Nebraska Department
of Environmental Quality

ENVIRONMENTAL GUIDANCE DOCUMENT

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RISK-BASED CORRECTIVE ACTION (RBCA)
AT PETROLEUM RELEASE SITES:
TIER 1/TIER 2 ASSESSMENTS & REPORTS

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Look-Up Tables

Appendix Tables

ACRONYMS

ACL	Alternate Cleanup Level
ASTM	American Society for Testing and Materials
AST	Aboveground Storage Tank
BaP	Benzo(a)pyrene
BGL	Below Ground Level
BTEX	Benzene, Toluene, Ethylbenzene, Xylenes
CERCLA	Comprehensive Environmental Recovery, Compensation, and Liability Act
CFR	Code of Federal Regulations
CGI	Combustible Gas Indicator
COC	Chemical of Concern
CP	Cathodic Protection
CRF	Concentration Reduction Factor
FID	Flame Ionization Detector
GC	Gas Chromatograph
HI	Hazard Index
HQ	Hazard Quotient
IELCR	Individual Excess Lifetime Cancer Risk
LAST	Leaking Aboveground Storage Tank
LEL	Lower Explosive Limit
LUST	Leaking Underground Storage Tank
LUT	Look-Up Table
MCL	Maximum Contaminant Level
MTBE	Methyl tertiary Butyl Ether
NDEQ	Nebraska Department of Environmental Quality
NELAC	National Environmental Laboratory Accreditation Conference
PAH	Polynuclear Aromatic Hydrocarbon
PID	Photoionization Detector
POC	Point of Compliance
POE	Point of Exposure
PRS	Petroleum Remediation Section
QA/QC	Quality Assurance/Quality Control
RAC	Remedial Action Class
RAP	Remedial Action Plan
RBCA	Risk-Based Corrective Action
RBSL	Risk-Based Screening Level
RP	Responsible Party
SSTL	Site Specific Target Level
TAC	Technical Advisory Committee
TEH	Total Extractable Hydrocarbons
USGS	United States Geological Survey
UST	Underground Storage Tanks
VRA	Voluntary Remedial Action
VOC	Volatile Organic Compound
WHPA	Wellhead Protection Area

SECTION 1.0 BACKGROUND & APPLICABILITY

The Petroleum Remediation Section (PRS) of the Nebraska Department of Environmental Quality (Department) has compiled this document for the purposes of conducting risk-based corrective action (RBCA) Tier 1 and Tier 2 site assessments and evaluations at **petroleum release sites**. It has been prepared in accordance with criteria contained in Nebraska Title 118 - Ground Water Quality Standards and Use Classification and Nebraska Title 126 - Rules and Regulations Pertaining to the Management of Wastes. Portions of this document are based on recommendations made by the Technical Advisory Committee (TAC), created by the Nebraska Legislature, and information contained in the American Society for Testing and Materials (ASTM) Standard E-1739 Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites (ASTM E-1739).

This document is intended to apply to all petroleum releases: those potentially eligible for reimbursement under Nebraska Title 200 - Rules and Regulations for Petroleum Release Remedial Action Reimbursement Fund, as well as those that are not (e.g., pipelines, transportation vessels). This guidance is not intended for investigations of petroleum wastes considered a hazardous waste in accordance with Nebraska Title 128 – Nebraska Hazardous Waste Regulations or a CERCLA-listed petroleum derivative identified in 40 CFR Part 302.

1.1 TITLE 200 WORKPLAN APPROVAL & COSTS

Costs associated with remedial actions taken due to releases from petroleum leaking underground storage tanks (LUSTs) and aboveground storage tanks (LASTs) are eligible for reimbursement consideration under Title 200. To secure reimbursement consideration for those releases where the Department has required remedial actions, the Department must first approve the responsible parties' (RP) workplans and review the associated cost estimates before any work is performed, unless expressly approved in other Department guidance documents. Taking remedial actions without first receiving approval from the Department may jeopardize Title 200 reimbursement eligibility for those actions.

For non-Title 200 eligible petroleum releases, workplans may also be required by the Department.

The Department also has available the Voluntary Remedial Action (VRA) process whereby the RP does not have to wait for approval of a work plan and may be eligible for reimbursement under Title 200 at a later time. The RP can proceed with appropriate remedial actions as per the Department's guidance documents and regulations if the Department has not yet required the RP to take remedial actions. The release, however, must first be reported to the Department in accordance with Title 126 to be considered eligible for Title 200 reimbursement.

For additional information regarding the Petroleum Remediation program, please view the Department's web page at www.deq.state.ne.us or call 402/471-2186. For information concerning the VRA process only, contact the Department at 402/471-3093. For additional questions regarding the RBCA program, contact 402/471-2668.

NOTE: Water wells and pumps must be installed by licensed personnel. In addition, sample collection from monitoring wells must be performed by certified Water Well Monitoring Technicians. In both cases, contact the Nebraska Health and Human Services System's Department of Regulation & Licensure for further information.

SECTION 2.0 OVERVIEW OF NDEQ'S RBCA PROCESS

2.1 INTRODUCTION

The term Risk-Based Corrective Action (RBCA) refers to a consistent decision-making process used to assess actual or likely human and/or environmental risk of exposure to a chemical release and determine appropriate remedial actions in response to such releases. Petroleum releases vary considerably in their potential risk based on a number of variables, including, but not limited to, the type of petroleum product, amount of released product, duration of the release, extent of the release, site geology/hydrogeology, number and type of exposure pathways, and location of human receptors relative to the source. Potential remedial actions may run the gamut from long-term active cleanup to no action. In recognition of this fact, the Department has developed a tiered approach to its petroleum release corrective action process to cost effectively manage impacted sites and focus the finite resources on the more critical sites.

2.2 GENERAL RBCA PROCESS

The Department's petroleum release RBCA process follows the general procedures outlined in the governing regulation, Title 118, Appendix B, Steps 5 – 11. Steps 1 – 4 deal with immediate threats from a release; such a site would not enter the RBCA process until the immediate threats have been mitigated. The following steps are included in the Department's RBCA process:

1. Pre-Investigation Site Visit *
2. Tier 1 Site Investigation *
3. Tier 1 Evaluation
4. Tier 2 Site Investigation *
5. Tier 2 Evaluation
6. Preparation of Remedial Action Plan *
7. Implementation of Remedial Action Plan *
8. Review of Remedial Action Effectiveness
9. Site Closure *

Those steps marked with an asterisk (*) require Department review and approval of workplans and cost estimates prior to work being performed for Title 200 eligible releases. Workplans and cost estimates are not required for work performed under the VRA program. Workplans and cost estimates may be required by the Department for non-Title 200 eligible releases.

The overall RBCA process is depicted in the form of a flow chart in Figure 2-1. Free product recovery is not addressed in this flow chart. Requirements for addressing free product are handled on a case-by-case basis. The presence of **free product suspends the Tier 1 investigation requirements for only those exposure pathways involving ground water (see Section 4.5). A report incorporating all other Tier 1 information is still required.**

2.3 THE INVESTIGATION PROCESS

During the Tier 1 investigation, sufficient site data is gathered to establish land use (present and future) in the area around the release site, the location of potential points of exposure, human receptors and pathways, chemical of concern (COC) concentration data in soils and ground water, and certain subsurface physical parameters. These data are used to generate a Site Conceptual Exposure Scenario and determine the appropriate risk-based screening levels (RBSLs) with which to compare the documented site COC concentrations. Data are collected to examine the potential risk of exposure to petroleum contaminants from the following exposure pathways:

- Dermal contact with, ingestion of, and outdoor inhalation through air of COCs from contaminated surface soils;
- Enclosed space inhalation of COCs from contaminated subsurface soils;

- Leaching of COCs from contaminated surface and subsurface soils to ground water;
- Enclosed space inhalation of COCs from contaminated, shallow ground water; and,
- Ingestion of COCs from contaminated ground water.

The purpose of the Tier 2 investigation is to gather additional site COC concentration data and subsurface physical parameter information that is more detailed than that gathered during the Tier 1 investigation. These data are used to generate site-specific target levels (SSTLs) that are compared to representative site COC concentrations for the completed exposure pathways from Tier 1. All COCs and all complete routes of exposure will be evaluated at Tier 2.

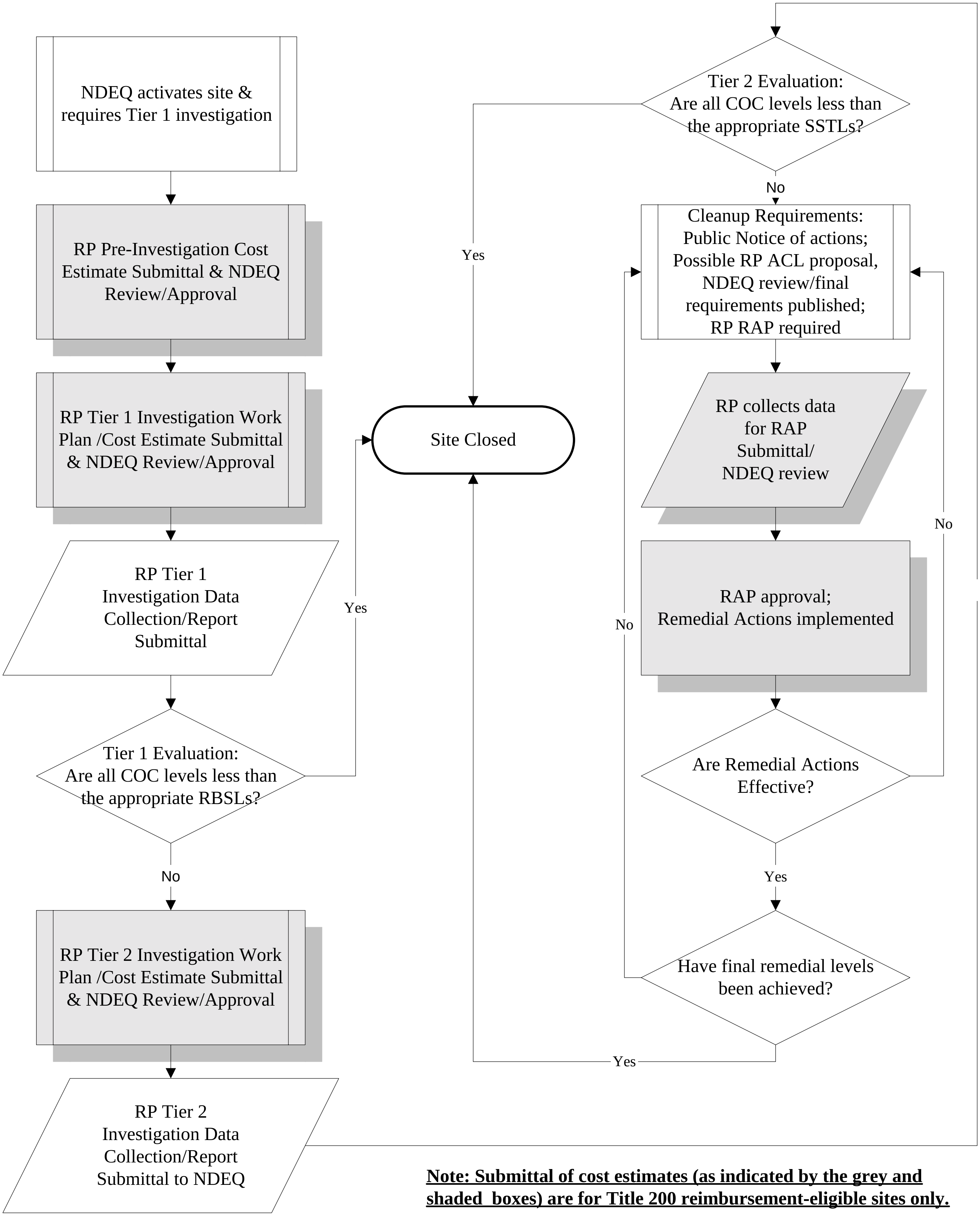
2.4 CHARACTERISTICS OF TIERED PROCESS

As defined in ASTM E-1739, a Tier 1 evaluation is “a risk-based analysis to develop non-site-specific values for direct and indirect exposure pathways utilizing conservative exposure factors and fate and transport [models] for potential pathways and various property use categories ... Values established under Tier 1 will apply to all sites that fall into a particular category.” (“Direct exposure” indicates that the point of exposure is at the source of the release; “indirect exposure” indicates the existence of an intervening medium of transport between the source and a point of exposure.)

A Tier 2 evaluation is a risk-based analysis applying the same exposure factors and models used for the Tier 1 evaluation but incorporating more site-specific data to develop site-specific target levels for all COCs and all complete exposure pathways.

Based on these definitions, certain general statements can be made when comparing the individual tiers. First, when proceeding from Tier 1 to Tier 2, the amount of data collected during the investigation phase increases. Additional work at the Tier 2 phase may include more complete soil sampling, additional ground water sampling and/or subsurface physical/chemical parameter testing. Second, as more data is collected, the level of conservatism used in the evaluation of the data usually decreases. This means that the Tier 2 SSTLs will generally be greater than the Tier 1 RBSLs for the same site. However, the target risk or level of protection remains the same for both tiers.

Figure 2-1. Generalized NDEQ RBCA Process Flow Chart



<u>Note: Submittal of cost estimates (as indicated by the grey and shaded boxes) are for Title 200 reimbursement-eligible sites only.</u>

SECTION 3.0 PRE-INVESTIGATION ASSESSMENT

3.1 SITE ACTIVATION

Upon activating a petroleum release site for a RBCA Tier 1 investigation, the Department notifies the responsible party (RP) in writing of its requirements. The first of these requirements is the submittal of a cost estimate (for Title 200 eligible sites) to conduct a pre-investigation assessment as described in Section 3.2.1 below. The pre-investigation assessment is to be performed within the time schedule set by the Department. Depending on the extent of the release, a pre-investigation assessment may not be necessary for non-Title 200 eligible releases.

3.2 PRE-INVESTIGATION ASSESSMENT AND SITE VISIT

An assessment of the current site conditions is necessary for sites entering the RBCA process. Prior to conducting a RBCA Tier 1 site investigation, the Department requires a pre-investigation assessment, including a site visit, be performed by the consultant.

3.2.1 Purpose of Pre-Investigation Assessment & Site Visit

The purpose of this assessment and site visit is to:

1. Conduct a file review and an on-site reconnaissance to determine the number and location of potential source areas, and potential complications for sampling the source areas;

2. Locate any water supply wells as described in Section 4.4.3;

3. Locate any surface water bodies within 1000 feet of the site;

4. Conduct an on-site utilities survey (including UST leak detection and leak prevention equipment) as an aid in determining potential site complications;

5. Determine the appropriate sampling and/or drilling locations to obtain the required COC concentrations;

6. Prepare a site map (to scale) showing the following:

   - the potential source areas
   - selected sampling and/or drilling locations
   - on-site water supply wells
   - buildings within 200 feet of the site
   - basements within 200 feet of the site
   - utilities within 200 feet of the site
   - tank system (current and former) locations, including tanks, piping, dispensers, and leak detection and prevention equipment
   - area(s) of any surface staining

7. Prepare an area map (to scale) showing all water supply wells and surface water bodies identified.

   Note: Selection of boring locations at facilities with any storage tanks (underground or aboveground) should be made with caution. Underground piping is typically non-metallic and may not be locatable. Steel tanks and piping may also be equipped with cathodic protection (CP). These CP systems may have wiring from the building to an anode bed surrounding the tanks and piping. “As-built” drawings are required to be kept at the tank location for location purposes prior to beginning any work. If you have any questions regarding these issues, please contact the State Fire Marshal’s Fuel Safety Division at 402/471-9465. Also, please keep in mind that for any subsurface investigation, “One Call” procedures need to be followed for locating utility services.

Upon completion of the pre-investigation assessment, the above referenced site diagram and a proposed cost estimate for a complete Tier 1 site investigation are to be submitted to the Department’s project manager. The site investigation is to be performed once the RP receives the Department’s approval letter and is to be completed within the time schedule set by the Department.

3.2.2 Location of Release Source Areas

Maximum COC concentrations are assumed to occur at the source areas. Therefore, the identification of source areas is of primary importance to the investigation. For the purposes of this document, source areas are determined as:

1. Areas surrounding documented points of leakage, such as holes in a tank or pipeline, leaking pipe joints as documented in a LUST/LAST removal/upgrade report, or overfills at other specific points such as dispensers or load out racks;

2. Visually discolored or stained surface and subsurface soils;

3. Elevated field screening levels and/or analytical sampling results compared to other areas documented during the tank removal/upgrade or subsequent to any other release event; and/or,

4. Any other known locations of a spill.

For service station sites where multiple holes are documented in one tank or in adjacent tanks, the tank area may be considered as one source area. In cases where an RP or their consultant believes the source area(s), as defined above, cannot be reasonably determined or believes the proximity of potential source areas may otherwise dictate a lesser number of sampling locations, the RP or their consultant must consult with the Department to select the appropriate number and location of sampling areas.

In cases where site conditions preclude investigation directly through a source area (e.g., a new building or building addition sitting over the former tank excavation location, concrete debris from tank removal disposed in former tank excavation, presence of utilities, lined secondary containment areas), the Department must be consulted in order to determine the appropriate number and location of sampling areas. Variables used in this discussion may include, but are not limited to, the degree of obstruction, expected ground water flow direction and depth to ground water. In extreme cases, the Department may consider alternatives to this document, such as sampling and monitoring of soil vapor and/or indoor air.

See Figure 3-1 for examples of source area(s) selection for various petroleum release scenarios.

Figure 3-1. Example Selection of Source Areas for Various Petroleum Releases

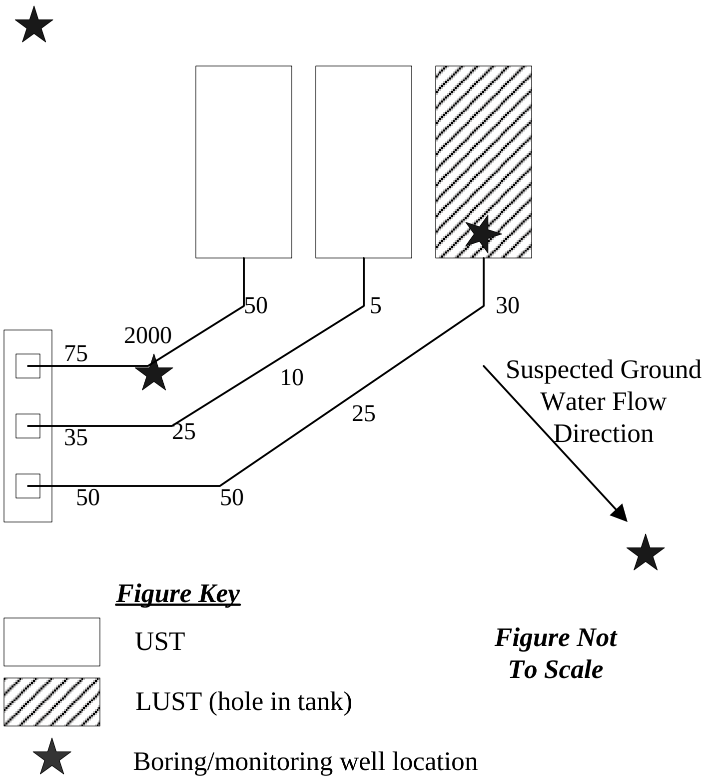


Figure Not To Scale

Figure 3-1a. This generalized LUST site layout (not to scale), based on a hypothetical Closure Assessment Report, provides an idealized example of determining potential source areas for monitoring well installation when conducting a RBCA Tier 1 investigation. The numbers along the product lines represent field screening measurements. The source areas are based on:

1) a documented point of leakage (corrosion holes) in one of the USTs, and
2) elevated field screening levels/laboratory anayses associated with a joint in the product piping.

