87E+00	1.05E+01	6.92E-01	6.9
	1.52E-01	1.06E+03 •	1.39E-01	6.63E+00	9.51E+02 †	4.47E+00	4 5
ne	2.00E-02	5.98E+01	3.27E-03	2.22E+00	1.76E-02	2.60E-02	2 6
	2.78E+01	1.81E+05 •	1.55E+01	4.76E+03 †	2.62E+03 †	4.99E+02	5 0
l-ether (MTBE)	3.62E+02	1.51E+06 •	4.61E+01	2.16E+04 †	7.89E+02	1.48E+03	1.4
	1.12E+01	7.11E+04 •	5.89E+00	2.61E+03 †	5.20E+03 †	1.89E+02	1 9
nzene	6.44E-02	4.00E+02 •	3.82E-01	2.59E+02	1.31E+01	8.59E-01	8.6
nzene	6.77E-02	3.96E+02 •	1.13E-01	7.65E+01	1.04E+01	6.88E-01	6.9
	2.25E+01	1.39E+05 •	1.07E+01	5.25E+03 †	4.92E+04 †	3.44E+02	3.4
	2.85E+01	1.76E+05 •	1.22E+01	8.25E+03 †	4.92E+04 †	3.44E+02	3 4
	9.12E+00	5.86E+04 •	5.21E+00	3.52E+03 †	3.28E+05 †	1.48E+02	1.4
	9.32E+00	5.97E+04 •	5.34E+00	3.62E+03 †	4.53E+04 †	1.48E+02	1.4
	2.82E+02 •	5.88E+05 •	5.60E+03 †	3.79E+06 †	7.50E+03 †	1.03E+02	1.0
	1.22E+01 •	5.49E+04 •	9.54E+01 †	6.46E+04 †	3.72E+03 †	5.16E+01	5 2
	1.73E+02 •	6.65E+05 •	8.39E+03 †	5.68E+06 †	3.72E+04 †	5.16E+02	5.2
ene	1.03E+04 •	1.83E+07 •	6.32E+07 †	4.28E+10 †	1.02E+00	5.16E+01	5 2
	1.40E+01 •	2.46E+04 •	2.43E+04 †	1.62E+07 †	1.02E-01	9.55E-03	9 6
hene	1.31E+03 •	2.40E+06 •	3.20E+06 †	2.17E+09 †	1.02E+00	5.16E+01	5 2
lene	6.19E+04 •	1.10E+08 •	4.38E+08 †	2.96E+11 †	3.84E+03 †	5.16E+01	5.2
hene	4.20E+02 •	8.07E+05 •	1.01E+06 †	6.85E+08 †	1.02E+01	5.16E+01	5 2
	1.19E+04 •	2.13E+07 •	1.06E+07 †	7.18E+09 †	1.02E+02 †	5.16E+01	5.2

TABLE Q.2

RESIDENT - CHILD
TIER 1 RISK-BASED SCREENING LEVELS

Chemical	Water Concentration		Soil Concentration			Air Concentration	
	Inhalation Indoor-Water [mg/l]	Inhalation Outdoor-Water [mg/l]	Inhalation Indoor-Soil [mg/kg]	Inhalation Outdoor-Soil [mg/kg]	Surficial Soil [mg/kg]	Inhalation Indoor Air [µg/m³]	Inhal Outdo [µg
racene	6.10E+04 *	1.09E+08 *	8.96E+08 †	6.07E+11 †	1.02E-01	5.16E+01	5.21
	2.28E+02 *	4.61E+05 *	7.17E+03 †	4.85E+06 †	5.03E+03 †	6.88E+01	6.95
yrene	7.03E+04 *	1.25E+08 *	5.01E+08 †	3.39E+11 †	1.02E+00	5.16E+01	5.21
	1.26E+00	5.10E+03 *	6.04E-01	4.09E+02 †	3.54E+03 †	5.16E+00	5.21
	9.00E+01 *	2.04E+05 *	5.37E+03 †	3.63E+06 †	3.78E+03 †	5.16E+01	5.21
	2.83E+03 *	5.09E+06 *	4.79E+05 †	3.24E+08 †	3.83E+03 †	5.16E+01	5.21
	na	na	na	na	1.10E+02	na	
	na	na	na	na	2.54E-01	na	
	na	na	na	na	7.94E+03	na	
	na	na	na	na	4.00E+02 †**	1.5 **	1.
	na	na	na	na	2.53E+02	na	
	na	na	na	na	2.16E+01	na	
	na	na	na	na	1.25E+05 †	na	

= These values exceed the pure component water solubilities.
= These values exceed the residual (saturated) soil concentrations.
= USEPA Section 403 Interim Lead Guidance, "Agency Guidance on Residual Lead-Based Paint, Lead-Contaminated Dust, and Lead-Contaminated Soil", July 14, 1994.