Note the placement of an upgradient and downgradient monitoring well.

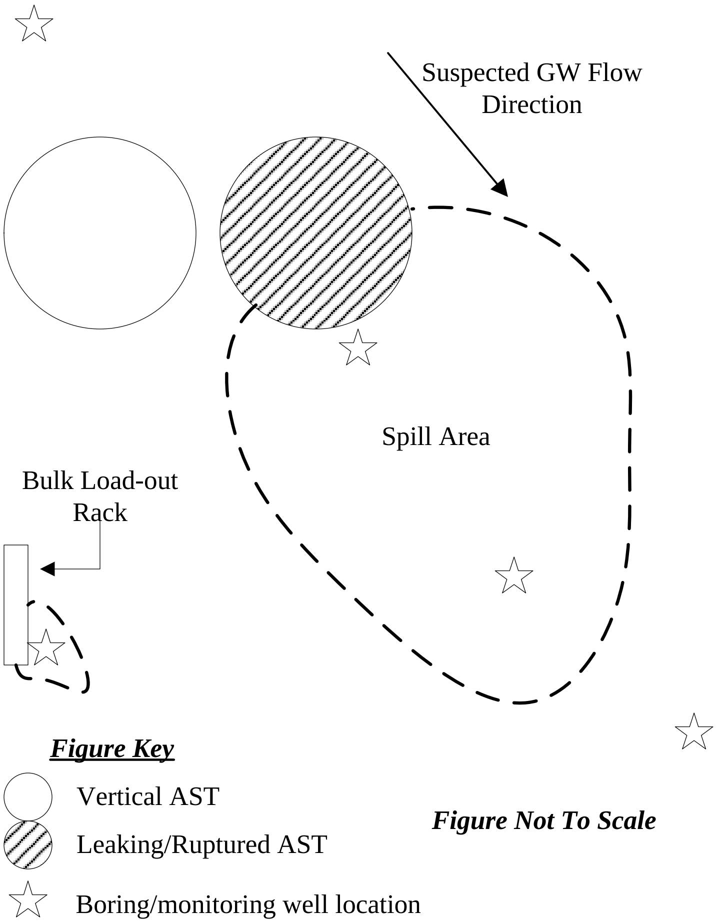


Figure Not To Scale

Figure 3-1b. Generalized AST release with no secondary containment around the ASTs. The actual number of source area borings (denoted by the stars within the spill area) will vary based on the size of the spill area and consultation with the Department. For such a surface release, low-lying areas where product may pool are likely candidates for boring placement. Also, this site contains a bulk load-out rack area where an unknown number of petroleum overfills have occurred and would need to be assessed during a Tier 1 investigation. Note the placement of an upgradient and down gradient monitoring well.

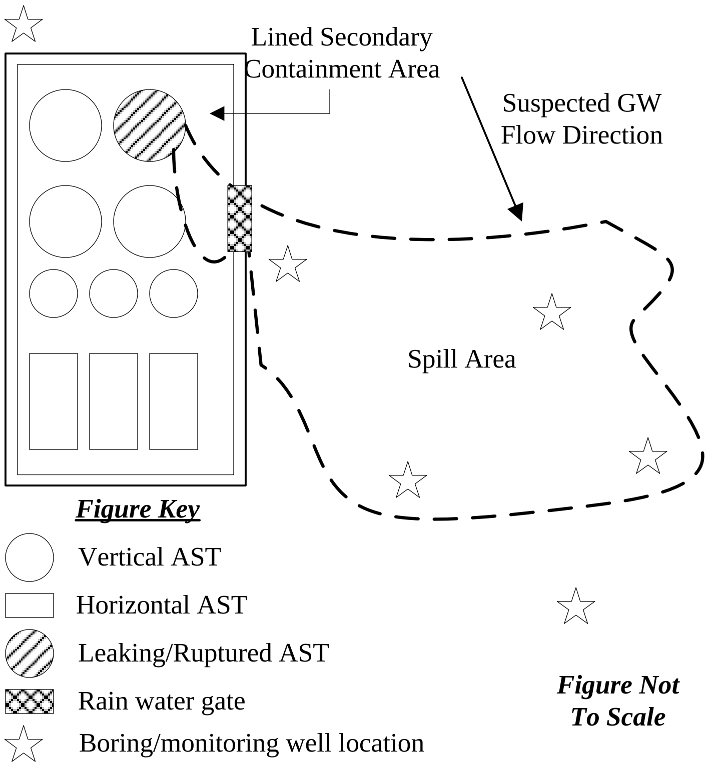


Figure 3-1c. Generalized AST bulk facility with lined secondary containment. To maintain the integrity of the liner, borings are generally not required within the secondary containment area. The actual number of source area borings/monitoring wells (denoted by the stars within the spill area) will vary based on the size of the spill area and consultation with the Department. For such a surface release, low-lying areas where product may pool are likely candidates for boring placement. Note the placement of an upgradient and down gradient monitoring well.

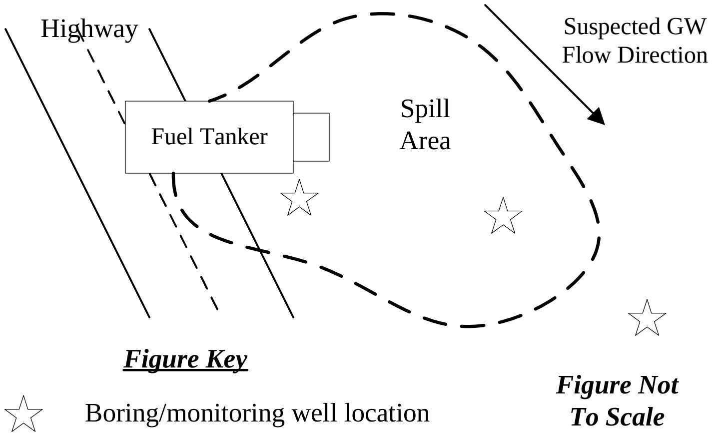


Figure 3-1d. Generalized transportation incident resulting in large volume petroleum release. The actual number of source area borings/monitoring wells (denoted by the stars within the spill area) will vary based on the size of the spill area and consultation with the Department. For such a surface release, low-lying areas where product may pool are likely candidates for boring placement.

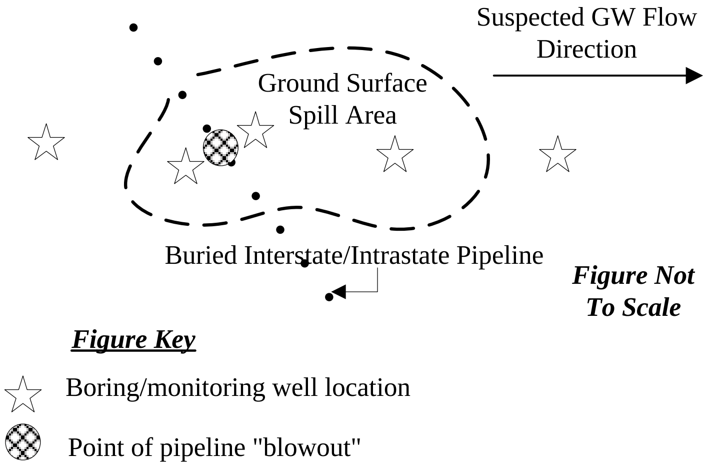


Figure 3-1e. Generalized high-volume pipeline "blowout" resulting in large volume petroleum release. The actual number of source area borings/monitoring wells (denoted by the stars within the spill area) will vary based on the size of the spill area and consultation with the Department. For such a surface release, low-lying areas where product may pool are likely candidates for boring placement.

SECTION 4.0 GENERAL RBCA SITE INVESTIGATION REQUIREMENTS

4.1 INTRODUCTION

Section 4.0 provides guidance regarding information required for both Tier 1 and Tier 2 investigations. Such information includes selection of COCs, general site and area information, evaluation of ground water and land use, water supply well information, free product requirements, general sampling requirements, and saturated zone characteristics.

4.2 NATURE OF THE RELEASE

4.2.1 Product Released and Chemicals of Concern (COCs)

The petroleum products released to the environment are to be identified based on the spilled material reported to the Department or the available product storage history and points of leakage information documented in the Department's petroleum release file. This information is used to determine the appropriate COCs for which sampling must be performed during the site investigation.

This guidance is written to address releases of petroleum, petroleum distillates, petroleum additives, and waste oil. The COCs typically sampled for most petroleum releases are provided below in Table 4-1. To assess the overall degree of petroleum contamination at the site, a total gross hydrocarbons analysis will also be required for middle and heavy distillates.

Allowable laboratory analysis methods for these COCs are also provided in Table 4-1. The contracted laboratory must be able to achieve the minimum quantification levels that are found in Table 4-1. The Department recommends that laboratory analysis of soil, ground water and/or vapor samples be performed by laboratories certified by the National Environmental Laboratory Accreditation Conference (NELAC).

4.2.2 Fuel/Waste Oil COCs and Alternative Use of TEH Analysis

RBCA requires that laboratory detection levels for COCs be below the potential target levels (i.e., the RBSLs and SSTLs). This is problematic for some of the polynuclear aromatic hydrocarbon (PAH) COCs, particularly benzo(a)pyrene which has a Maximum Contaminant Level (MCL) (and corresponding RBSL for the ground water ingestion pathway) of 0.0002 mg/L.

In recognition of this potential dilemma, the Department has developed an alternative to a chemical-specific detection method for the specified PAHs. The alternate methodology takes a surrogate approach where TEH levels are used to estimate the on-site concentrations of the PAH COCs, based on a percentage of the particular COC in the original product. A more detailed discussion of this surrogate method can be found in Appendix A.

At the Tier 1 level, all PAHs are evaluated based on the TEH surrogate. Therefore, the Department will not require chemical-specific analysis for the PAH COCs.

For the Tier 2 process, where SSTLs are developed, a somewhat different approach is taken. Based on the information provided in Appendix A, the PAH COC driving the evaluation of diesel fuel is naphthalene. For waste oil, it is benzo(a)pyrene (BaP). **For the evaluation of diesel fuel (and other middle distillates) at the Tier 2 level, the Department will require chemical-specific sampling for naphthalene**. This will allow for a more accurate evaluation of naphthalene and a more reasonable determination of appropriate SSTLs. For waste oil releases, the Department will still use the TEH surrogate method to establish SSTLs and sampling for BaP is not necessary.

Table 4-1. Chemicals of Concern for Different Petroleum Product Releases

Chemical of Concern	Gasoline	JP-4	Diesel/ #2 Fuel Oil	Kerosene/Other Jet Fuels	Heavy Distillates	Waste Oil	Acceptable Test Method(s)[1,2]	Minimum Quantification Level	
								Water (mg/L)	Soil (mg/kg)
ALKANES									
n-Hexane	X	X					8260[3,6], OA-1[4,6]	0.050	0.100
AROMATICS									
Benzene	X	X	X	X		X	8260[6], OA-1[6]	0.005	0.005
Toluene	X	X	X	X		X	Same as Benzene	0.005	0.005
Ethylbenzene	X	X	X	X		X	Same as Benzene	0.005	0.005
Xylenes	X	X	X	X		X	Same as Benzene	0.005	0.005
OTHER VOCs									
MTBE	X	X					8260[6], OA-1[6]	0.020	0.020
PAHs[7]									
Naphthalene			X	X	X	X	Tier 1: Test for TEH Tier 2: 8260[6], OA-1[6]	0.020	1.0
Pyrene			X	X	X	X	Test for TEH	NA	NA
Benzo(a)pyrene			X	X	X	X	Test for TEH	NA	NA
Total Extractable Hydrocarbons (TEH)			X	X	X	X	OA-2[4,6,8], 8015B[3,6] (based on product type)	1.0	10.0
OTHER POTENTIAL ANALYTES									
Chlorinated Solvents						X[5]			
Ethylene glycol						X[5]			
Metals						X[5]			

X: COC to be analyzed
VOCs: Volatile Organic Compounds
MTBE: Methyl tertiary-butyl ether
PAHs: Polycyclic Aromatic Hydrocarbons
NA: Not Applicable; COC Screening Levels based on TEH Concentration

NOTES:

1 The Department recommends consulting with a NELAC laboratory prior to collecting samples for analysis to determine its ability to analyze for the COCs.

2 Other test methodologies not listed here may be appropriate for a specific COC. If an alternate laboratory methodology is desired, a prior written request must be submitted to the Department with appropriate supporting material.

3 Methods promulgated by USEPA. Specific information regarding these methods can be found in EPA SW-846 Test Methods for Evaluating Solid Waste.

4 The Iowa Hygienics Laboratory methods OA-1 and OA-2 are not EPA promulgated methods, but the Department has approved them for use. Method OA-1 will analyze specifically for the BTEX compounds; Method OA-2 is to be used in conjunction with the TEH surrogate method.

5 The need to sample and analyze for these chemicals will be determined on a case-by-case basis as dictated by the product storage history and approved by the Department.

6 Analyze with most current test method revision.

7 Also refer to discussion in Section 4.2.2.

8 When utilizing Method OA-2, request the laboratory to use the standard for those “heavy” petroleum products that were or may have been released, but not specifically mentioned in Table 4-1, such as naphtha, Stoddard solvent, motors oils, home heating and fuel oils, hydraulic oil, etc.

4.3 SITE INFORMATION

4.3.1 Maps

A number of maps depicting a variety of relationships between the release and the affected environment and potential receptors must be prepared for the investigation report. General and specific map requirements are provided below.

4.3.1.1 General Map Requirements

Maps may be in 8.5- by 11-inch format or 11- by 17-inch format.

Maps are to be to scale and include:

- north arrows;
- numeric and bar scales; and,
- a legend which includes the site name, Department spill file number, map title, map date and explanation of any symbols used.

4.3.1.2 Area Map

The Area Map is to be a general map showing the location of the facility within the bounds of the community or area in which it is found (e.g., from a USGS topographic map). In addition to the general map requirements listed above, this map must show the location of all water supply wells as designated under Section 4.4.3, all surface water bodies within 1000 feet and all dwellings and sensitive population centers (see also Section 4.4.1) within 500 feet of the site's source area(s).

4.3.1.3 Site Map

The Site Map is to be a larger scale map providing detail of the area within approximately 200 feet of the facility's source area(s). In addition to the general map requirements listed above, this map must provide the location of all subsurface structures and utilities, any water supply wells, any surface water bodies, any dwellings and sensitive population centers, all sampling point locations (including vapor assessment locations) and the ground water flow direction within this area (including ground water elevation contours). This map is also to include the location of a semi-permanent to permanent benchmark from which the locations of all monitoring wells (and respective ground water samples) are referenced in the investigation narrative.

4.3.1.4 Free Product Map

The Free Product Map is to be a larger scale map providing details about the location, orientation, and apparent free product thickness of a free product plume (if discovered during the course of a Tier 1 investigation). In addition to the general map requirements listed above, this map must provide isopleths for plume thickness, the location of all buildings, subsurface structures and utilities, any water supply wells, any surface water bodies, any sensitive population centers, all sampling point locations (including vapor assessment locations) and the local ground water flow direction.

4.3.1.5 Tier 2 Contaminant Plume Maps

The Tier 2 Contaminant Plume Maps are to be larger scale maps providing details about the location, orientation, and quantitative sampling results of the COCs under investigation. Because sampling locations are limited at the Tier 1 level, and the specific extent of contamination has not been defined, the Contaminant Plume Maps are required only for releases that initiate a Tier 2 investigation. Individual plume maps are to be provided for each individual COC for each media being investigated (i.e., ground water, subsurface soils, soil vapor) and include isoconcentration lines for the lateral extent of the specific COC (include all analytical sampling results). In addition to the general map requirements listed above, these maps must provide the location of all buildings, subsurface structures and utilities, any water supply wells, any surface water bodies, any sensitive population centers, all sampling point locations (including vapor assessment locations) and the ground water flow direction within this area.

4.3.2 On-site Ground Water Use

Information is to be provided regarding ground water use within the property boundaries of the release site. Documentation of this information is to include the number and use of any water supply wells, as well as any information regarding the construction and production capacities of the wells (depth, screened interval, diameter, etc.). If no on-site water supply wells exist, information is to be provided regarding the on-site water supply source.

4.3.3 Regional Hydrogeology & Aquifer Characteristics

Information is to be provided regarding the regional hydrogeology and nature of the underlying aquifer. This information includes, but is not limited to, depth to ground water, seasonal fluctuations, regional ground water flow direction, controls over ground water flow in the area, subsurface stratigraphy, and aquifer thickness and aquifer parameters (e.g., hydraulic conductivity, transmissivity, storativity). Potential sources of this information include, but are not limited to the USGS and the University of Nebraska Conservation and Survey Division.

4.4 ADJACENT LAND USE & RECEPTOR INFORMATION

4.4.1 Current Land Use

Information regarding land use in the area around a petroleum release is needed for site evaluation and determination of the appropriate RBSLs and SSTLs. At the RBCA Tier 1 level, the Department classifies each release site as “Residential” or “Commercial” based on land use within a 500-foot radius of the site. “Residential,” for the purposes of this document, refers to the presence of dwellings (e.g., houses, apartments) and/or sensitive population centers (e.g., schools, day care centers, hospitals, nursing homes). Sites that cannot be classified as residential, based on the preceding definition, are characterized as being in a “Commercial” setting.

At the RBCA Tier 2 level, on-site and off-site land use will be determined on a site-specific basis for properties directly or potentially affected by the petroleum release.

4.4.2 Future Land Use

The potential for future changes in area land use must be considered during the data collection process. The current property owner is to be interviewed for known development or land use changes that would affect the property’s classification as residential or commercial (with the interview documented in the Tier 1 report).

4.4.3 Water Well Survey

Information regarding the location and distance of water supply wells must be gathered. Water supply wells include municipal, domestic, irrigation, industrial, and stock water wells. This definition also includes sand points, hand-pumped wells, etc. used in activities such as, but not limited to, lawn irrigation or as a park water supply. The RP/consultant is to collect information on:

- all municipal wells within 2000 feet of the source area(s),
- domestic, irrigation, industrial, and stock wells within 1000 feet, and
- sand points and hand-pumped wells within 500 feet.