TABLE Q.3

COMMERCIAL WORKER
TIER 1 RISK-BASED SCREENING LEVELS

Chemical	Water Concentration		Soil Concentration			Air Concentration	
	Inhalation Indoor-Water [mg/l]	Inhalation Outdoor-Water [mg/l]	Inhalation Indoor-Soil [mg/kg]	Inhalation Outdoor-Soil [mg/kg]	Surficial Soil [mg/kg]	Inhalation Indoor Air [μg/m³]	Inh Outd [μ
	7.39E-02	1.82E+01	1.58E-01	2.73E-01	1.95E+01	4.93E-01	4 9
	1.11E+00	3.13E+02 •	4.25E+00	1.95E+00	4 98E+03 †	1.33E+01	1 3
ne	3.51E-02	4.22E+00	5.95E-03	1.56E-01	3.32E-02	1.86E-02	1.8
	2.03E+02 •	5.33E+04 •	4.74E+02 †	1.40E+03 †	2.08E+04 †	1.48E+03	1 4
l-ether (MTBE)	2.65E+03	4.45E+05 •	1.41E+03	6.35E+03	6.33E+03	4 39E+03	4.3
	8.18E+01	2.09E+04 •	1.80E+02	7.67E+02 †	3.90E+04 †	5.62E+02	5.6
enzene	4.72E-01	1.18E+02 •	2.80E+00	7.60E+01	1.01E+02	2.56E+00	2 5
enzene	4.96E-01	1.16E+02 •	8.28E-01	2.25E+01	8.09E+01	2.04E+00	2.0
	1.65E+02	4.09E+04 •	3.27E+02 †	1.54E+03 †	2.91E+05 †	1.02E+03	1.0
	2.09E+02 •	5.19E+04 •	3.27E+02 †	2.43E+03 †	2.91E+05 †	1.02E+03	1.0
	6.68E+01	1.72E+04 •	1.41E+02	1.04E+03 †	4.01E+05 †	4.39E+02	4.3
	6.83E+01	1.75E+04 •	1.41E+02	1.06E+03 †	2.06E+05 †	4.39E+02	4.3
	2.07E+03 •	1.73E+05 •	4.11E+04 †	1.12E+06 †	4.99E+04 †	3.07E+02	3 0
	8.92E+01 •	1.61E+04 •	6.99E+02 †	1.90E+04 †	2.49E+04 †	1.53E+02	1.5
	1.26E+03 •	1.95E+05 •	6.14E+04 †	1.67E+06 †	2.49E+05 †	1.53E+03	1.5
ene	7.52E+04 •	5.39E+06 •	4.63E+08 †	1.26E+10 †	1.93E+00	1.53E+02	1.5
	2.44E+01 •	1.74E+03 •	4.24E+04 †	1.15E+06 †	1.93E-01	6.81E-03	6.8
thene	9 62E+03 •	7.05E+05 •	2.34E+07 †	6.37E+08 †	1.93E+00	1.53E+02	1.5
lene	4.54E+05 •	3.24E+07 •	3.20E+09 †	8.71E+10 †	3.03E+04 †	1.53E+02	1.5
thene	3.07E+03 •	2.37E+05 •	7.41E+06 †	2.01E+08 †	1.93E+01	1.53E+02	1.5
	8.74E+04 •	6.26E+06 •	7.77E+07 †	2.11E+09 †	1.93E+02 †	1.53E+02	1.5