The information should include the depth of well, screened interval, type and duration of use, and Nebraska Department of Natural Resources Registration number, where available.

At the Tier 1 level, all water supply wells described above are treated as potential points of exposure (POEs). At the Tier 2 level, only those water wells that influence or are threatened by the contaminant plume are considered potential POEs.

4.4.4 Receptors and Points of Exposure

"**Receptor**" refers to any humans potentially exposed acutely (short-term) or chronically (long-term) to any COCs from a petroleum release.

"**Points of Exposure**" (POE) refers to the locations at which the receptor is potentially exposed, such as water wells or basements. POEs may be actual or hypothetical (future-use) locations, depending on ground water use or the location of structures in the area.

4.4.5 Ecological Exposures Survey

Permanent surface water bodies within 1000 feet of the source are to be visually inspected for petroleum sheens possibly emanating from the source. Permanent surface water bodies refer to any river, stream, lake, pond, wetland, sand pit, quarry or similar water body which is likely to have water year round or a significant portion of the year. All surface water bodies must be assessed for the presence of free product, petroleum sheen or petroleum contaminated seeps. When any of these situations are encountered on or in surface water, the Department project manager must be contacted by the next business day. The need for additional assessment of these surface water bodies or other potential ecological exposures (e.g., endangered or threatened species considerations) will be determined by the Department.

4.5 FREE PRODUCT ON GROUND WATER

Free product will be defined as measurable (≥ 0.01 feet) petroleum product thickness that is present as a non-aqueous phase liquid (but will not include a product sheen). If free product is detected on ground water during the site investigation, the Tier 1 or Tier 2 site assessment for exposure pathways involving ground water will be amended to include a subsurface investigation to assess the extent of the free product plume. Many of the site ground water investigation data requirements will be suspended until free product has been removed at the site. The minimum investigation data requirements for a free product assessment are provided below.

4.5.1 Minimum Free Product Assessment Data Requirements

1. Items 1 – 5 of Section 5.1 (covering historical information, land use assessment, identification of petroleum product released and appropriate COCs, location and number of source areas, and potential POE information).

2. Subsurface soil and surface soil (where applicable) samples must be collected, for the appropriate COCs analysis. The actual number of samples to be analyzed is described in Section 5.2.1 (for subsurface soils) and Section 5.2.2 (for surface soils).

3. The extent and magnitude of free product must be assessed by placing monitoring wells outward from the source areas in such a manner as to allow for the full lateral delineation of the free product plume and by measurement of apparent free product thickness in the wells.

4. On-site subsurface structures, including but not limited to sewer lines (storm and sanitary), utility conduits, and basements, must be assessed for the presence of vapors. Subsurface utilities must be assessed for the presence of explosive vapors. Buildings directly above the free product plume must be assessed for the presence of **any** petroleum vapors using the procedure provided in Sections 4.5.3 and 4.6.6.

5. In instances where a water supply well is impacted or may be threatened, installation and ground water sampling of a sentinel monitoring well(s) placed between the water supply well and the free product plume may be required by the Department's project manager. Several sentinel monitoring wells may be required and may be screened at varying depths.

4.5.2 Free Product Map

The Free Product Map is to be a larger scale map providing details on the location, orientation, and apparent free product thickness of a free product plume (if discovered during the course of a Tier 1 investigation). In addition to the general map requirements listed above, this map must provide isopleths for plume thickness, the location of all buildings, subsurface structures and utilities, any water supply wells, any surface water bodies, any sensitive population centers, all sampling point locations (including vapor assessment locations), permanent or semi-permanent benchmark, and the area ground water flow direction.

4.5.3 Vapor Assessment

An initial vapor assessment of potentially impacted subsurface structures (e.g., basements, sanitary and storm sewers) is to be conducted using a photoionization detector (PID) or flame ionization detector (FID). If elevated levels of contamination are detected with the PID/FID, additional site screening is to be performed using a combustible gas indicator (CGI) or other explosimeter. If explosive vapor concentrations are detected at a level >1% of the lower explosive limit (LEL) within a structure, as indicated by the explosimeter, the local fire department, State Fire Marshal's Office (see Appendix F), and the Department must be contacted immediately. These agencies will then determine the need for immediate mitigative actions.

If any vapor concentrations are detected within a building and do not represent an explosive hazard as described in the preceding paragraph, then the Department must be contacted by the next business day. The Department will then determine what actions are needed in the immediate, short-term and long-term time frames to mitigate the vapor problem.

If no vapor concentrations are detected, the Department's project manager is to be provided with this information by the next business day when alerted about the presence of free product. When the free product assessment work has been completed, a free product assessment report must be completed using the report format sheets designated by the Department (see Appendix B). The free product assessment report must be submitted on or before the original compliance date set for the site investigation report. Required remedial actions will be determined by the Department based on this report.

4.6 GENERAL SAMPLING REQUIREMENTS

4.6.1 General Subsurface Advancement/Sample Collection Methods

Samples must be obtained using one of the following methods:

1. Boring and monitoring well drilling methods must adhere to the criteria described below. Monitoring wells are to be constructed as directed under Nebraska Title 178 - Water Well Standards (administered by the Nebraska Health and Human Services System's Department of Regulation and Licensure). NOTE: The Department prefers that monitoring wells screened above the ground water table be sealed using bentonite granules or chips, and that wells screened below the water table be sealed using only bentonite granules.

2. Direct push technologies that allow for the collection of all data required under this section, allow for the identification and measurement of apparent free product thickness, and do not violate Title 178 requirements. Use of a direct push technology for the installation of permanent monitoring wells is currently not an acceptable method under Title 178.

3. Other methods approved by the Department.

A hollow stem auger is the preferred drilling method for environmental assessments. Solid stem augers may be used when the material being drilled will maintain its integrity throughout the length of the boring without the aid of outside support and **only** after Department approval. If there is any chance the borehole will distort (i.e., cave, heave, slough, etc.), solid stem augers are not to be used. Samples must be collected ahead of the drill string when either auger drilling method is used.

Air rotary, mud rotary and/or cable tool drilling methods may be necessary in certain circumstances (e.g., excessive ground water depth, near surface bedrock). However, such methods generally preclude the collection of soil samples as required by the Department. In such cases, either hollow stem augers will need to be used in conjunction with the alternate drilling method for subsurface soil sampling or the consultant must provide adequate evidence that the required and representative soil samples can be collected using the alternate drilling method. Contact the Department's project manager for approval of alternate drilling methods and additional requirements.

4.6.2 Soil Sample Collection Methods

Methods to be used in the sample collection of subsurface soils are as follows:

4.6.2.1 Continuous Sampling

Since one of the objectives in the sampling of a source area is to collect samples from what are suspected or perceived as the most contaminated portions of the boring, continuous sampling of all borings used to characterize soil contamination is required. Soil samples are to be collected using split-barrels (split-spoons) or thin-walled tubes as described in ASTM D 1586-84 Method for Penetration Test and Split-Barrel Sampling of Soils and ASTM D 1587-83 Practice for Thin-Walled Tube Sampling of Soils.

All soil samples will be split into at least two different portions or aliquots at the time of sampling. One portion will be used for headspace analysis and characterization. The other portion(s) will be transferred to and sealed in an appropriately prepared sample jar for possible laboratory analysis, and immediately placed on ice.

Tier 1 borings: Continuous sampling is required at all source area boring/monitoring well locations. Continuous sampling is not required at any non-source boring/monitoring well location.

Tier 2 borings: Continuous sampling will be required at downgradient and cross gradient locations to characterize the geology across the site in addition to the borings used to characterize soil contamination. Where a boring is continuously sampled solely for the purposes of describing the site geology, analytical samples are not required. This information will be used to construct geologic cross sections parallel and perpendicular to the ground water flow direction.

4.6.2.2 Field Analysis

For consistency, only static headspace analysis for field analysis of soil samples is to be used. Static headspace analysis must be performed using the following method:

a. Place the soil sample in a clean, wide-mouth glass jar with a screw-on, airtight lid. (Plastic bags are not allowed for field and laboratory analysis.)
b. Fill the jar one-half full with the soil sample.
c. Cover the mouth of the jar immediately with aluminum foil and secure the lid.
d. Place the jar in an environment above 60^{o} F for 30 minutes.
e. Measure the contaminant level by removing the lid and puncturing the foil immediately with the instrument probe.
f. Record the highest level that the instrument registers.

Acceptable field instruments are Photoionization Detectors (PIDs), Flame Ionization Detectors (FIDs), and portable Gas Chromatographs (GCs). At a minimum, all field instruments are to be cleaned prior to use at each site and calibrated immediately before use and at regular intervals during use in accordance with the manufacturer's specifications.

4.6.2.3 Laboratory Analysis

The following procedure is to be used in collecting laboratory samples:

a. Prior to sampling, contact the laboratory for specific apparatus requirements.
b. Place soil samples (do not compact soil) in glass jars and quickly seal with air tight, Teflon-lined, screw-on lids.
c. Leave as little headspace as possible in the container.

In an effort to limit the loss of volatile organics during sample collection and shipping, portion(s) of each soil sample interval must be delivered to an appropriately prepared sample jar for possible laboratory analysis and immediately placed on ice. Once all field analyses have been performed, the appropriate number of samples, corresponding to the locations of highest contamination as documented by field analysis, is to be submitted for laboratory analysis.

4.6.2.4 Sampling of Surface Soils

Surface soil samples are to be obtained from a depth between 0.5 and 3 feet BGL using split-barrel or thin-walled tubes (see Section 4.6.2.1). Field screening of a portion of the sample is to be performed in accordance with Section 4.6.2.2. The portion of the cored sample used for laboratory analysis is to be collected in accordance with Section 4.6.2.3.

4.6.3 Monitoring Well Development

While there is some debate regarding the effectiveness of well development on monitoring wells that straddle the water table and/or are installed in fine-grained materials, Nebraska Title 178 requires that all cased water wells be developed. Monitoring wells are to be developed using a method that will maintain the integrity of the well materials. Well development should continue until visibly clear water is discharged from the well or until indicator parameters (i.e., temperature, pH, conductivity) have stabilized. Any drilling method that involves the use of drilling fluids (e.g., mud rotary or head of water on hollow stem augers) must account for the volume of the fluid used when developing the well.

Sufficient time must be allowed following monitoring well installation and/or development for ground water in the well to reach equilibrium conditions before ground water samples for analytical analyses are collected. This time will vary based on site-specific conditions and will be at the discretion of the consultant. Well development does not suffice as a purging event.

4.6.4 Purging of Monitoring Wells

4.6.4.1 Monitoring Wells in Sands or Gravels

Monitoring wells screened in sands or gravels and sampled for dissolved phase contaminants must be purged prior to sample collection (but never purge a well dry). Allowable methods of purging are:

- pneumatic pumps;
- centrifugal pumps;
- positive displacement pumps;
- bailing (provided the bailer is lowered gently into ground water)

The method used must minimize the agitation of formation water entering the well during the purging process. Three to five well volumes are to be removed, or the well is to be purged until the physical parameters of pH and conductivity stabilize within ±10% difference and temperature within ±1% for three consecutive readings. These physical parameters are to be measured after removing each well volume. The total water volume removed and field measurements are to be included in the assessment report.

4.6.4.2 Monitoring Wells in Fine Grained Materials (clays, silts, or very fine sands)

Low-yield wells in which the screen intersects the ground water table and which may bail dry are not to be purged. Low-yield wells totally screened below the water table are to be purged of stagnant water only to the top of the screen. The method used must minimize the agitation of formation water entering the well and any fine-grained material within the well. The preferable method is to use low-flow pumps.

4.6.5 Ground Water Sample Collection Methods

Any method used to collect ground water samples must minimize agitation. Suction, airlift (inertial lift) or peristaltic pumps are not to be used to collect samples. Acceptable sampling methods include the use of:

- gear-drive pumps;
- helical rotor pumps;
- pneumatic piston pumps (sealed drive gas);
- bladder pumps;
- passive diffusion bag samplers (for wells totally screened below the water table where MTBE is not identified and a vertical gradient is not present in the aquifer;
- bailing (provided the bailer is lowered gently into ground water)
- Hydrosleeves®

Laboratory requirements for sample containers and methods of preservation must be followed. These requirements may be COC-specific. Always include the sampling method in workplans and investigation report narratives. Once the monitoring wells have been opened and allowed to equilibrate, wells are to be sampled from least contaminated to most contaminated. Ground water samples are to be collected in the following order:

(1) VOCs (BTEX, n-hexane, MTBE)
(2) Total Extractable Hydrocarbons

4.6.6 Vapor Assessment

Initial vapor assessment of potentially impacted subsurface structures (e.g., on-site basements [including craw spaces and similar structures] and on-site and proximate sanitary and storm sewers) is to be conducted using a photoionization detector (PID) or flame ionization detector (FID). If elevated levels of contamination are detected with the PID/FID, additional site screening is to be performed using a combustible gas indicator (CGI) or other explosimeter to determine the extent of the vapor impact. If explosive vapor concentrations are detected at a level >1% of the lower explosive limit (LEL) within a structure, as indicated by the explosimeter, the local fire department, State Fire Marshal's Office (see Appendix F), and the Department must be contacted immediately. These agencies will then determine the need for immediate mitigative actions.

If any vapor concentrations are detected within a building and do not represent an explosive hazard as described in the preceding paragraph, then the Department must be contacted by the next business day. The Department will then determine what actions are needed in the immediate, short-term and long-term time frames to mitigate the vapor problem.

4.7 SATURATED ZONE CHARACTERISTICS

4.7.1 Hydraulic Conductivity

Site-specific values for hydraulic conductivity based on slug or pump tests will not be required for Tier 1 and Tier 2 investigations. Hydraulic conductivity values are to be selected from the values provided in Table 4-2, based on sediment type and other descriptive features (e.g., sorting) from the boring logs.

4.7.2 Hydraulic Gradient

The hydraulic gradient is to be determined by taking the difference in hydraulic head (in feet) between two or more wells screened in the same aquifer aligned in the direction of ground water flow and dividing by the distance (in feet) between the wells.

4.7.3 Depth to Ground Water

The depth to ground water is one of the factors used to determine the appropriate RBSLs and calculation of SSTLs for the following exposure pathways:

- Soil leaching to ground water
- Intrusion of vapors to structure from contaminated ground water

For estimating RBSLs and SSTLs for the intrusion of vapors from contaminated ground water pathway, depth to ground water must be measured from below the bottom of a basement or crawl space, if present, or from ground surface, if no basement or craw space is present.

The thickness of the vadose zone is based on the depth below grade at which the ground water interface is encountered. Depth to ground water information must be collected as follows:

1. Reference elevations to a local or United States Geological Survey (USGS) benchmark. A local benchmark would be any arbitrary, permanent, nearby feature or structure to which all subsequent elevation can be referenced over a number of years. Measure the depth to water to within 0.01 foot from the top of the monitoring well casing.
2. Place a permanent mark on the well casing so all subsequent sampling events are measured from the same spot.
3. Take measurements with an interface probe or electronic measure tape (E-line).

Static water levels are dependent on site-specific conditions, including well construction, which could lead to aberrant ground water level readings. The use of stick-up wellhead protectors and vented caps may greatly reduce the time needed to obtain true static water levels; however, vented caps are not to be used when the well is constructed in an area prone to flooding or surface drainage. Open all wells and allow adequate time for water levels to stabilize prior to taking water level measurements. All water levels for the development of ground water contour maps are to be obtained during a single measurement event. All water level measurements and the time (i.e., date, hour, minutes) they were taken are to be recorded and submitted as part of the assessment report.

4.7.4 Ground Water Table Variations

Seasonal variations in water table depth and flow direction should be included, if known. This information may be gathered as either: 1) site specific data or 2) “areal” information based on past investigation and monitoring at other nearby release sites.

Table 4-2. Estimated Hydraulic Conductivity (K) Values from Particle Size Descriptions

Grain Size	Degree of Sorting			Silt Content		
	Poor ft/d	Moderate ft/d	Well ft/d	Slight ft/d	Mod. ft/d	Very ft/d
Clay and Silt						
Clay	0.7	----	----	----	----	----
Clay, silty	1.3	----	----	----	----	----
Silt, clayey	2.7	----	----	----	----	----
Silt	6.7	----	----	----	----	----
Silt, sandy	10.7	----	----	----	----	----
Sand and Gravel						
Very fine sand	13.4	20.1	26.7	22.7	18.7	13.4
VF to F sand	26.7	26.7	----	24.1	20.1	13.4
VF to M sand	36.1	----	----	32.1	26.7	20.7
VF to C sand	48.1	----	----	40.1	30.7	24.1
VF to VC sand	58.8	----	----	50.8	40.1	29.4
VF sand to F gravel	76.2	----	----	66.8	52.1	38.1
VF sand to M gravel	98.9	----	----	80.2	65.5	49.5
VF sand to C gravel	128.3	----	----	107	85.6	64.2
Fine sand	26.7	40.1	53.5	33.4	26.7	20.1
F to M sand	53.5	66.8	----	48.1	39.4	30.1
F to C sand	57.5	----	----	53.5	42.8	32.1
F to VC sand	70.2	----	----	60.2	47.5	34.8
F sand to F gravel	88.2	----	----	73.5	58.8	44.1
F sand to M gravel	113.6	----	----	93.6	74.9	56.8
F sand to C gravel	145.1	----	----	107	86.9	72.2
Medium sand	66.8	80.2	93.6	63.5	51.5	40.1
M to C sand	73.5	93.6	----	72.2	57.5	42.1
M to VC sand	84.2	----	----	73.5	60.8	48.8
M sand to F gravel	103.6	----	----	83.6	68.2	52.1
M sand to M gravel	131	----	----	113.6	81.6	65.5
M sand to C gravel	164.4	----	----	133.7	108.3	82.2
Coarse sand	80.2	107	133.7	93.6	73.5	53.5
C to VC sand	93.6	133.7	----	93.6	74.9	56.8
C sand to F gravel	116.3	----	----	107	87.6	68.2
C sand to M gravel	147.1	----	----	113.6	93.6	73.5
C sand to C gravel	184.5	----	----	133.7	99.6	92.2
Very coarse sand	107	147.1	187.2	113.6	93.6	73.5
VC sand to F gravel	133.7	213.9	----	120.3	103.6	86.9
VC sand to M gravel	169.8	----	----	147.1	123	98.9
VC sand to C gravel	207.2	----	----	160.4	131.7	103.6
Gravel						
Fine gravel	160.4	213.9	267.4	160.4	140.4	107
F to M gravel	200.5	334.2	----	200.5	167.1	133.7
F to C gravel	244.7	----	----	234	189.2	144.4
Medium gravel	240.6	320.9	401.1	240.6	200.5	160.4
M to C gravel	294.1	467.9	----	294.1	242.6	190.5
Coarse gravel	334.2	467.9	601.6	334.2	284.1	234

Source: NDEQ Wellhead Protection Program (modified from Reed and Piskin, UNL-CSD)

4.7.5 Porosity

For Tier 1, values for soil porosity (symbolized as "n") are either of two default values; sands/gravels (n = 0.30) or silts/clays (n = 0.35). The default porosity is determined based on the predominant sediment type in which a documented or potential POE (e.g., well screen, basement) occurs.

For Tier 2, porosity values are to be selected from the values provided in Table 6-2 (see Section 6.4.1).

4.8 QUALITY ASSURANCE/QUALITY CONTROL CONSIDERATIONS

To improve the overall quality and consistency of the data collected, the Department requires that certain quality assurance/quality control (QA/QC) actions be taken during the Tier 1 and Tier 2 investigations. A QA/QC program ensures that the quality of the data generated is sufficiently reliable for the RBCA process and that the results are representative, accurate, precise and comparable. Be aware that if the following QA/QC samples are not collected and the results documented in the report, the chain-of-custody is broken, or any other event occurs that may cast doubt on the quality of the data, the samples must be recollected. For Title 200 eligible releases, the costs associated with the first sampling event will likely not be considered for reimbursement.

QA/QC considerations include the following:

4.8.1 "Blind" Duplicate Samples

One duplicate ground water sample is required for every five monitoring wells sampled. This means that a typical Tier 1 investigation, consisting of four wells, would require collecting one duplicate sample. Two duplicates are required for a six to ten well investigation, three duplicates for an 11 to 15 well investigation, etc. The duplicate samples are to be collected from monitoring wells known or suspected to be contaminated. Take care to ensure that sampling bottles are not labeled as "duplicate." Duplicate samples are to be collected and analyzed for the same COCs as the original sample. Provide results in the designated Report Form.

4.8.2 Field Blanks

The purpose of field blanks is to assess the potential contribution of airborne contaminants to ground water samples. Field blanks are to be prepared by the laboratory. The sample container and preservation requirements are to comply with the laboratory requirements for the specific contaminants. Field blanks are to be analyzed for all applicable COCs for which ground water samples are being collected. A minimum of one field blank per day of sampling must be collected. One additional field blank is required whenever site conditions (e.g., when moving work efforts from a low-activity or low-traffic area like a residential area to a high-activity or high-traffic area like along a highway on the same site) and/or weather conditions change.

During the ground water monitoring well sampling event, the field blank must be opened and exposed to ambient conditions for a period equal to the time typically taken to obtain the monitoring well sample (any subsequent field samples are to be exposed for the same duration as the first. Record how long the field blank was exposed to ambient conditions on the QA/QC form. After closing the blank VOC vials, inspect them for bubbles and note any problems on the chain-of-custody only. Provide results in the designated Report Form.

4.8.3 Trip Blanks

The purpose of the trip blank is to assess if sample bottle preparation, sample shipment, and laboratory handling and storage practices impact sample integrity. The blank water sample(s) must be prepared by the laboratory or in the office prior to traveling to the site for the sampling event and must remain untouched while in the shipping container. The trip blank must be preserved as required by the laboratory and maintained under the same chain-of-custody as the other samples. One trip blank of is required for each cooler used during the sampling event. Trip blanks are to be analyzed for all applicable COCs for which ground water samples are being collected. Provide results in the designated Report Form.

4.8.4 Temperature Blanks

The purpose of a temperature blank is to ensure that samples have been maintained at a temperature of 4°C from the time of collection through their delivery to the laboratory. Temperature blanks may be provided by the laboratory or the temperature may be measured in the field using a laboratory-grade thermometer prior to sealing the shipping container. If the samples are not delivered at 4°C (±2°C), the laboratory must note this on the chain-of-custody. Consequently, the Department may consider the data quality questionable. One temperature blank is required for each shipping container. Provide results in the designated Report Form.

4.8.5 Chain-of-Custody

The chain-of-custody record is to be started upon creation of the trip blank(s). A copy of the chain-of-custody is to accompany each sampling event through delivery of the samples to laboratory. A copy of the chain-of-custody record is to be included in the investigation report. All samples must be maintained under the chain-of-custody. If the chain-of-custody is broken, samples must be recollected after informing the Department of the event. A site investigation report will not be accepted by the Department when the chain-of-custody has been broken.

4.8.6 Field Instrumentation Calibration

Field instruments are to be calibrated immediately before use and at regular intervals during use according to the manufacturer's specifications. Calibration intervals are to be included in the narrative section of the final report.

4.8.7 Decontamination of Sampling Equipment

In addition to ensuring field instruments are cleaned and properly maintained, new or laboratory cleaned sample containers must be used for the collection of each soil or ground water sample. In addition, the following decontamination requirements apply to ancillary sampling equipment.

4.8.7.1 Soil Samples

The sample collection device (e.g., split-spoon, Shelby tube), and any other instrument contacting the sample, must be decontaminated between each sample. At a minimum, decontamination is accomplished by washing the device with a laboratory-grade detergent (e.g., Alconox, Detergent 8) after removing all loose material, followed by two clean water rinses (final rinse of deionized water). The soil sample must be placed in a new or laboratory cleaned sample container. Auger stems are to be decontaminated (e.g., steamed-cleaned, scrubbed with a laboratory grade detergent) before drilling a new borehole.

4.8.7.2 Ground Water Samples

The order of sampling is to be from the least contaminated to most contaminated well. Any device used to purge (where applicable) or sample a monitoring well must be appropriately decontaminated (see 4.8.7.1) prior to introduction into the well. If a bailer is to be used to collect a water sample, it must be a new, disposable bailer or a laboratory cleaned, reusable bailer. New bailer line must be used for each well (unless Teflon-coated, allowing for decontamination). The water sample must be placed in a new or laboratory cleaned sample container.

Refer to ASTM Standard D 5088-90 Standard Practice for Decontamination of Field Equipment Used at Nonradioactive Waste Sites for additional information concerning the decontamination of drilling and sampling equipment exposed to other contaminants.

4.9 DOCUMENTATION OF NEBRASKA RBCA INVESTIGATION

The information gathered for the RBCA investigation is to be documented and recorded on the forms provided by the Department for the particular RBCA Tier assessment. Hard copies of these Report Forms can be found in Appendix B (Tier 1) and Appendix C (Tier 2). Usable versions of these forms in Microsoft Excel format may be obtained upon request or downloaded from the Department's web page (www.deq.state.ne.us; see Publications/Forms).

In addition to the Report Forms cited above, the following additional information is to be provided in the general formats discussed below.

4.9.1 Maps

Maps as discussed in Section 4.3.1 are to be included in the investigation report.

4.9.2 Boring/Monitoring Well Data

4.9.2.1. Boring Logs

Boring logs (or the results obtained from direct push technologies or other approved methods) are to include the following information:

a. Consultant company name.
b. Project name.
c. Drilling contractor name (if other than consultant) and license number.
a. Names of personnel present in field.
b. Date and time drilling started and ended.
f. Boring identification number.
g. Surface elevation.
h. Boring location.
i. Drilling method.
j. Sediment description and classification (provide system used).
k. Sample collection depth intervals.
l. Field screen/laboratory analysis results.
m. Sample collection method.
n. Total depth of boring.
o. Depth to water at time of drilling. Include date and time of measurement.
p. Stabilized depth to water. Include date and time of measurement.
q. Indicate if the boring was abandoned or completed as a permanent monitoring well.

4.9.2.2. Monitoring Wells

Information for monitoring wells is to include the information listed below.

a. Well identification number.
b. Installation date.
c. Top of casing elevation.
d. Ground level elevation.
e. Screen slot size.
f. Casing and screen material.
g. Length of screen (should never be >10 feet unless approved).
h. Screened interval depths.
i. Stabilized water level.
j. Gravel-pack material and interval.
k. Bentonite seal interval(s).

l. Bottom of well elevation.
m. Grout type and interval(s).
n. Name and certification number of well driller.
o. Nebraska Department of Natural Resources registration number.
p. Lapsed development time, if applicable.

4.9.3 Sampling Data

The following information, at a minimum, is to be noted or provided as an appendix to the final report:

- Analytical method and version employed,
- All laboratory analysis sheets produced by the analytical laboratory, and
- All chain-of-custody sheets generated.

SECTION 5.0 TIER 1 SITE INVESTIGATION

Prior to initiating a Tier 1 site investigation, the Department requires that a workplan, complete with the proposed sampling locations, and cost estimate be submitted for review for Title 200 eligible sites. A workplan, without a cost estimate, is required for non-Title 200 eligible sites. The RP is to proceed with the Tier 1 site investigation within the established time schedule once they receive the Department's approval letter.

The following provides guidance regarding the information required to complete the requirements of a Tier 1 investigation. The Minimum Site Assessment Data Requirements section provides a general outline of the required information. Detailed requirements for specific tasks in the site investigation are referenced as needed.

Direct push technologies may be used to collect data for a Tier 1 investigation, with the exception of installing permanent monitoring wells (not allowed under Nebraska Title 178). However, if additional remedial actions are required at any other time during the remedial action process, permanent monitoring points constructed in accordance with Title 178 regulations may be required.

5.1 MINIMUM TIER 1 SITE ASSESSMENT DATA REQUIREMENTS

The minimum investigation data needs for a petroleum release Tier 1 site assessment are as follows:

1. Historical information, particularly of past releases and the results of any associated investigation(s), if any.

2. Identification, location, and number of source areas to be investigated. See Section 3.0.

3. Identification of petroleum product(s) released to the environment (used to determine the appropriate COCs). See Section 4.2.

4. An assessment of land use in the area of the release site. See Section 4.4.

5. Information regarding:

   - The location and distance of water supply wells as provided in Section 4.4.3;
   - The location of permanent surface water bodies within 1000 feet of the source area(s); and,
   - The location of all structures, including all buildings (and depths of any associated basements) and subsurface utilities within 200 feet of the source area(s). It is important to ascertain if the buildings have subsurface structures (e.g., basements).

   NOTE: It is only since 1993 that domestic water wells had to be registered with the State. Many domestic wells will not appear in the Nebraska Department of Natural Resources registered well database. Consequently, it is very important that a house-to-house survey be conducted to determine if any domestic drinking water wells are located within 1000 feet of the source area(s). In addition, local water/utility superintendents are a useful source of such information.

6. The presence of free phase petroleum product on ground water should be determined as described under Section 4.5.

When free product is encountered on ground water, certain site investigation requirements for Tier 1 ground water sampling will be suspended until all free product issues have been resolved. In such an instance, the RP is still responsible for performing all actions and providing all information described in the FREE PRODUCT ON GROUND WATER section (Section 4.5) by the Department's established compliance date.

7. Soil and ground water samples must be collected for analysis of the appropriate COCs associated with the petroleum product(s) released to determine the on-site COC concentrations. Specific information regarding COCs and appropriate analytical methods are found in Section 4.2 and Table 4-1.

8. The actual number of samples to be obtained for laboratory analysis of the COCs is provided in Sections 5.2 (for soils) and 5.3 (for ground water).

9. An evaluation of vertical migration of the dissolved plume must be made where a water supply well may be of sufficient proximity and/or pumping capacity to influence the dissolved product plume.

10. The depth to ground water and its flow direction must be established, and saturated zone parameters (hydraulic conductivity, porosity and gradient) must be collected or provided in order to calculate ground water flow velocity. See Section 4.7.

5.2 NUMBER OF SOIL SAMPLES

The actual number of COC samples to be obtained for laboratory analysis is as follows:

5.2.1 Subsurface Soils

One to three subsurface soil samples from the vadose zone are to be analyzed from each applicable source boring/monitoring well, depending on the depth to ground water.

- Where ground water is <10 feet BGL, only one soil sample is required at the point where the highest level of contamination is measured by field instrumentation.
- Where ground water is ≥10 feet, but ≤25 feet BGL, two subsurface soil samples must be collected at the points where the highest levels of contamination are measured by field instrumentation.
- Where ground water is >25 feet BGL, two or three soil samples must be collected. Two soil samples must be obtained within the initial 25 feet BGL. For borings extending deeper than 25 feet, one additional soil sample is required **if** field instrumentation readings indicate a concentration greater than those identified in the first 25 feet of the boring. See Figure 5-1.

5.2.2 Surface Soils

Where surface soil contamination is present (i.e., recognized from ground surface staining), three soil samples are to be collected **within** each surface source area in excess of approximately one hundred square feet (100 ft^2), at different points of obvious contamination. Where the surface source area is less than approximately 100 ft^2, a minimum of one sample is to be collected. Additional samples may be collected at the discretion of the field collector. The surface soil sample(s) must be collected at the point where the highest level of contamination is measured, evident or suspected. The Department will assess the need for additional surface soil sampling during its review. (Surface soils are defined as those unsaturated materials located between 0 and 3 feet BGL. Surface soil samples are to be obtained from a depth between 0.5 and 3 feet BGL).

5.3 NUMBER OF GROUND WATER SAMPLES

The actual number of samples to be obtained for laboratory analysis is based on the following:

- One ground water sample is to be collected from a single monitoring well located upgradient of the source area(s) to establish background water quality.
- One ground water sample is collected from **each** source area.

- One ground water sample is to be collected from a minimum of one monitoring well located downgradient of the source area where petroleum contamination is of the greatest concentration.
- At least one sample is to be collected at depth from a monitoring well located between the source and water supply well if vertical migration of the dissolved plume is suspected where a water supply well may be of sufficient proximity or pumping capacity to influence the dissolved product plume, or potential downgradient recharge areas exist. The depth from which the samples are to be collected is to be based on the professional judgment of the consultant and in consultation with the Department.

5.4 TIER 1 WAIVER OF GROUND WATER SAMPLING

Drilling to and sampling of ground water may be waived if ***all*** the following conditions are met:

1. All potential source areas are investigated.

2. Clear evidence from field screening analyses and other field observations indicates the probability or likelihood that contamination has not migrated through the entire thickness of the vadose zone. (That is, field analysis no longer detects contamination in the vadose zone.)

3. The unsaturated zone interval between the point where contamination is no longer detectable with field instrumentation and the estimated depth of ground water at the site (based on regional information or past investigations in the area) is greater than 25 feet.

4. Two subsurface soil samples for laboratory analysis are collected from each boring: 1) at a minimum of five feet below the last indication of contamination and 2) a minimum of 10 feet below the bottom of the previous sample interval. These two samples are in addition to the subsurface soil samples collected at the suspected points of highest contamination as described in Section 5.2.1.

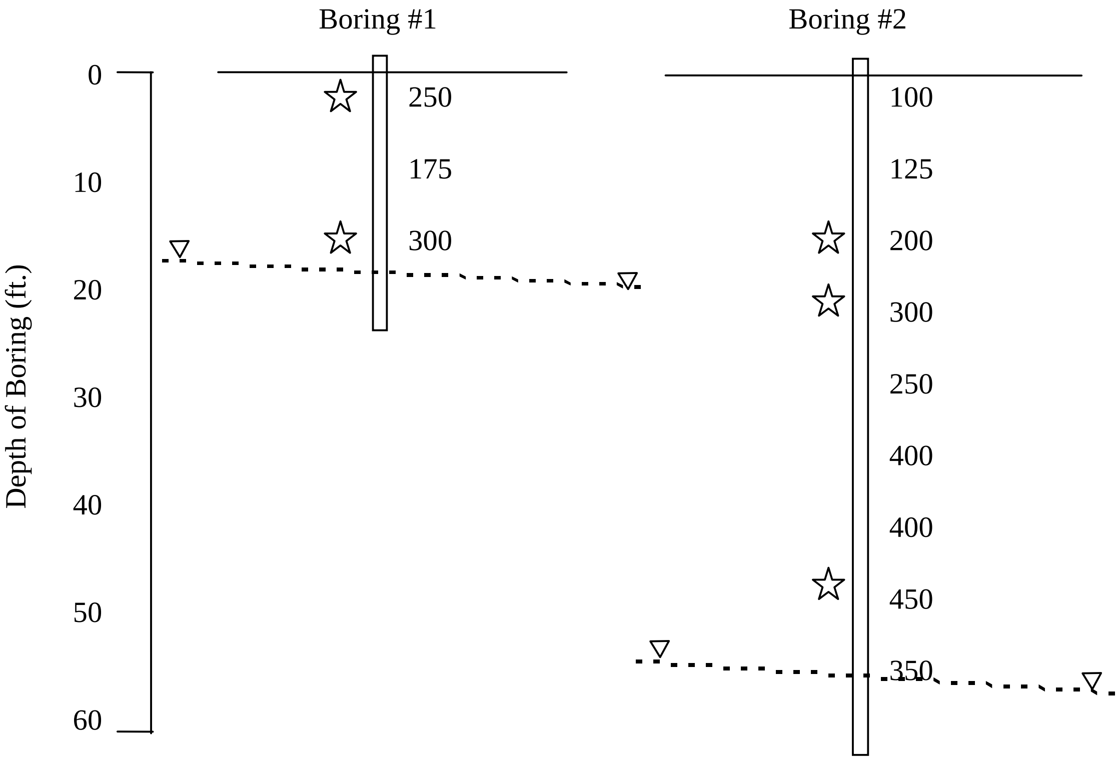
See Figure 5-2 for a visual explanation of these sampling requirements. Documentation that supports the contention that ground water is at substantial depth (i.e., information from regional ground water maps, past environmental reports) must be provided in the investigation report.

Should auger refusal (or near refusal) occur at depth before encountering ground water, a soil sample is to be collected for laboratory analysis and the results (with the collection depth) submitted in the Tier 1 investigation report. A decision concerning the use of an alternate drilling method will be made after the laboratory soil analysis results have been discussed with the Department.