TABLE Q.3

COMMERCIAL WORKER
TIER 1 RISK-BASED SCREENING LEVELS

Chemical	Water Concentration		Soil Concentration			Air Concentration	
	Inhalation Indoor-Water [mg/l]	Inhalation Outdoor-Water [mg/l]	Inhalation Indoor-Soil [mg/kg]	Inhalation Outdoor-Soil [mg/kg]	Surficial Soil [mg/kg]	Inhalation Indoor Air [µg/m³]	Inhal Outdo [µg/
acene	4.46E+05 •	3.19E+07 •	6.57E+09 †	1.78E+11 †	1.93E-01	1.53E+02	1.53
	1.67E+03 •	1.36E+05 •	5.25E+04 †	1.43E+06 †	3.32E+04 †	2.04E+02	2.04
yrene	5.15E+05 •	3.68E+07 •	3.67E+09 †	9.97E+10 †	1.93E+00	1.53E+02	1.53
	9.21E+00	1.50E+03 •	4.91E+00	1.20E+02 †	1.04E+04 †	1.53E+01	1.53
	6.59E+02 •	5.99E+04 •	3.93E+04 †	1.07E+06 †	2.49E+04 †	1.53E+02	1.53
	2.07E+04 •	1.50E+06 •	3.51E+06 †	9.54E+07 †	2.96E+04 †	1.53E+02	1.53
	na	na	na	na	1.35E+02	na	
	na	na	na	na	7.46E-02	na	
	na	na	na	na	4.77E+04	na	
	na	na	na	na	4.00E+02 †**	1.5 **	1.5
	na	na	na	na	3.83E+02	na	
	na	na	na	na	1.56E+01	na	
	na	na	na	na	7.54E+05 †	na	

= These values exceed the pure component water solubilities.
= These values exceed the residual (saturated) soil concentrations.
= USEPA Section 403 Interim Lead Guidance, "Agency Guidance on Residual Lead-Based Paint, Lead-Contaminated Dust, and Lead-Contaminated Soil", July 14, 1994.

TABLE Q.4

CONSTRUCTION WORKER
TIER I RISK-BASED SCREENING LEVELS

Chemical	Water Concentration		Soil Concentration			Air Concentration	
	Inhalation Indoor-Water [mg/l]	Inhalation Outdoor-Water [mg/l]	Inhalation Indoor-Soil [mg/kg]	Inhalation Outdoor-Soil [mg/kg]	Surficial Soil [mg/kg]	Inhalation Indoor Air [μg/m^3]	Inhal Outdo [μg
	3.25E+00	8.02E+02	4.42E-01	1.20E+01	2.65E+02	2.17E+01	2.17
	2.78E+00	7.82E+02 •	4.25E-01	4.87E+00	1.14E+03 †	3.32E+01	3.32
e	1.37E+00	1.65E+02	2.26E-01	6.13E+00	2.97E+00	7.28E-01	7.28
	5.08E+02 •	1.33E+05 •	1.29E+02 †	3.50E+03 †	4.00E+04 †	3.70E+03	3.70
ether (MTBE)	6.64E+03	1.11E+06 •	5.84E+02	1.59E+04 †	1.64E+04 †	1.10E+04	1.10
	2.04E+02	5.22E+04 •	7.06E+01	1.92E+03 †	3.52E+04 †	1.41E+03	1.41
zene	1.18E+00	2.94E+02 •	6.99E+00	1.90E+02	1.28E+02	6.39E+00	6.39
zene	1.24E+00	2.91E+02 •	2.07E+00	5.63E+01	1.02E+02	5.11E+00	5.11
	4.13E+02 •	1.02E+05 •	1.42E+02 †	3.86E+03 †	8.56E+04 †	2.56E+03	2.56
	5.22E+02 •	1.30E+05 •	2.23E+02 †	6.06E+03 †	8.56E+04 †	2.56E+03	2.56
	1.67E+02	4.31E+04 •	9.53E+01	2.59E+03 †	3.98E+04 †	1.10E+03	1.10
	1.71E+02	4.39E+04 •	9.78E+01	2.66E+03 †	3.84E+04 †	1.10E+03	1.10
	5.16E+03 •	4.32E+05 •	1.03E+05 †	2.79E+06 †	6.69E+04 †	7.67E+02	7.67
	2.23E+02 •	4.03E+04 •	1.75E+03 †	4.75E+04 †	1.24E+04 †	3.83E+02	3.83
	3.16E+03 •	4.89E+05 •	1.54E+05 †	4.17E+06 †	2.13E+05 †	3.83E+03	3.83
ne	1.88E+05 •	1.35E+07 •	1.16E+09 †	3.14E+10 †	1.85E+02 †	3.83E+02	3.83
	1.53E+03 •	1.09E+05 •	2.65E+06 †	7.16E+07 †	1.83E+01 †	4.26E-01	4.26
nene	2.40E+04 •	1.76E+06 •	5.86E+07 †	1.59E+09 †	1.85E+02 †	3.83E+02	3.83
ene	1.13E+06 •	8.11E+07 •	8.01E+09 †	2.18E+11 †	1.08E+05 †	3.83E+02	3.83
nene	7.68E+03 •	5.93E+05 •	1.85E+07 †	5.03E+08 †	1.85E+03 †	3.83E+02	3.83
	2.19E+05 •	1.57E+07 •	1.94E+08 †	5.28E+09 †	1.85E+04 †	3.83E+02	3.83