5.5 TIER 1 REPORTING REQUIREMENTS

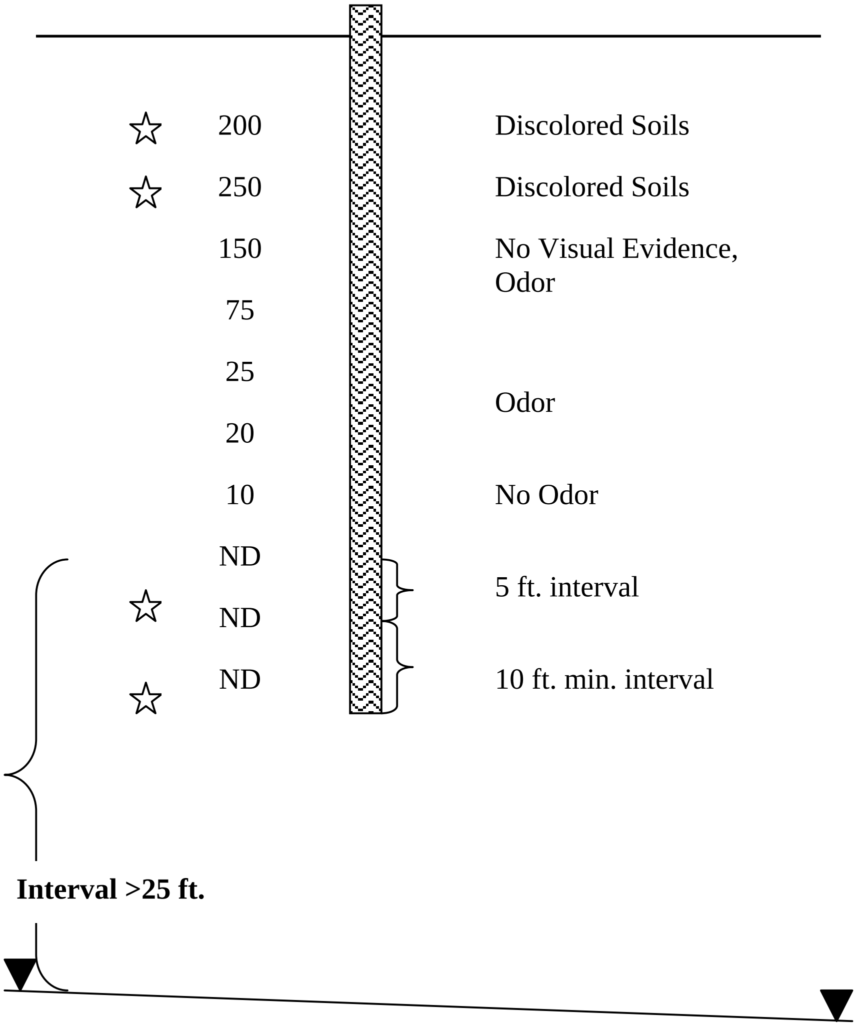
The Department has established a reporting format that the RP or their consultant is required to use for the submittal of the investigation results. The report format consists of Report Forms generated in Microsoft Excel for most of the required data. The Report Forms for Tier 1 reporting are located in the Department's RBCA software package under the Excel file: ***TIER_1_FORMS.xls***. Anyone preparing an investigation report must use these forms, copies of which can be found in Appendix B. Usable versions of these forms in Microsoft Excel format may be obtained upon request or downloaded from the Department's web page (www.deq.state.ne.us).

Figure 5-1. Example Subsurface Soil Collection Points



This figure provides a visual explanation for determining the need to collect 2 or 3 subsurface soil samples from a boring. Factors involved in this decision are depth to ground water and relative degree of contamination with depth. Field instrument readings are on the right side of the borings. Ground water is indicated by the dashed lines. Approximate sampling depths are marked by the star symbols. For Boring #1, the depth to ground water is less than 25 feet BGL, but greater than 10 feet BGL. In this circumstance, two soil samples would be required, since both samples could be used to evaluate the soil leaching to ground water exposure pathway and the enclosed space inhalation from contaminated subsurface soils exposure pathway. For Boring #2, ground water is in excess of 25 feet BGL and there is some indication of higher contaminant levels at depth as evidenced by increasing field instrument readings with depth. Under these circumstances, three soil samples would be necessary. The two samples taken within the top 25 feet of the borehole would be used to evaluate the enclosed space inhalation from contaminated subsurface soils exposure pathway. A third sample from a perceived point of higher gross contamination at depth would be needed to evaluate the soil leaching to ground water pathway.

Figure 5-2. Conditions for Discontinuing Borehole to Ground Water



This idealized figure (not to scale) illustrates the conditions under which drilling through a source area may be discontinued without completing the boring to ground water during a RBCA Tier 1 investigation. Visual, olfactory and field instrument evidence indicates no contamination is present at a point that is greater than 25 feet above the assumed level of ground water. In addition to the subsurface soil samples necessary to evaluate those exposure pathways associated with subsurface soils (see Fig. 5-1), two more subsurface soil samples for laboratory analysis are required for each source area investigated to confirm the field observations. The first sample is to be collected at a point 5 feet below the last indication of contamination, and the second collected at a minimum of 10 feet below the bottom of the previous sample interval. Approximate sampling locations in the above example boring are indicated by the star symbols.

SECTION 6.0 TIER 2 SITE INVESTIGATION

Prior to initiating a Tier 2 site investigation, the Department requires that a workplan, complete with the proposed sampling locations, and cost estimate be submitted for review for Title 200 eligible sites. A workplan, without a cost estimate, is required for non-Title 200 eligible sites. The RP is to proceed with the Tier 2 site investigation within the established time schedule once they receive the Department's approval letter.

Direct push technologies may be used to collect data for a Tier 2 investigation, with the exception of installing permanent monitoring wells (not allowed under Nebraska Title 178). However, if additional remedial actions are required after the Tier 2 evaluation, permanent monitoring wells constructed in accordance with Title 178 regulations may be required.

6.1 MINIMUM TIER 2 SITE ASSESSMENT DATA REQUIREMENTS

The minimum investigation requirements needed for a Tier 2 site assessment are presented below on an exposure pathway by exposure pathway basis. The Tier 2 investigation is to collect only that information necessary to evaluate specific pathways that failed the Tier 1 evaluation.

6.1.1 Ground Water Ingestion Pathway

1. Monitoring points must be installed to collect ground water samples for laboratory analysis of the appropriate COCs and relevant site-specific aquifer parameters. Monitoring points are to be placed in such a manner that the dissolved plume is both areally and vertically delineated to the specific COC levels found in Table 6-1.

Table 6-1. COC Ground Water Plume Delineation Levels

Chemical of Concern	Plume Delineation Concentration (mg/L)
Benzene	0.005
Toluene	1.0
Ethylbenzene	0.700
Xylenes	10.0
n-Hexane	4.0
MTBE	0.020
Naphthalene	0.020
TEH (as diesel)	10.0
TEH (as waste oil)	6.66

2. All monitoring points, including those monitoring wells from the previous Tier 1 investigation, are to be sampled for the appropriate COCs.

3. Where a water supply well (as determined during the Tier 1 investigation) may be of sufficient proximity and/or pumping capacity to influence the dissolved product plume, or potential on-site or downgradient recharge areas exist, it must be determined if vertical migration of the dissolved plume is occurring. The appropriate methods or means (e.g., multiple monitoring wells screened at different intervals) used to collect this information are to be included in the Tier 2 work plan. Boring logs and pump screen interval depth for the water supply well are to be submitted. (If pumping data or other well use information are available for a water supply well, it is also to be included in the investigation report.)

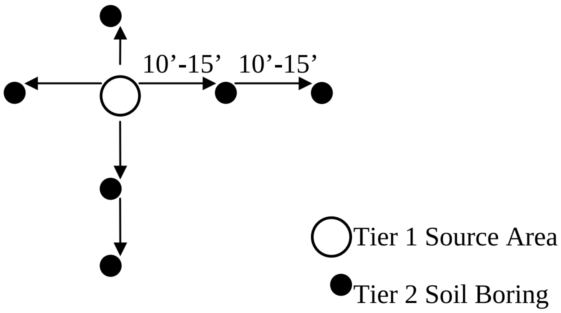
4. Depth to ground water is to be measured in all monitoring wells (after water levels have adequately stabilized) for the purposes of determining the water table gradient and refining the ground water flow direction established during Tier 1.

6.1.2 Soil Leaching to Ground Water Pathway

1. The extent of source area subsurface soil contamination (i.e., “soil contaminant plume”) in the vadose zone is to be closely estimated using soil borings (or direct push soil sampling technologies). Sampling points are to be concentrated around the source area(s) identified during the Tier 1 assessment. Where possible, sampling points are to be placed outward from the source area (at approximately 90-degree angles to each other; see Figure 6-1) at 10- to 15-foot intervals until no field evidence of source area soil contamination is found. Where such sampling is not possible, the Department is to be consulted for alternate sampling requirements. Sampling points are to be continuously sampled to determine the location(s) of maximum soil contamination and to accurately describe the site geology. Sampling of soils should be avoided where field evidence indicates contamination may be only associated with the capillary fringe away from the source area.

Figure 6-1. Idealized Placement of Tier 2 Soil Sampling Points

Idealized placement of sampling points around a source area for the Tier 2 investigation of the soil leaching to ground water or intrusion of vapors to an enclosed space from contaminated subsurface soils exposure pathways. Not to scale. Distance between Tier 1 source area sampling point and Tier 2 sampling points is approx. 10-15



2. All borings are to be sampled for the appropriate COCs and submitted for laboratory analysis. The number of soil samples collected per boring is the same as described in Sections 4.5.1 and 5.2.1.

3. Soil samples are to be collected for determination of the following physical/chemical parameters: bulk soil density (dry) and fractional organic carbon content. See Section 6.4.

6.1.3 Intrusion of Vapors to Structure from Contaminated Ground Water Pathway

1. Monitoring points must be installed to collect ground water samples for laboratory analysis of the appropriate COCs. Monitoring points are to be located to delineate the dissolved plume COCs to the levels found in Table 6-1.

2. All monitoring points are to be sampled for the appropriate COCs and the samples submitted for the appropriate laboratory analysis.

3. During the placement of the monitoring points, soil samples must be collected above the water table for determination of the volumetric water content (see Section 6.4.4).

4. Depth to ground water is to be measured in all monitoring wells (after water levels have adequately stabilized) for the purposes of determining the water table gradient and refining the ground water flow direction established during Tier 1.

5. A survey of building structures within the contaminant plume must be performed and a list of building owners (or owners' representatives), daytime telephone numbers, mailing addresses, and typical uses of space (e.g., residence, daycare, storage, etc.) must be provided in the Tier 2 Investigation Report. It is important to determine if the buildings have basements or similar structures that are habitable.

6.1.4 Intrusion of Vapors to Structure from Contaminated Subsurface Soils Pathway

1. The extent of source area subsurface soil contamination (i.e., "soil contaminant plume") within the upper 25 feet of the vadose zone around the release area is to be closely delineated using soil borings or soil gas probe points. Borings/probe points are to be concentrated in the source area(s) identified in the Tier 1 assessment. Where possible, sampling points are to be placed around the source area (at approximately 90-degree angles to each other; see Figure 6-1) at 10- to 15-foot intervals outward until no field evidence of soil contamination is found. Where such sampling is not possible, the Department is to be consulted for alternate sampling requirements. Sampling points are to be continuously sampled to determine the assumed or perceived location(s) of maximum soil contamination and to accurately describe the site geology.

2. All borings/probe points are to be sampled for the appropriate COCs and submitted for laboratory analysis. Two subsurface soil samples are to be analyzed from each sampling point. These samples are to be collected at the points where the highest level of contamination is measured by field instrumentation and are to be obtained within the initial 25 feet BGL or at points above the groundwater table, whichever is less.

3. Soil samples are to be collected for determination of the following parameters: bulk soil density (dry), fractional organic carbon content and volumetric water content. (See Section 6.4.)

4. A survey of building structures within the contaminant plume must be performed and a list of building owners (or owners' representatives), daytime telephone numbers, mailing addresses, and typical uses of space (e.g., residence, daycare, storage, etc.) must be provided in the Tier 2 Investigation Report. It is important to determine if the buildings have basements or similar structures that are habitable.

6.2 NUMBER OF BORINGS/PROBE POINTS & SOIL SAMPLES

Sampling points are to be concentrated around the source area(s) identified during the Tier 1 assessment. Where possible, borings/probe points should be placed outward from the source area (at approximately 90-degree angles to each other; see Figure 6-1) at 10- to 15-foot intervals until no field evidence of source area soil contamination is found. Where such sampling is not possible, the Department is to be consulted about alternate sampling requirements. Sampling of soils should be avoided where field evidence indicates the contamination may be only associated with a "smear zone" within the capillary fringe away from the source area.

6.2.1 Soil Leaching to Ground Water Pathway

Where ground water is less than 25 feet BGL, only one sample per boring at the identified point of maximum contamination need be obtained for quantifying contamination at depth. Where ground water is greater than 25 feet BGL, two soil samples from each boring are to be obtained: one sample within the initial 25-foot interval and a second sample between 25 feet BGL and the water table. Samples are to be obtained from intervals where maximum contamination is evident, as outlined previously.

6.2.2 Intrusion of Vapors to Structure from Contaminated Subsurface Soils Pathway

Two subsurface soil samples are to be collected from each sampling point. These samples are to be collected at points where the highest level of contamination is measured by field instrumentation and are to be obtained within the initial 25 feet BGL or at points above the ground water table, whichever is less.

6.3 NUMBER OF GROUND WATER SAMPLES

Ground water samples are to be collected within the source area(s), upgradient, and downgradient of the release in such a manner that the dissolved plume is delineated to the COC levels found in Table 6-1. For the ground water ingestion pathway, samples are also to be collected from depth if vertical migration of the dissolved plume is occurring or suspected where a water supply well may be of sufficient proximity and/or pumping capacity to influence the dissolved product plume, or potential downgradient recharge areas exist.

6.4 VADOSE ZONE SOIL CHARACTERISTICS

Certain soil parameters or characteristics used in the Department's fate and transport equations are to be selected based on the predominant soil type or determined by sampling and laboratory analysis during the Tier 2 assessment. This section provides and discusses the parameters for which the Department requires site-specific information used in the calculation of the Tier 2 SSTLs.

6.4.1 Soil Porosity

Porosity is a variable used in the Tier 2 fate and transport equations for all exposure pathways examined by the Department. Estimated values for soil porosity are to be selected from Table 6-2.

Table 6-2. Estimated Soil Porosity Values

Sediment Type	Porosity
Clay	0.42
Silt/Loess	0.47
Till, predominantly silt	0.34
Till, predominantly sand	0.31
Sand, fine	0.43
Sand, medium	0.39
Sand, coarse	0.39
Gravel, fine	0.34
Gravel, medium	0.32
Gravel, coarse	0.28

Source: Adapted from Todd (1980)

6.4.2 Capillary Zone Thickness

The relatively greater percentage of pore water in the capillary zone, compared to that of the overlying vadose zone, has a limiting effect on the diffusion of contaminant vapors partitioning from a dissolved contaminant plume in ground water. When examining the intrusion of vapors to a structure from contaminated ground water exposure pathway, information regarding the capillary zone thickness and its volumetric water content (see Section 6.4.4) must be obtained. Conservative estimated values for capillary zone thickness, based on predominant soil type, are to be selected from Table 6-3.

Table 6-3. Estimated Capillary Zone Thickness

Sediment Type	Capillary Zone Thickness (cm)
Silt/Clay	105
Sand (fine)	42
Sand (medium to coarse)	13.5
v. coarse Sand to fine Gravel	2.5
Gravel (medium to coarse)	0

Source: Adapted from Todd (1980)

Site-specific values for soil dry bulk density, volumetric water content, and fractional organic carbon content in soil are required to calculate SSTLs for the following indirect exposure pathways:

- Soil leaching to ground water
- Intrusion of vapors to structure from contaminated ground water
- Intrusion of vapors to structure from contaminated subsurface soils

6.4.3 Dry Bulk Density

6.4.3.1 Number of Samples

The number of samples needed for the analysis of dry bulk density depends on the stratigraphy of the vadose zone. One representative sample is required for each sediment variation or facies encountered.

6.4.3.2 Sample Collection Methods

Samples obtained for dry bulk density analysis are to be collected using a thin-walled Shelby tube sampler for clay samples in general accordance with ASTM D-1587 or a split-barrel sampler for sand samples in general accordance with ASTM D-4220, or some other method approved by the Department.

6.4.4 Volumetric Water Content

6.4.4.1 Number of Samples

One representative sample is required for each sediment variation or facies encountered within the vadose and capillary zones.

6.4.4.2 Sample Collection Methods

Samples obtained for volumetric water content analysis are to be collected using a thin-walled Shelby tube sampler for clay samples in general accordance with ASTM D-1587 or a split-barrel sampler for sand samples in general accordance with ASTM D-4220, or some other method approved by the Department. Samples obtained for volumetric water content analysis are to be placed in a small glass jar and tested as described in ASTM Standard D-2216 or some similar method approved by the Department. Results are to represent a volumetric value. Laboratory results provided for gravimetric values may be converted to volumetric values using the following relationship:

$$\theta_{wv} = \theta_{wg} \times \frac{\rho_s}{\rho_w}$$

where:
θ_{wv} = volumetric water content (cm^3-water/cm^3-soil)
θ_{wg} = gravimetric water content (grams-water/grams-dry soil)
ρ_s = dry bulk soil density (grams-dry soil/cm^3-soil)
ρ_w = density of water (grams-water/cm^3-water) = 1

6.4.5 Fractional Organic Carbon Content in Soil

6.4.5.1 Number of Samples

The number of samples needed for the analysis of fractional organic carbon content is dependent on the stratigraphy of the vadose zone. One representative sample is required for each sediment variation or facies within which contamination has been encountered; however, the sample(s) must be obtained from uncontaminated soils to avoid analysis interference from organic carbon associated with the petroleum contamination.

6.4.5.2 Sample Collection Methods

Samples obtained for fractional organic carbon content analysis are to be collected in a small glass jar and tested as described in ASTM Standard D-2974 or some similar method approved by the Department.

The boring location(s), depth(s), and facies from which the samples were collected for Sections 6.4.2, 6.4.3 and 6.4.4 must be documented in the Tier 2 report.

6.5 DISTRIBUTION OF COCs IN SOIL VAPOR

At the Tier 2 level, soil gas sampling may be substituted for other media sampling (with the approval of the Department) for the following exposure pathways once the ground water flow direction has been established:

- Intrusion of vapors to structure from contaminated ground water
- Intrusion of vapors to structure from contaminated subsurface soils

6.5.1 Number & Location of Soil Gas Samples

Soil gas samples are to be gathered from points located at or in:

- The source area(s);
- Adjacent to on-site and nearest off-site structures; and,
- At least one location between the source area(s) and each structure.

The depth to which sample points are to be driven, at a minimum and where applicable, are:

- The depth where the most contaminated Tier 1 soil sample was taken within a source area (for inhalation concerns from soils contamination pathway);
- Between three and six feet BGL at locations between the source area(s) and a structure (for inhalation concerns from soil contamination pathway);
- Within three feet of the ground water table over the areal extent of the ground water contaminant plume (for inhalation concerns from ground water contamination pathway);
- A depth equivalent to the bottom of and next to a basemented structure, when present (for both soils and ground water pathways); and/or,
- Between three and six feet below grade next to a slab-on-grade structure.

Note: Final soil gas sampling locations and depths will be established as part of Department's review of the Tier 2 investigation workplan and cost estimate.

6.5.2 Soil Gas Sample Collection Methods

Soil gas samples are to be collected using the following criteria:

1. The sampling point is sufficiently sealed to prevent the introduction of ambient air into the sample;
2. The sample point is purged prior to sampling to ensure a representative sample of soil gas is collected (purging times and volumes to be included in investigation narrative);
3. The soil gas sample is to be collected and analyzed using one of the following protocols:

    - In the field using a lab-quality gas chromatograph to avoid loss of volatiles in transport; or,

- Sample collection in a summa canister or similar collection device and submitted for laboratory analysis.

Soil gas sampling procedures are subject to the applicable QA/QC requirements as soil and ground water sampling procedures provided in Section 4.8. If using a field laboratory, ensure that analysis reports, company name, and analyst's name is submitted with the Tier 2 investigation report.

6.6 TIER 2 REPORTING REQUIREMENTS

The Department has established a reporting format that the RP or their consultant must use to document and submit the investigation results. The report format consists of Report Forms generated in Microsoft Excel for most of the required data. The Tier 2 Report Forms are located in the Department's RBCA software package under the Excel file: ***TIER_2_FORMS.xls***. Anyone preparing an investigation report must use these forms, copies of which can be found in Appendix C. Usable versions of these forms in Microsoft Excel format may be obtained upon request or downloaded from the Department's web page (www.deq.state.ne.us).

Additional information is to be provided in the general formats discussed under Section 4.9. In addition, geological cross sections of the investigated subsurface, including indications of contamination, are to be submitted. The cross sections are to include one cross section parallel to the ground water flow direction and an appropriate number of cross sections normal to ground water flow through the source area(s) in order to provide an understanding of the subsurface geology and subsurface contamination.

SECTION 7.0 RISK-BASED EVALUATION: GENERAL CONSIDERATIONS

7.1 INTRODUCTION

The Tier 1 and Tier 2 RBCA evaluations are performed by Petroleum Remediation Section staff using the assessment information collected by the RPs and their consultants. Sections 7.0, 8.0 and 9.0 of this document outline the procedure and parameters the Department uses for the evaluations.

Note: While the Department may provide additional material (e.g., computational computer software) to interested parties, an RP and their consultant will only be responsible for providing the site data and information outlined in previous sections of the document and the Report Forms provided by the Department. Any evaluation of the site, other than that required by the Department, will not be eligible for Title 200 reimbursement consideration for those sites that are eligible for reimbursement.

After the appropriate site assessment data has been collected, it is used to evaluate the release based on risk considerations. The initial action is to develop a site-specific exposure scenario wherein several general factors (i.e., current and potential land use, receptors, points of exposure and potential routes of exposure) are examined to determine where any potential exposures are most likely to occur. Subsequently, target levels are determined for all complete exposure scenarios. At the Tier 1 level, this consists of comparing the COC levels encountered during the site assessment to initial RBSLs developed from non-site-specific criteria. At the Tier 2 level, this consists of comparing the COC levels encountered during the site assessment to site-specific target levels (SSTLs) calculated using site-specific data. The need for initial abatement actions, monitoring and/or long-term active cleanup will then be determined by the Department.

7.2 DEVELOPMENT OF SITE CONCEPTUAL EXPOSURE SCENARIO

A Site Conceptual Exposure Scenario for each release is to be developed using the information gathered during the investigation process and characterizing the exposure pathways at risk due to the release. General factors to be examined during the development of the Site Conceptual Exposure Scenario include current and potential land use, receptors, points of exposure, and potential routes of exposure. The exposure scenario is displayed in graphical form in Figure 7-1.

7.2.1 Land Use

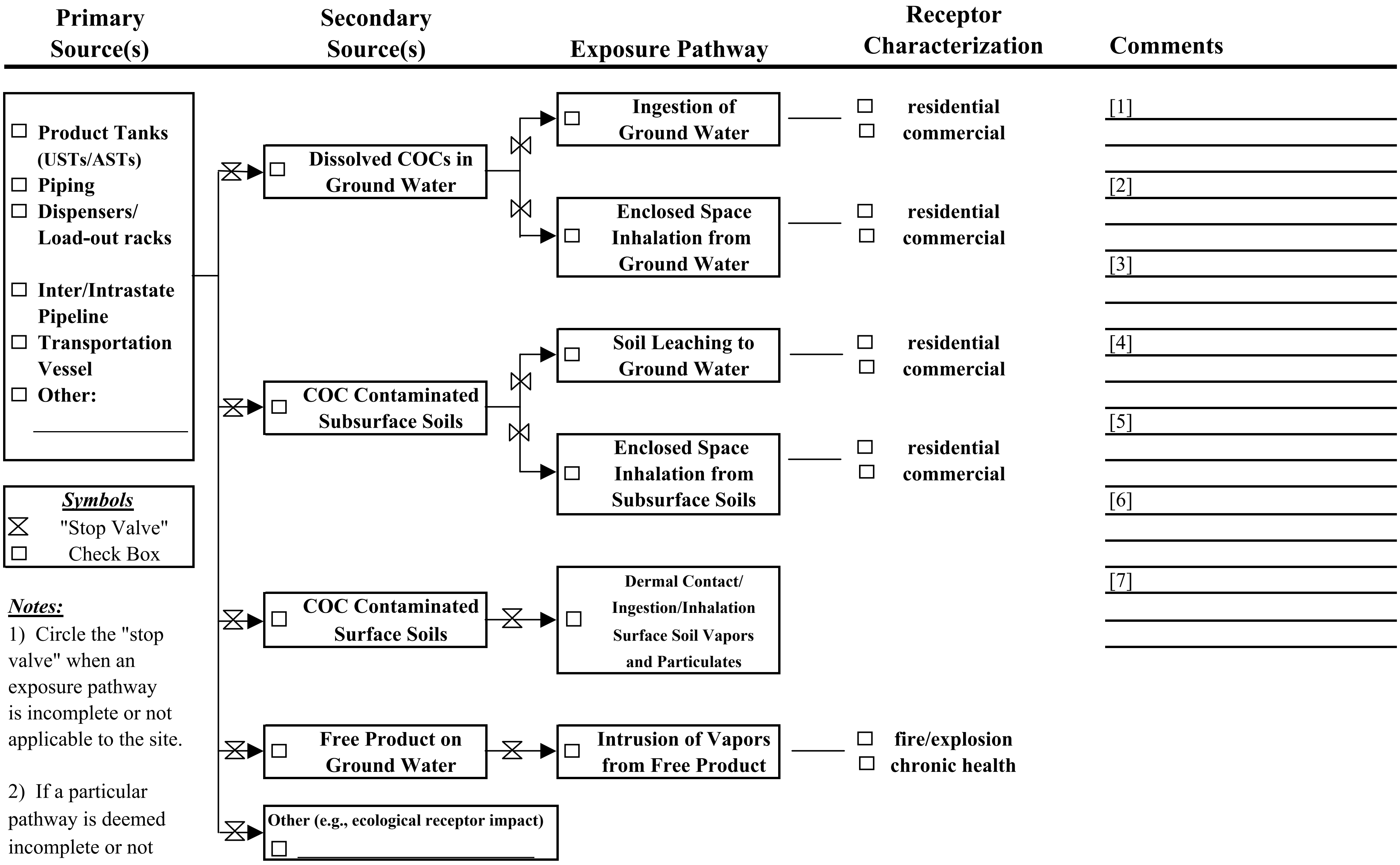
As discussed in Section 4.4, the Department will classify each site as “Residential” or “Commercial” based on land use within a 500-foot radius of the site. “Residential” refers to the presence of dwellings (e.g., houses, apartments) and/or sensitive population centers (e.g., schools, day care centers, hospitals, nursing homes). Sites that cannot be classified as residential will be characterized as being in a “Commercial” setting. In addition, potential changes in future land use must be investigated.

7.2.2 Receptors & Points of Exposure

“Receptor” refers to any humans potentially exposed to any COCs from a petroleum release.

“Points of Exposure” (POE) refers to the locations at which the receptor is potentially exposed, such as water wells or basements. Points of exposure may be actual or hypothetical (future-use) locations, depending on ground water use or the location of structures in the area.

Figure 7-1. Site Conceptual Exposure Scenario Worksheet



Notes:

1) Circle the "stop valve" when an exposure pathway is incomplete or not applicable to the site.

2) If a particular pathway is deemed incomplete or not applicable, number the stop valve and provide the rationale for this decision in the corresponding number in the Comments section.

3) Complete the pathways as appropriate by using the check boxes.

7.2.3 Exposure Pathways of Concern

The Department examines the following exposure pathways of concern for releases of petroleum:

- Dermal contact with, ingestion of, and outdoor inhalation of COCs emanating from contaminated surface soils;
- Enclosed space inhalation of COCs emanating from contaminated subsurface soils;
- Leaching of COCs from contaminated surface and subsurface soils to ground water;
- Enclosed space inhalation of COCs emanating from contaminated, shallow ground water; and,
- Ingestion of COCs in contaminated ground water.

Surface soils are defined as those unsaturated materials located between 0 and 3 feet BGL. Subsurface soils are defined as those unsaturated materials located ≥3 feet BGL. For the enclosed space inhalation exposure pathway from shallow ground water, “shallow” is defined as ground water less than 15 feet below the base of a structure or 15 feet BGL where no structure is present. Idealized illustrations of these exposure pathways can be found in Figures 7-2 and 7-3.

For an exposure pathway to be considered complete, the following conditions must be met:

1. A source and mechanism for a petroleum release into the environment must be present (e.g., a tank system);
2. A transport medium must be present (e.g., ground water, soil vapor) for the COCs to travel from the source to the POE (e.g., drinking water well, basement);
3. A potential POE (including potential future use) with the medium must be documented (e.g., a drinking water well); and,
4. An exposure route or means for taking COCs into a human body must be possible (e.g., ingestion of water, inhalation of vapors).

In cases where an exposure pathway is not complete under both current and future conditions, that particular exposure pathway is not subject to a quantitative evaluation. In cases where an exposure route may be complete but eliminated with use of appropriate engineering control(s) (e.g., abandoning an on-site water supply well), that particular exposure pathway is not subject to quantitative evaluation, provided the appropriate control(s) are implemented and effective.

Figure 7-2. Idealized Illustration of Ground Water Ingestion & Soil Leaching to Ground Water Exposure Pathways

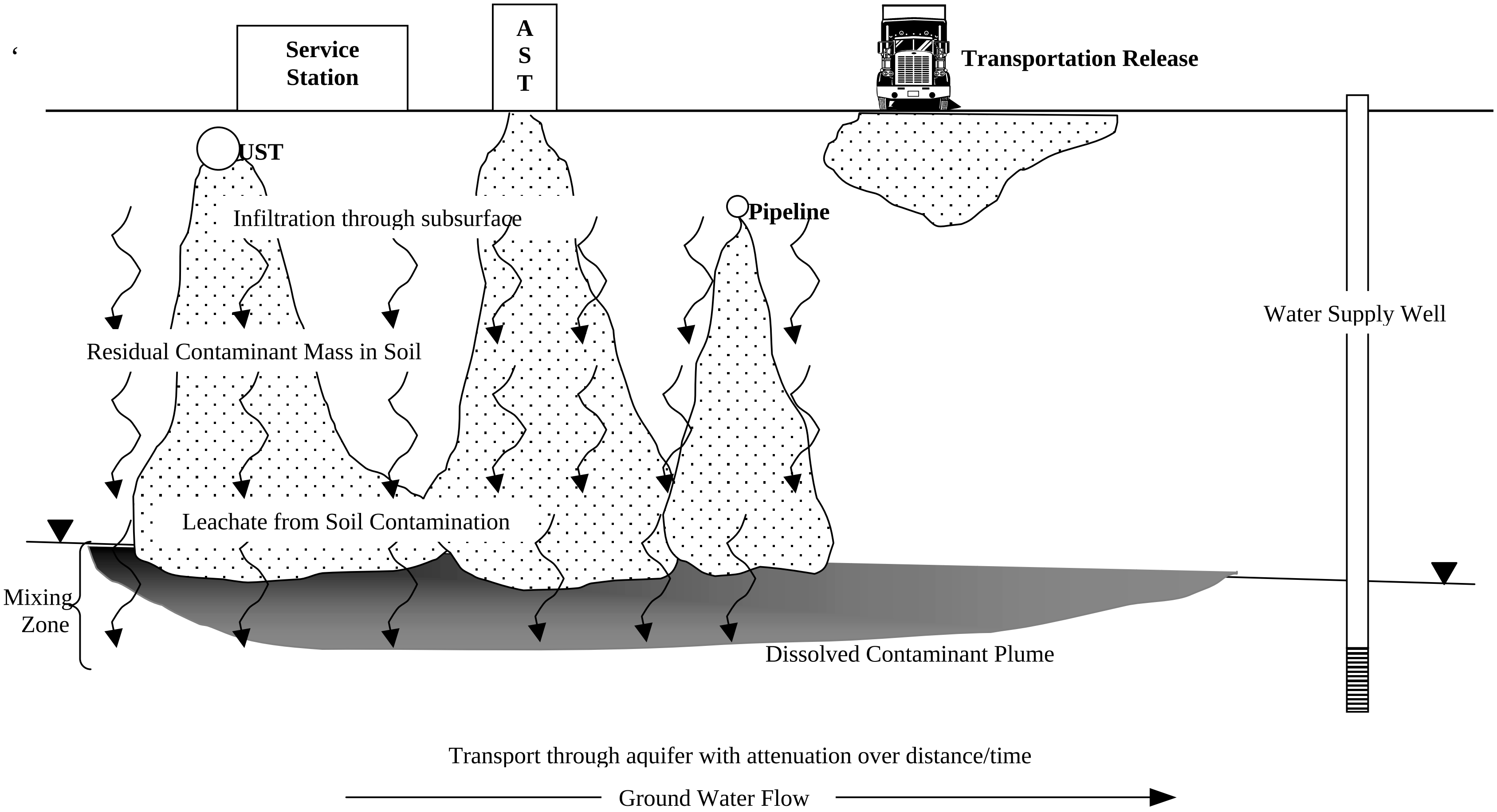


Figure Not to Scale

Figure 7-3. Idealized Illustration of Enclosed Space Inhalation Exposure Pathways

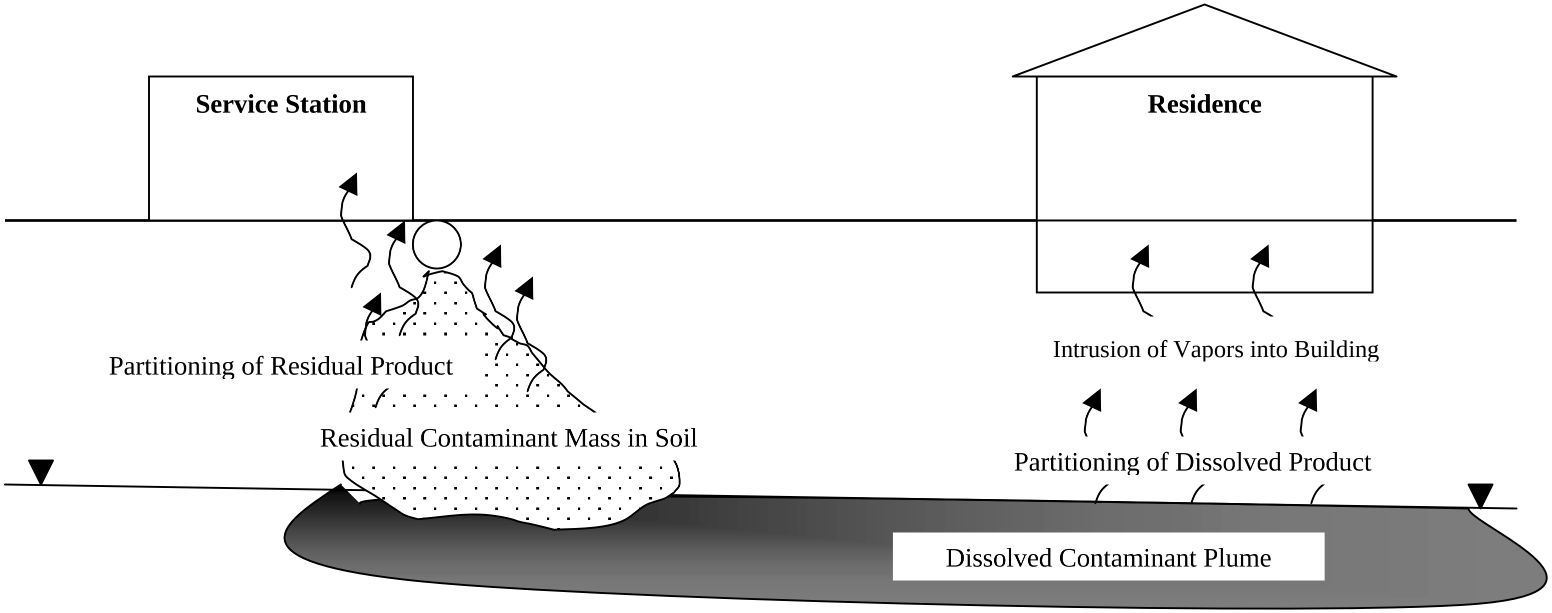


Figure Not to Scale

7.3 CALCULATION OF TARGET LEVELS

"Target levels" refer to either the Tier 1 screening levels (i.e., RBSLs) or the Tier 2 site-specific target levels (i.e., SSTLs) to which the contamination levels found during the site assessment are compared. Input parameters required to develop target levels include:

- Allowable concentrations (e.g., MCLs) at a POE for ground water protection
- Target risk limit
- COC-specific physical and chemical properties
- COC-specific quantitative toxicity factors
- Fate and transport parameters
- Additional uptake models (models that determine dose)

7.3.1 Target Risk Limit

A target risk limit is an acceptable level of risk. It is used to calculate an allowable or acceptable intake of a COC into the human body. The specific target risk limits used in this document are Individual Excess Lifetime Cancer Risk (IELCR) for carcinogenic effects, and Hazard Quotients and Indices (HQ and HI) for non-carcinogenic effects.

7.3.1.1 Carcinogenic Effects

Chemical-specific MCLs are used to back-calculate the appropriate Tier 1 RBSLs or Tier 2 SSTLs in the ground water ingestion and soil-leaching to ground water exposure pathways of concern for a RAC-1 release. (See Section 7.4.1 for definitions of RACs.)

An IELCR of 10^{-6} is used in the calculation of the appropriate target levels for a carcinogen in the dermal contact/soil ingestion exposure pathway and inhalation pathways where structures are present.

An IELCR of 10^{-5} is used for a carcinogen in the ground water ingestion and soil leaching to ground water exposure pathways of concern for a RAC-2 release and the inhalation exposure pathways where no structures are present.

7.3.1.2 Non-carcinogenic Effects

Chemical-specific MCLs (or some other level determined by the Department when an MCL has not been promulgated for a particular COC) are used to calculate the appropriate target levels for a non-carcinogen in the ground water ingestion and soil-leaching to ground water exposure pathways of concern for a RAC-1 release.

The target risk limit used to calculate appropriate target levels for non-carcinogenic chronic health effects is a Hazard Index (HI) of 1 (HI=1) for the dermal contact/soil ingestion exposure pathway and the enclosed space inhalation pathways where a structure is present.

A HI=10 is used to calculate the appropriate target levels for the ground water ingestion and soil-leaching to ground water exposure pathways for a RAC-2 release and the enclosed space inhalation pathways where no structure is present.