TABLE Q.4

CONSTRUCTION WORKER
TIER 1 RISK-BASED SCREENING LEVELS

hemical	Water Concentration		Soil Concentration			Air Concentration	
	Inhalation Indoor-Water [mg/l]	Inhalation Outdoor-Water [mg/l]	Inhalation Indoor-Soil [mg/kg]	Inhalation Outdoor-Soil [mg/kg]	Surficial Soil [mg/kg]	Inhalation Indoor Air [µg/m^3]	Inhalat Outdoo [µg/m
cene	1.12E+06 •	7.98E+07 •	1.64E+10 †	4.46E+11 †	1.85E+01 †	3.83E+02	3.83E
	4.17E+03 •	3.39E+05 •	1.31E+05 †	3.57E+06 †	5.52E+04 †	5.11E+02	5.11E
ene	1.29E+06 •	9.20E+07 •	9.18E+09 †	2.49E+11 †	1.85E+02 †	3.83E+02	3.83E
	2.30E+01	3.75E+03 •	1.11E+01	3.00E+02 †	1.38E+03 †	3.83E+01	3.83E
	1.65E+03 •	1.50E+05 •	9.83E+04 †	2.67E+06 †	4.14E+04 †	3.83E+02	3.83E
	5.19E+04 •	3.74E+06 •	8.77E+06 †	2.38E+08 †	9.28E+04 †	3.83E+02	3.83E
	na	na	na	na	1.34E+01	na	na
	na	na	na	na	1.85E-01	na	na
	na	na	na	na	1.68E+04	na	na
	na	na	na	na	4.00E+02 †**	1.5 **	1.5
	na	na	na	na	3.98E+01	na	na
	na	na	na	na	2.64E+00	na	na
	na	na	na	na	2.66E+05 †	na	na

These values exceed the pure component water solubilities.

These values exceed the residual (saturated) soil concentrations.

= USEPA Section 403 Interim Lead Guidance, "Agency Guidance on Residual Lead-Based Paint, Lead-Contaminated Dust, and Lead-Contaminated Soil", July 14, 1994.