7.3.1.3 Additive effects

Carcinogens. Additivity of cancer risk is not explicitly considered at either the Tier 1 or Tier 2 level for several reasons. First, of the listed NDEQ COCs, benzene is the lone carcinogenic COC for gasoline releases and benzo(a)pyrene (BaP) the lone carcinogenic COC for waste oil releases. Benzene and BaP are both COCs for diesel fuel releases. However, BaP is neither volatile nor very soluble; hence, its impact will be localized compared to benzene and no volatilization issues are associated with it. Second, it is assumed that the number of exposure pathways that may be considered complete will be limited at any particular site. Third, the conservative assumptions used in the generation of the target levels are assumed to provide a margin of safety in this regard. Lastly, target levels calculated using an MCL (as for the ground water ingestion pathway) are not readily comparable to target levels when calculated using a specific IELCR (as for the enclosed space inhalation pathways).

Non-carcinogens. The HI represents the sum of all Hazard Quotients (HQs) for each COC affecting the same target organs and causing the same adverse health effect. For the purposes of the Tier 1 and Tier 2 assessments, benzene, toluene, ethylbenzene and total xylenes are considered to have additive health effects. While the carcinogenic effects of benzene outweigh its non-carcinogenic effects (meaning the target levels for benzene are based on its carcinogenic effect), its additive effect with toluene, ethylbenzene and total xylenes must be taken into account.

In Tier 1, a cumulative HI = 1 (or =10 for RAC-2 releases or where no structure is present for inhalation concerns) for additive effects of the BTEX compounds is established by assigning an HQ = 0.25 (or =2.5) to each individual compound. In Tier 2, additivity is addressed by totaling the cumulative risk for each individual BTEX component using the ratio between the actual site concentrations and the appropriate SSTLs for each exposure pathway. That is, SSTLs for each BTEX component are calculated using an HQ = 1 and the ratio between the representative concentration and the calculated SSTL is determined. If the sum of the BTEX ratios is ≤1, the BTEX contamination is considered to pose no risk from exposure.

7.3.2 COC Physical & Chemical Parameters

Appendix D, Table D-1 provides the pertinent physical and chemical properties used to establish or calculate the appropriate target level for each COC.

7.3.3 Quantitative Toxicity Factors

Appendix D, Table D-2 provides the quantitative toxicity factors used to establish or calculate the appropriate target level for each COC.

7.3.4 Applicable Exposure Factors

The applicable exposure factors (e.g., body weight, exposure duration) used to calculate the appropriate target level for a residential and commercial receptor are provided in Appendix D, Table D-3.

7.3.5 Mathematical Fate & Transport Models

Fate and transport equations are used to model the reduction in COC concentrations as COCs move from the source to the POE; data inputs include various soil and aquifer parameters and the physical and chemical properties of the COCs. The equations used in the calculation of the Tier 1 RBSLs are summarized in Appendix E. Default values for input into these equations are discussed in Section 7.3.6 and provided in Appendix D. Chemical-specific data are also provided in Appendix D. The models used are:

- Domenico and Summers models for back-calculating allowable dissolved COC concentrations in ground water from a POE and allowable soil leachate concentrations from those ground water concentrations.
- Farmer's model for calculating soil and ground water concentrations protective of indoor inhalation.
- USEPA's model (1991) for estimating outdoor inhalation from surface soils.
- USEPA's models (1991) for estimating uptake.

All modeling equations are further described and referenced in Appendix E.

7.3.6 Fate & Transport Parameters

Appendix D, Table D-4 provides the pertinent data parameters and default values used in the fate and transport models and to determine the appropriate target level for each COC. General comments concerning these parameters include:

- Unless otherwise noted in this section, default values are taken directly from the ASTM E-1739 Standard Appendix.
- Values for the calculation of source area (30 feet by 30 feet) are based on a review of tank removal reports and are reflective of a typical service station where 3-4 tanks are located in a single excavation.
- Default values for the saturated hydraulic conductivity, hydraulic gradient, total porosity of the saturated zone, infiltration rate, and fractional organic carbon content vary between Tier 1 look-up tables.
- Thickness of the mixing zone (default: 5 feet) is based on the general monitoring well construction practice for petroleum releases of screening a well with the ground water/unsaturated zone interface at the mid-point of the well screen length (commonly 10 feet).
- The unsaturated zone concentration reduction factor (CRF) varies with depth to ground water. The possible values of 1 and 2 are empirical depending on the depth to ground water.

7.4 PROTECTION OF GROUND WATER

The following is provided from Nebraska Title 118 – *Ground Water Quality Standards and Use Classification*, Appendix B – Remedial Action Protocol for Petroleum Releases, Step 7:

> "Most ground water in the principal aquifer (closest underlying major aquifer) is of drinkable quality and is used by nearly all Nebraskans as drinking water. Water of drinking water quality is usually suitable for all other beneficial uses. For these reasons, protecting ground water for drinking water use is most important and normally protects it for all uses."

In addition to the protection of ground water itself, consideration must also be given to residual contamination in soils as a source of continued ground water contamination. Considerations to be made for the protection of ground water are provided below.

7.4.1 Remedial Action Classes (RACs)

Protection of ground water as a drinking water source under Title 118 directly relates to the Remedial Action Class (RAC) established for the release by the Department. The RAC categories are not intended to represent a ground water classification system, but rather a pollution release-ranking scheme. It gives the Department a method to determine the importance of remedial action based on the use of the ground water. RACs are determined by:

- The location of drinking water wells in the area of the release;
- Potential future drinking water use considerations; and,
- The degree of ground water contamination encountered during the Tier 1 and Tier 2 investigations

A RAC is defined for pollution occurrences in three types of ground water (or overlying soils) depending on the degree (or potential) of use of the ground water as drinking water. The extent of remedial action required will differ depending, in part, on the RAC of the contaminated (or likely to be contaminated) ground water. (Note that the RAC assigned is determined from the condition of the ground water prior to the occurrence of pollution. The Department will do this based on information submitted by the RP in the RBCA Tier 1 and Tier 2 site investigations and other available information.) Below are definitions of the three RAC categories followed by some further explanation. (Definitions of Classes GA, GB, GC and GC(R) can be found in Title 118, Chapter 7 and Appendix B. Class GA waters also include designated Wellhead Protection Areas [WHPAs].)

RAC-1. This category includes ground waters of Class GA (ground water used or proposed to be used for a public drinking water source) and a portion of Class GB (ground water currently being used as a private drinking water source), and ground water within a designated WHPA. In addition, RAC-1 shall be automatically assigned anytime a public or private drinking water supply well has been polluted. RAC-1 will usually receive the most extensive remedial action measures.

RAC-2. This category includes ground waters of Class GB (except for the portion of Class GB placed in RAC-1; i.e., ground water with the potential to be used as public or private drinking water source) and Class GC(R) (ground water resources where the Department determines that restoration or cleanup may be appropriate).

RAC-3. This category includes, but is not limited to, ground waters of Class GC (except for Class GC(R) which was placed in RAC-2; i.e., ground water not currently used and has little or no potential to be used as a public or private drinking water source). RAC-3 will usually receive the least extensive remedial action measures.

RAC-1 is the category of highest rank; it represents that ground water actually being used for drinking water and that ground water intended to be used in a public drinking water supply. Therefore, RAC-1 occurrences will normally receive the most conservative RBCA target levels and most extensive remedial action measures.

RAC-2 occurrences involve ground water currently not used as drinking water, but having a reasonable potential to be used in the future. Potential use exists if the ground water is located in a highly populated area or is part of a regional, high-yielding aquifer, or if otherwise justified. The RAC-2 category also includes ground water with prior contamination that may be treated easily or cost-effectively to drinking water quality.

RAC-3 pollution occurrences are of lowest importance if the ground water involved is not used, or not likely to be used, as drinking water. Generally, remedial action measures will be least extensive for this category since the future use of such ground water as a drinking water supply is improbable. Justification for assigning occurrences to RAC-3 is based on a combination of factors, including:

- The water is of such poor natural quality that it is unfit for human consumption.
- Insufficient yield may limit or exclude the ground water being used for drinking water.
- Historical contamination may have contaminated the ground water to a point that it is not suitable for consumption (see NRS § 81-1505(2)(d)). This historical contamination may now be uneconomical to treat.
- Past and present intensive land use may also be a reason why ground water could be unusable as drinking water. This includes areas of concentrated industrial development or densely populated areas where ground water is likely to be contaminated or will not be used as drinking water.

7.4.2 Location and Type of Water Supply Wells

Water supply wells must be located and documented during the Tier 1 site investigation in accordance with Section 4.4.3. Water supply wells include municipal, domestic, irrigation, industrial or any other well from which water is withdrawn for beneficial purposes. Water supply wells do not include monitoring wells or recovery wells used for corrective actions.

At the Tier 1 level, all water supply wells documented in accordance with Section 4.4.3 are treated as potential POEs (see also, Section 7.4.4, Step 1). At the Tier 2 level, only those wells that may be impacted by the contaminant plume are considered potential POEs. This determination is based on the orientation and extent of the contaminant plume, along with consideration of the effects of any pumping wells on the contaminant plume.

In defining a RAC, Title 118 only refers to drinking water supply wells, or ground water used or capable of being used as drinking water. This emphasis on drinking water creates a potential dilemma in the RBCA process where RAC-2 designation is assigned to a site (and correspondingly higher target levels are used compared to a RAC-1 situation); consequently, a nearby non-drinking water well (e.g., irrigation well, industrial well) may not receive the appropriate protection. Therefore, in the RBCA evaluation process, drinking and non-drinking water wells will be examined separately. To remain protective of beneficial ground water use for a non-drinking water supply well, target levels are set at ten times the level for a drinking water supply well, given the same site characteristics.

7.4.3 Location of Compliance Wells

A point of compliance (POC) is a location within a source area or between a source area and the potential POEs where the concentrations of COCs must be at or below the determined target levels. For Tier 1, the borings/monitoring wells located within the source area(s) are the compliance point(s) for subsurface soil and ground water. At Tier 2, additional compliance points are set at select locations between the source area(s) and a potential POE for which individual SSTLs are calculated. These wells are located to monitor and assess the dynamics of the contaminant plume. They will also help to assess the validity of the fate and transport equations used by the Department and to ensure that ground water concentrations are decreasing. (See also Section 7.4.4, Step 3.)

7.4.4 Calculation of Target Levels Protective of Ground Water

Target levels for soils and water that are protective of ground water and water supply wells (i.e., POEs) in the area are determined as provided below. The key steps in these calculations include:

1. Identification of POEs;
2. Target concentrations at a POE;
3. Identification of appropriate POCs;
4. Target concentrations at a POC; and,
5. Target concentrations in the source soils.

7.4.4.1 Identification of POEs

The identification of POEs is based on: 1) the RAC of the release and 2) the existence and type of water supply wells (drinking vs. non-drinking wells) near the site. For RAC-1 releases, the POE of most concern is the closest of the following:

- Municipal wells within 2000 feet,
- Domestic, irrigation and industrial wells within 1000 feet,
- Sand points and hand-pump wells within 500 feet, and
- A hypothetical POE at a distance of 750 feet where the RAC-1 designation is based on the presence of a Wellhead Protection Area (WHPA).

Where a non-drinking water well (e.g., irrigation or industrial well) in a RAC-1 area is closer to a source area than a drinking water well, an evaluation must be made of both the non-drinking water well and the nearest drinking water well. The more conservative target level will be established as the allowable COC concentrations.

For RAC-2 releases, a hypothetical drinking water well located at 500 feet from the source area is considered to be a POE.

For the Tier 2 evaluation, only those water supply wells that are downgradient, or other wells of sufficient proximity and/or pumping capacity to influence the migration of the contaminant plume, are considered potential POEs.

7.4.4.2 Target Concentrations at a POE

Allowable COC target concentrations at a POE in the Tier 1 and Tier 2 evaluations vary based on the RAC designation of the release. The levels for RAC-1 releases in both tiers are based on MCLs (or other levels) for the individual COC. Where a non-drinking water well is in closer proximity to a source area than a drinking water well in a RAC-1 situation, allowable target levels at the well are calculated at ten times the RAC-1 allowable level.

The allowable target concentrations at a POE for a RAC-2 release in a Tier 1 evaluation are calculated assuming adult ingestion of water with the following target risk limits:

- Carcinogens: IELCR = 10^{-5}
- Non-carcinogens: HQ for BTEX = 2.5; for others = 10

For a RAC-2 release in a Tier 2 evaluation, the HI for BTEX = 10, and will be based on the sum of the ratios of the representative site concentrations to the allowable intake concentration of the individual BTEX constituents.

Table 7-1 provides the allowable COC concentrations at a POE for various ground water uses.

Table 7-1. Allowable COC Target Concentrations (mg/L) at a POE

Chemical of Concern	RAC-1	Non-Drinking Well	RAC-2
Benzene	0.005	0.050	0.0155
Toluene	1.00	10.0	18.3
Ethylbenzene	0.700	7.00	9.13
Xylenes	10.0	100	183
n-Hexane	4.00	40.0	13.0
MTBE	0.020	0.200	0.473
Naphthalene	0.020	0.200	7.30
TEH (as diesel)	10.0	100	116
TEH (as waste oil)	6.66	66.6	38.8

In both RAC-1 and RAC-2 sites, soil and POC target concentrations must be protective of the identified POEs. For RAC-3 sites, the ground water ingestion pathway is considered incomplete; however, the inhalation exposure pathways and free product concerns must be considered.

7.4.4.3 Identification of POCs

As discussed in Section 7.4.3, compliance wells are located at the source or between the source and POE in the downgradient direction. Existing monitoring wells are used as POCs for this pathway to determine the effectiveness of the model used to estimate soil target concentrations protective of ground water.

At Tier 1, at least one well at the source and one downgradient well is required. At Tier 2, at least one well at the source and multiple downgradient monitoring wells along the centerline of the contaminant plume are used as POCs.

7.4.4.4 Target Concentrations at a POC and Source Soils

The Department establishes target levels for POCs and source area soils by back-calculating allowable contaminant levels in ground water from a POE to the source area(s) and/or other compliance wells. In Tier 1, target levels are RBSLs established using non-site specific criteria; at Tier 2, the Department calculates the SSTLs for each source area and appropriate downgradient compliance well. The specific equations used to calculate compliance well target levels are provided in Appendix E.

7.4.5 Protection of Deeper Ground Water

In areas where surface recharge and/or a water supply well(s) may be contributing to the vertical migration of a ground water contaminant plume, compliance wells screened at appropriate depths may be required by the Department to assess the vertical migration of the plume.

7.5 PROTECTION OF SURFACE WATER & WETLANDS

Where surface waters or wetlands have been impacted by a petroleum release, the Department will determine the appropriate mitigation measures to be taken on a case-by-case basis. Such measures may include free product recovery from the surface water, mitigating the continued discharge to the surface water body, or additional ecological assessment of the release (see Section 7.6). At a minimum, all pertinent Department surface water quality standards, as detailed in Nebraska Title 117 – Nebraska Surface Water Quality Standards, must be met for the impacted water body.

7.6 ECOLOGICAL EXPOSURES

In instances where ecological exposures (e.g., threatened and endangered species habitat) may be present, the Department, in consultation with the Nebraska Game & Parks Commission, will determine the appropriate actions to be taken to mitigate the exposure. The extent of the assessment will be determined on a case-by-case basis.

7.7 ESTIMATION OF REPRESENTATIVE CONCENTRATIONS FOR CONTAMINATED SOIL & GROUND WATER

In evaluating individual exposure pathways, the applicable RBSLs or SSTLs are compared to representative concentrations. The representative concentrations are based on the analytical samples collected during the site investigation. To determine the representative site COC concentrations, the Department differentiates between *maximum* COC concentrations versus *average* COC concentrations.

7.7.1 Representative Ground Water Concentrations

7.7.1.1. Ground Water Ingestion Pathway

For the ground water ingestion pathway, maximum COC concentrations are used. The fate and transport model used for this exposure pathway incorporates natural attenuation processes between two discrete points (i.e., between a water supply well and a source area). Because this model essentially deals with plume attenuation dominated in a single dimension (i.e., the direction of ground water flow), maximum COC concentrations are best used for the evaluation.

7.7.1.2. Enclosed Space Inhalation from Contaminated Ground Water Pathway

For evaluating the enclosed space inhalation pathways from contaminated ground water (and subsurface soils; see Section 7.7.2.2), the model used to calculate the appropriate RBSLs or SSTLs is based on the emission and diffusion of COCs over three dimensions. Because this model considers effects of area and depth for calculating contaminant emissions into a structure, it has been determined that averaging COC concentration levels is an appropriate means of establishing a representative contaminant concentration for these exposure pathways. The average contaminant concentration is calculated from samples with detectable levels of contamination taken immediately upgradient and surrounding the building. Samples that show non-detectable levels are not used to calculate the average concentration. Where no building is present, all ground water samples with detectable levels of contamination are used for calculating the average, assuming a building could be located on top of these locations. This applies to buildings both with and without basements.

7.7.2 Representative Subsurface Soil Concentrations

7.7.2.1. Soil Leaching to Ground Water Pathway

Because the soil leaching to ground water exposure pathway greatly impacts the ground water ingestion pathway, the maximum subsurface soil COC concentration levels are used for evaluation.

7.7.2.2. Enclosed Space Inhalation from Contaminated Subsurface Soils Pathway

Averaging COC concentration levels is an appropriate means of determining a representative contaminant concentration for this exposure pathway. The average contaminant concentration is calculated from samples with detectable levels of contamination. Samples that show non-detectable levels are not used to calculate the average concentration.

Because soil samples may be obtained from variable depths within the vadose zone, an associated, average sample depth is needed as well. For the evaluation, the average depth of subsurface soil contamination is based on the following relationship (Salhotra, 2002, pers. com.):

$$d_{avg} = \frac{C_1 + C_2 + C_3 + ... + C_n}{\left(\frac{C_1}{d_1} + \frac{C_2}{d_2} + \frac{C_3}{d_3} + ... + \frac{C_n}{d_n} \right)}$$

where: d_{avg} is the average depth to the contaminant mass (in feet)
C_n is the concentration of the n-th sample (in mg-contaminant/kg-soil), and
d_n is the depth from which the n-th sample was obtained (in feet).

7.7.3 Representative Surface Soil Concentrations

When multiple surface soil samples have been collected, the maximum concentration is considered representative of the COC concentration levels for the dermal contact with, ingestion of, and inhalation (through outdoor air) of COCs from contaminated surface soils.

SECTION 8.0 TIER 1 EVALUATION

8.1 STEP 1: DEVELOPMENT OF SITE CONCEPTUAL EXPOSURE SCENARIO

Using the information gathered from the Tier 1 site assessment pertaining to land use, ground water use, receptors and POEs, a site-specific Site Conceptual Exposure Scenario (see Figure 7-1) can be created to determine the complete exposure pathways.

To determine whether an exposure pathway may be considered complete or incomplete, the evaluation flowchart in Figure 7-1 is used to follow the release from its point(s) of leakage to the current or future point(s) of exposure. This provides a graphical representation of site conditions and potential exposure pathway impacts for evaluation. Provided below are pathway-specific criteria to be used to determine whether a pathway is complete.