TABLE Q.5
SOIL CONCENTRATIONS PROTECTIVE OF DRINKING WATER STANDARD

	Drinking Water Standard mg/l	Leaching Factor [(mg/l)/(mg/kg)]	0 ft. mg/kg	100 ft. mg/kg	200 ft. mg/kg	300 ft. mg/kg	400 ft. mg/kg	500 ft. mg/kg	600 ft. mg/kg	700 ft. mg/kg	800 ft. mg/kg	900 ft. mg/kg
	0.005	1.37E-01	3.66E-02	2.16E-01	7.67E-01	1.69E+00	2.97E+00	4.63E+00	6.65E+00	9.04E+00	1.18E+01	1.49E+0
	0.005	2.36E-01	2.12E-02	1.25E-01	4.44E-01	9.76E-01	1.72E+00	2.68E+00	3.85E+00	5.23E+00	6.83E+00	8.64E+0
e	0.005	1.89E-01	2.64E-02	1.56E-01	5.54E-01	1.22E+00	2.15E+00	3.34E+00	4.80E+00	6.53E+00	8.52E+00	1.08E+0
	0.005	6.74E-02	7.42E-02	4.38E-01	1.55E+00	3.42E+00	6.03E+00	9.38E+00	1.35E+01	1.83E+01	2.39E+01	3.03E+0
er	0.05	2.99E-01	1.67E-01	9.86E-01	3.50E+00	7.70E+00	1.36E+01	2.11E+01	3.04E+01	4.13E+01	5.39E+01	6.81E+0
	0.005	5.13E-02	9.76E-02	5.75E-01	2.04E+00	4.49E+00	7.93E+00	1.23E+01	1.77E+01	2.41E+01	3.15E+01	3.98E+0
nzene	0.005	3.08E-03	1.62E+00	9.57E+00	3.40E+01	7.48E+01	1.32E+02	2.05E+02	2.95E+02	4.01E+02	5.23E+02	6.62E+0
nzene	0.005	1.18E-02	4.23E-01	2.49E+00	8.86E+00	1.95E+01	3.43E+01	5.35E+01	7.68E+01	1.04E+02	1.36E+02	1.72E+0
	0.005	5.38E-02	9.30E-02	5.48E-01	1.95E+00	4.28E+00	7.55E+00	1.18E+01	1.69E+01	2.30E+01	3.00E+01	3.79E+0
	0.005	4.31E-02	1.16E-01	6.84E-01	2.43E+00	5.35E+00	9.43E+00	1.47E+01	2.11E+01	2.87E+01	3.74E+01	4.73E+0
	0.005	3.06E-02	1.64E-01	9.65E-01	3.43E+00	7.54E+00	1.33E+01	2.07E+01	2.97E+01	4.04E+01	5.27E+01	6.67E+0
	0.005	3.06E-02	1.63E-01	9.63E-01	3.42E+00	7.53E+00	1.33E+01	2.07E+01	2.97E+01	4.04E+01	5.27E+01	6.66E+0
	0.05	1.74E-03	2.87E+01	1.69E+02	6.01E+02	1.32E+03	2.33E+03	3.63E+03	5.21E+03	7.08E+03	9.25E+03	1.17E+0
	0.05	3.20E-03	1.56E+01	9.22E+01	3.28E+02	7.20E+02	1.27E+03	1.98E+03	2.84E+03	3.86E+03	5.04E+03	6.38E+0
	0.05	5.69E-04	8.79E+01	5.18E+02	1.84E+03	4.05E+03	7.14E+03	1.11E+04	1.60E+04	2.17E+04	2.83E+04	3.58E+0
e	0.05	5.83E-06	8.58E+03	5.06E+04	1.80E+05	3.95E+05	6.97E+05	1.08E+06	1.56E+06	2.12E+06	2.77E+06	3.50E+0
	0.0002	2.07E-05	9.67E+00	5.70E+01	2.03E+02	4.46E+02	7.86E+02	1.22E+03	1.76E+03	2.39E+03	3.12E+03	3.94E+0
ene	0.05	1.46E-05	3.42E+03	2.01E+04	7.16E+04	1.57E+05	2.77E+05	4.32E+05	6.21E+05	8.44E+05	1.10E+06	1.39E+0
ne	0.05	5.08E-06	9.85E+03	5.81E+04	2.06E+05	4.54E+05	8.00E+05	1.25E+06	1.79E+06	2.43E+06	3.18E+06	4.02E+0
ene	0.05	1.46E-05	3.42E+03	2.01E+04	7.16E+04	1.57E+05	2.77E+05	4.32E+05	6.21E+05	8.44E+05	1.10E+06	1.39E+0
	0.05	4.03E-05	1.24E+03	7.31E+03	2.60E+04	5.71E+04	1.01E+05	1.57E+05	2.25E+05	3.06E+05	4.00E+05	5.06E+0
cene	0.05	2.44E-06	2.05E+04	1.21E+05	4.30E+05	9.45E+05	1.67E+06	2.59E+06	3.73E+06	5.07E+06	6.61E+06	8.36E+0
	0.05	1.11E-03	4.51E+01	2.66E+02	9.45E+02	2.08E+03	3.66E+03	5.70E+03	8.20E+03	1.11E+04	1.45E+04	1.84E+0
yrene	0.05	5.03E-06	9.94E+03	5.86E+04	2.08E+05	4.58E+05	8.08E+05	1.26E+06	1.81E+06	2.46E+06	3.21E+06	4.06E+0
	0.05	5.59E-02	8.94E-01	5.27E+00	1.87E+01	4.12E+01	7.26E+01	1.13E+02	1.62E+02	2.21E+02	2.88E+02	3.65E+0
	0.05	5.69E-04	8.79E+01	5.18E+02	1.84E+03	4.05E+03	7.14E+03	1.11E+04	1.60E+04	2.17E+04	2.83E+04	3.58E+0
	0.05	2.12E-04	2.36E+02	1.39E+03	4.95E+03	1.09E+04	1.92E+04	2.99E+04	4.30E+04	5.84E+04	7.62E+04	9.64E+0
	0.1	2.00E-03	4.99E+01	2.94E+02	1.05E+03	2.30E+03	4.05E+03	6.31E+03	9.07E+03	1.23E+04	1.61E+04	2.03E+0
	1.3	1.27E-04	1.02E+04	6.02E+04	2.14E+05	4.71E+05	8.30E+05	1.29E+06	1.86E+06	2.52E+06	3.29E+06	4.17E+0
	0.015	3.19E-04	4.70E+01	2.77E+02	9.85E+02	2.17E+03	3.82E+03	5.94E+03	8.54E+03	1.16E+04	1.52E+04	1.92E+0
	0.3	2.00E-03	1.50E+02	8.83E+02	3.14E+03	6.90E+03	1.22E+04	1.89E+04	2.72E+04	3.70E+04	4.83E+04	6.10E+0
	0.1	5.09E-04	1.97E+02	1.16E+03	4.12E+03	9.06E+03	1.60E+04	2.49E+04	3.57E+04	4.86E+04	6.34E+04	8.02E+0
	na	--	na	na	na	na	na	na	na	na	na	na

exposure point distance "X" ft. from the impacted site = Drinking Water Standard * (Dilution Attenuation Factor in saturated zone) / (Leaching Factor that accounts for mixing beneath the site and equili

(UNDER DISCUSSION)

APPENDIX S
INACTIVATION OF A PETROLEUM IMPACTED SITE

S.1 Site Inactivation Procedures

SITE INACTIVATION is an interim determination that no further investigation or response will be required by the responsible party at this time. This procedure shall be in effect until such a time that NYSDEC's Site Closure Guidance for Petroleum Impacted Sites (RBCA) has been approved and published according to NYS and NYSDEC's procedures for policy development and promulgation. Once the DEC's RBCA policy has been finalized, the site shall be reevaluated for closure according to those guidelines.

An Inactivation decision shall be based on implementation of all of the following requirements:

1. satisfactory source removal (where applicable) and site assessment and characterization; and

2. risk evaluation and determination that the contamination, both on-site and off-site (if applicable), meets the selected Tier requirements identified in NYSDEC's Draft "Interim Procedures for Inactivation of Petroleum-Impacted Sites" for the determined use of the property; and

3. no off-site migration of the plume or continued migration of the off-site portion of the plume as follows:

    a. for sites with only on-site petroleum contamination, satisfaction of the selected tier requirements discussed in paragraph 2 above; and taking appropriate and reasonable measures to ensure, or provide appropriate information to DEC that, groundwater at or around the property line will not violate NYS Drinking Water Standards, at a minimum.

    b. for sites with both on-site and off-site petroleum contamination, satisfaction of the selected tier requirements discussed in paragraph 2 above; and implementation of appropriate measures to minimize or eliminate further migration of the contaminated groundwater off-site. The appropriateness of the above measures will be evaluated based on current technical and economic feasibility guidelines.

4. implementation of an appropriate compliance monitoring program in accordance with Section 6.0 of this document; and

5. submittal of the recorded deed restriction (if applicable) in accordance with Section 5.10 of this document.

S.2 Site Inactivation Letter

Upon satisfaction by the DEC that the actions taken or the information provided meets the criteria stated in Section S.1 of this Appendix the following letter requiring no further action will be provided to the responsible party:

Ref: (Insert Site Name and Location)

Dear (Insert Addressee's Name):

The Department is pleased to report that it is satisfied that the inactivation evaluation of and corrective actions (if applicable) at the parcel of real property located at ________________ County, New York, a map of which is attached hereto ("Site"), meets Department guidelines for inactivation of the site. So long as no information has been withheld from the Department or mistake made as the hazard posed by, or the nature and extent of, the petroleum existing on, at or under the Site as of this date ("Existing Contamination"), the Department believes that no further investigation or response will be required at the Property to render the Site safe for use as *[insert intended use, e.g. commercial facility]* and the Site will be inactivated in the Department's files. Once the Department has finalized new guidelines for closure of spill sites, the Department will review nd make a final determination as to any further investigation or remediation activities which may be necessary at the site. If the Department determines that no further work is necessary, the Department will then issue a closure letter for the Site.

Nevertheless, the Department hereby reserves all of its rights concerning, and such forbearance shall not extend to, any further investigation or remedial action the Department deems necessary:

i. due to the off-site migration of petroleum contaminants that was not addressed by the Inactivation Evaluation and Corrective Action Plan (if applicable).

ii. due to environmental conditions related to the Site what were unknown to the Department at the time of its approval of the Inactivation Evaluation Report and Corrective Action Plan (if applicable) or the last written Department-approved modification thereto; or

iii. due to information received, in whole or in part, after the Department's approval of the final Inactivation Evaluation Report and Corrective Action Plan (if applicable), which indicates that the Inactivation evaluation and/or corrective action is not sufficiently protective of human health for the reasonably anticipated *[insert intended use]* of the Site.

iv. due to fraud in obtaining the Inactivation.

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

By: ________________________
Title: ________________________