8.1.1 Ground Water Ingestion

The ground water ingestion exposure pathway is considered incomplete if any of the following conditions are met:

- Ground water has not been impacted and is not likely to be impacted.
- It has been demonstrated that contamination is limited to the overlying source areas, as detailed in Section 5.4.
- The release has received a RAC-3 designation (free product must still be considered).

8.1.2 Soil Leaching to Ground Water

The soil leaching to ground water exposure pathway is considered incomplete if soils have not been impacted or the release has received a RAC-3 designation (free product must still be considered).

8.1.3 Intrusion of Vapors to Structure from Contaminated Ground Water

The intrusion of vapors to a structure from contaminated ground water exposure pathway is considered incomplete if any of the following conditions are met:

- Ground water has not been impacted.
- Ground water is demonstrated to be greater than 15 feet below floor level of a basement, crawl space or similar subsurface structure.
- Ground water is demonstrated to be greater than 15 feet below floor level of a building with no basement, crawl space or similar structure.
- Ground water is demonstrated to be greater than 15 feet below ground level where no building is present.

The depth to ground water is based on the shallowest depth encountered during the investigation.

8.1.4 Intrusion of Vapors to Structure from Contaminated Subsurface Soils

The intrusion of vapors to a structure from contaminated subsurface soils exposure pathway is considered incomplete if any of the following conditions are met:

- Subsurface soils have not been impacted.
- The average depth of subsurface soil contamination is demonstrated to be greater than 15 feet below floor level of a basement, crawl space or similar subsurface structure.
- The average depth of subsurface soil contamination is demonstrated to be greater than 15 feet below floor level of a building with no basement, crawl space or similar structure.

- The average depth of subsurface soil contamination is demonstrated to be greater than 15 feet below ground level where no building is present.

8.2 STEP 2: SELECTION OF RELEVANT TIER 1 RBSLS

For those exposure pathways that are complete or potentially complete, representative contaminant concentrations are compared to the Tier 1 RBSLs. To account for the considerable variability of sediment characteristics, aquifer properties and depth to ground water across Nebraska, the RBCA Tier 1 RBSLs have been developed for several different site conditions. The site conditions include the following:

- Land use scenarios (i.e., residential or commercial);
- Two default hydrogeological scenarios (see Table 8-1 below);
- RAC designation;
- Proximity of water supply wells;
- Thickness of the vadose zone; and,
- Presence/absence of on-site/off-site structures (e.g., buildings with or without basements)

The default hydrogeological scenarios are characterized by the factors provided in Table 8-1.

Table 8-1. Applicable Factors for Tier 1 Default Hydrogeological Scenarios

Factor	Hydrogeology 1	Hydrogeology 2
Darcy velocity (cm/year)	111.25	11125
Porosity in vadose zone (--)	0.35	0.30
Organic carbon content (g-C/g-soil)	0.01	0.005
Infiltration rate (cm/year)	3.8	7.6

The factors under the Hydrogeology 1 scenario are representative of a less permeable soil than that of Hydrogeology 2. Consequently, sites with predominantly silty and clayey soils would be assumed to fall under Hydrogeology 1 and sandy soils under Hydrogeology 2. Under Tier 1, the soils in the vadose zone and in the saturated zone are assumed to be homogeneous and have the same hydrogeological characteristics.

As part of the Tier 1 evaluation, the hydrogeological scenario to be utilized must be determined. The determination is based on the ground water Darcy velocity at the site. If the Darcy velocity is <0.1 feet/day (36.5 feet/year or 1112.5 cm/year), the site falls under Hydrogeology 1. The site falls under Hydrogeology 2 if the Darcy velocity is ≥ 0.1 feet/day.

The RBSLs are provided in Look-Up Tables 8-2 to 8-10.

8.3 STEP 3. COMPARISON OF RBSLS WITH REPRESENTATIVE CONTAMINANT CONCENTRATIONS

The appropriate RBSLs are selected from Table 8-2 to 8-10 and compared to the representative contaminant concentrations. The calculation of representative concentrations (maximum or average) depends on the exposure pathway as discussed in Section 7.7.

LOOK-UP TABLES

GROUND WATER INGESTION EXPOSURE PATHWAY

Table 8-2. Ground Water Flow Rate ≥0.1 feet/day
Table 8-3. Ground Water Flow Rate <0.1 feet/day

SOIL LEACHING TO GROUND WATER EXPOSURE PATHWAY

Table 8-4. Ground Water Flow Rate ≥0.1 feet/day
Table 8-5. Ground Water Flow Rate <0.1 feet/day

ENCLOSED SPACE INHALATION EXPOSURE PATHWAYS

Table 8-6. Residential Exposure; Building Present
Table 8-7. Residential Exposure; No Building Present
Table 8-8. Commercial Exposure; Building Present
Table 8-9. Commercial Exposure; No Building Present

DERMAL CONTACT, INHALATION & INGESTION OF SURFACE SOILS EXPOSURE PATHWAY

Table 8-10. Allowable Contaminant Concentrations in Surficial Soils

Look-Up Table 8-2

Ground Water Ingestion Exposure Pathway
Ground Water Flow Rate >0.1 feet/day

Table 2A - Drinking Water Wells (municipal, domestic, hand-pump)

Remedial Action Class	Distance from Source (ft)	CHEMICALS OF CONCERN							
		Benzene	Toluene	Ethylbenzene	Xylenes	n-Hexane	MTBE	TEH (as diesel oil)	TEH (as waste oil)
RAC-1	0	0.005	1.00	0.700	10.0	4.00	0.020	10.0	6.66
	250	0.174	50.4	26.1	>Sol	>Sol	0.692	700	>Sol
	500	0.699	285	112	>Sol	>Sol	2.75	5200	>Sol
	750	1.59	>Sol	>Sol	>Sol	>Sol	6.23	>Sol	>Sol
RAC-2	[500]	2.17	>Sol	>Sol	>Sol	>Sol	65.2	>Sol	>Sol

Table 2B - Non-Drinking Water Wells (irrigation, industrial, other)

	Distance from Source (ft)	CHEMICALS OF CONCERN							
		Benzene	Toluene	Ethylbenzene	Xylenes	n-Hexane	MTBE	TEH (as diesel oil)	TEH (as waste oil)
For use only when non-potable well present	0	0.050	10.0	7.00	100	>Sol	0.200	100	66.6
	250	1.74	504	>Sol	>Sol	>Sol	6.92	7000	>Sol
	500	6.99	>Sol	>Sol	>Sol	>Sol	27.5	>Sol	>Sol
	750	15.9	>Sol	>Sol	>Sol	>Sol	62.3	>Sol	>Sol

NOTES:

1) All RBSL concentrations in mg/L.
2) RBSLs used for both residential and commercial land uses.
3) [500]: Distance from source of a hypothetical future well in a RAC-2 release.
4) >Sol: The selected target level is not exceeded for all possible dissolved levels.

Look-Up Table 8-3

Ground Water Ingestion Exposure Pathway
Ground Water Flow Rate <0.1 feet/day

Table 3A - Drinking Water Wells (municipal, domestic, hand-pump)

Remedial Action Class	Distance from Source (ft)	CHEMICALS OF CONCERN							
		Benzene	Toluene	Ethylbenzene	Xylenes	n-Hexane	MTBE	TEH (as diesel oil)	TEH (as waste oil)
RAC-1	0	0.005	1.00	0.700	10.0	4.00	0.020	10.0	6.66
	250	1.24	>Sol	>Sol	>Sol	>Sol	1.67	>Sol	>Sol
	500	22.5	>Sol	>Sol	>Sol	>Sol	14.3	>Sol	>Sol
	750	184	>Sol	>Sol	>Sol	>Sol	64.1	>Sol	>Sol
RAC-2	[500]	69.7	>Sol	>Sol	>Sol	>Sol	338	>Sol	>Sol

Table 3B - Non-Drinking Water Wells (irrigation, industrial, other)

	Distance from Source (ft)	CHEMICALS OF CONCERN							
		Benzene	Toluene	Ethylbenzene	Xylenes	n-Hexane	MTBE	TEH (as diesel oil)	TEH (as waste oil)
For use only when non-potable well present	0	0.050	10.0	7.00	100	>Sol	0.200	100	66.6
	250	12.4	>Sol	>Sol	>Sol	>Sol	16.7	>Sol	>Sol
	500	225	>Sol	>Sol	>Sol	>Sol	143	>Sol	>Sol
	750	>Sol	>Sol	>Sol	>Sol	>Sol	641	>Sol	>Sol

NOTES:

1) All RBSL concentrations in mg/L.
2) RBSLs used for both residential and commercial land uses.
3) [500]: Distance from source of a hypothetical future well in a RAC-2 release.
4) >Sol: The selected target level is not exceeded for all possible dissolved levels.

Look-Up Table 8-4

Soil Leaching to Ground Water Exposure Pathway
Ground Water Flow Rate >0.1 feet/day

Table 4A - Unsaturated zone thickness 0-50 feet

Well Type	Remedial Action Class	Distance from Source (ft)	CHEMICALS OF CONCERN							
			Benzene	Toluene	Ethylbenzene	Xylenes	n-Hexane	MTBE	TEH (as diesel oil)	TEH (as waste oil)
Drinking Water Well	RAC-1	0	0.337	187	>Sat	>Sat	>Sat	0.602	16,100	>Sat
		250	11.7	>Sat	>Sat	>Sat	>Sat	20.8	>Sat	>Sat
		500	47.1	>Sat	>Sat	>Sat	>Sat	83.0	>Sat	>Sat
		750	107	>Sat	>Sat	>Sat	>Sat	188	>Sat	>Sat
	RAC-2	[500]	146	>Sat	>Sat	>Sat	>Sat	1960	>Sat	>Sat
Non-Drinking Water Well	Well Present	0	3.37	>Sat	>Sat	>Sat	>Sat	6.02	>Sat	>Sat
		250	117	>Sat	>Sat	>Sat	>Sat	208	>Sat	>Sat
		500	471	>Sat	>Sat	>Sat	>Sat	830	>Sat	>Sat
		750	>Sat	>Sat	>Sat	>Sat	>Sat	1880	>Sat	>Sat

Table 4B - Unsaturated zone thickness >50 feet

Well Type	Remedial Action Class	Distance from Source (ft)	CHEMICALS OF CONCERN							
			Benzene	Toluene	Ethylbenzene	Xylenes	n-Hexane	MTBE	TEH (as diesel oil)	TEH (as waste oil)
Drinking Water Well	RAC-1	0	0.673	375	>Sat	>Sat	>Sat	1.20	32,000	>Sat
		250	23.5	>Sat	>Sat	>Sat	>Sat	41.7	>Sat	>Sat
		500	94.1	>Sat	>Sat	>Sat	>Sat	166	>Sat	>Sat
		750	215	>Sat	>Sat	>Sat	>Sat	375	>Sat	>Sat
	RAC-2	[500]	292	>Sat	>Sat	>Sat	>Sat	3930	>Sat	>Sat
Non-Drinking Water Well	Well Present	0	6.73	>Sat	>Sat	>Sat	>Sat	12.0	>Sat	>Sat
		250	235	>Sat	>Sat	>Sat	>Sat	417	>Sat	>Sat
		500	>Sat	>Sat	>Sat	>Sat	>Sat	1660	>Sat	>Sat
		750	>Sat	>Sat	>Sat	>Sat	>Sat	3750	>Sat	>Sat

NOTES:

1) All RBSL concentrations in mg/kg.
2) RBSLs used for both residential and commercial land uses.
3) [500]: Distance from source of a hypothetical future well in a RAC-2 release.
4) >Sat: The selected target level is not exceeded for all possible saturated levels in soil.

Look-Up Table 8-5

Soil Leaching to Ground Water Exposure Pathway
Ground Water Flow Rate <0.1 feet/day

Table 5A - Unsaturated zone thickness 0-50 feet

			CHEMICALS OF CONCERN							
Well Type	**Remedial Action Class**	**Distance from Source (ft)**	**Benzene**	**Toluene**	**Ethylbenzene**	**Xylenes**	**n-Hexane**	**MTBE**	**TEH (as diesel oil)**	**TEH (as waste oil)**
Drinking Water Well	RAC-1	0	0.014	8.51	4.37	147	>Sat	0.022	770	152,666
		250	3.43	>Sat	>Sat	>Sat	>Sat	1.82	>Sat	>Sat
		500	62.4	>Sat	>Sat	>Sat	>Sat	15.6	>Sat	>Sat
		750	510	>Sat	>Sat	>Sat	>Sat	69.8	>Sat	>Sat
	RAC-2	[500]	193	>Sat	>Sat	>Sat	>Sat	368	>Sat	>Sat
Non-Drinking Water Well	Well Present	0	0.139	85.1	43.7	>Sat	>Sat	0.218	7700	>Sat
		250	34.3	>Sat	>Sat	>Sat	>Sat	18.2	>Sat	>Sat
		500	624	>Sat	>Sat	>Sat	>Sat	156	>Sat	>Sat
		750	>Sat	>Sat	>Sat	>Sat	>Sat	698	>Sat	>Sat

Table 5B - Unsaturated zone thickness >50 feet

			CHEMICALS OF CONCERN							
Well Type	**Remedial Action Class**	**Distance from Source (ft)**	**Benzene**	**Toluene**	**Ethylbenzene**	**Xylenes**	**n-Hexane**	**MTBE**	**TEH (as diesel oil)**	**TEH (as waste oil)**
Drinking Water Well	RAC-1	0	0.027	17.0	8.74	294	>Sat	0.043	1535	305,000
		250	6.85	>Sat	>Sat	>Sat	>Sat	3.64	>Sat	>Sat
		500	125	>Sat	>Sat	>Sat	>Sat	31.10	>Sat	>Sat
		750	>Sat	>Sat	>Sat	>Sat	>Sat	140	>Sat	>Sat
	RAC-2	[500]	387	>Sat	>Sat	>Sat	>Sat	736	>Sat	>Sat
Non-Drinking Water Well	Well Present	0	0.277	170	87.4	>Sat	>Sat	0.435	15,350	>Sat
		250	68.5	>Sat	>Sat	>Sat	>Sat	36.4	>Sat	>Sat
		500	>Sat	>Sat	>Sat	>Sat	>Sat	311	>Sat	>Sat
		750	>Sat	>Sat	>Sat	>Sat	>Sat	1400	>Sat	>Sat

NOTES:

1) All RBSL concentrations in mg/kg.
2) RBSLs used for both residential and commercial land uses.
3) [500]: Distance from source of a hypothetical future well in a RAC-2 release.
4) >Sat: The selected target level is not exceeded for all possible saturated levels in soil.

Look-Up Table 8-6

Enclosed Space Vapor Inhalation Exposure Pathways
Residential Exposure; Building Present

			CHEMICALS OF CONCERN						
Media	**Subsurface Sediments**	**Vertical Interval between Contamination and Structure**	**Benzene**	**Toluene**	**Ethylbenzene**	**Xylenes**	**n-Hexane**	**MTBE**	**TEH (as diesel oil)**
Ground Water	**Sands**	**<3 feet**	**4.83**	>Sol	>Sol	>Sol	**5.77**	**391**	>Sol
		3 - 6 feet	**8.88**	>Sol	>Sol	>Sol	**10.4**	**797**	>Sol
		>6 feet	**9.77**	>Sol	>Sol	>Sol	**11.2**	**953**	>Sol
	Silts/Clays	**<3 feet**	**0.553**	**73.9**	>Sol	**137**	**0.528**	**88.1**	**6500**
		3 - 6 feet	**1.46**	**195**	>Sol	>Sol	**1.38**	**241**	>Sol
		>6 feet	**2.03**	**271**	>Sol	>Sol	**1.92**	**341**	>Sol
Subsurface Soils	**Sands**	**<3 feet**	**0.008**	**2.95**	**5.12**	**9.26**	**0.167**	**0.622**	**2390**
		3 - 6 feet	**0.241**	**89.4**	>Sat	>Sat	**5.06**	**18.9**	**72,500**
		>6 feet	**0.485**	**180**	>Sat	>Sat	**10.2**	**38.0**	>Sat
	Silts/Clays	**<3 feet**	**0.008**	**3.61**	**6.12**	**11.6**	**0.166**	**0.607**	**3085**
		3 - 6 feet	**0.268**	**110**	>Sat	**352**	**5.05**	**18.4**	**93,500**
		>6 feet	**0.539**	**220**	>Sat	>Sat	**10.1**	**37.0**	**188,000**

NOTES:

1) All RBSL concentrations in mg/L for ground water or mg/kg for soil.
2) RBSLs for volatilization hazards from all contaminants of concern are based on a structure within the source area.
3) These pathways are to be considered incomplete for releases of waste oil, as all determined RBSLs for this product are greater than the highest expected concentration in pure product.
4) >Sol: The selected risk level is not exceeded for all possible dissolved levels.
5) >Sat: The selected target level is not exceeded for all possible saturated levels in soil.
6) RBSLs for benzene soil contamination in contact with an enclosed space may be below detection limits for most approved laboratory methods. This particular exposure pathway shall be considered clear if soil analytical results are non-detect at laboratory detection limits acceptable to the Department. The Department will provide guidance on acceptable detection limits at a later date.

Look-Up Table 8-7

Enclosed Space Vapor Inhalation Exposure Pathways
Residential Exposure; No Building Present

			CHEMICALS OF CONCERN						
Media	**Subsurface Sediments**	**Depth to Contaminant Mass (from Ground Surface)**	**Benzene**	**Toluene**	**Ethylbenzene**	**Xylenes**	**n-Hexane**	**MTBE**	**TEH (as diesel oil)**
Ground Water	**Sands**	**<3 feet**	**48.3**	>Sol	>Sol	>Sol	>Sol	**3910**	>Sol
		3 - 6 feet	**88.8**	>Sol	>Sol	>Sol	>Sol	**7970**	>Sol
		>6 feet	**97.7**	>Sol	>Sol	>Sol	>Sol	**9530**	>Sol
	Silts/Clays	**<3 feet**	**5.53**	>Sol	>Sol	>Sol	**5.28**	**881**	>Sol
		3 - 6 feet	**14.6**	>Sol	>Sol	>Sol	>Sol	**2410**	>Sol
		>6 feet	**20.3**	>Sol	>Sol	>Sol	>Sol	**3410**	>Sol
Subsurface Soils	**Sands**	**<3 feet**	**0.079**	**29.5**	**51.2**	**92.6**	**1.67**	**6.22**	**23,950**
		3 - 6 feet	**2.41**	>Sat	>Sat	>Sat	**50.6**	**189**	>Sat
		>6 feet	**4.85**	>Sat	>Sat	>Sat	>Sat	**380**	>Sat
	Silts/Clays	**<3 feet**	**0.083**	**36.1**	**61.2**	**116**	**1.67**	**6.07**	**30,850**
		3 - 6 feet	**2.68**	>Sat	>Sat	>Sat	**50.5**	**184**	>Sat
		>6 feet	**5.39**	>Sat	>Sat	>Sat	**102**	**370**	>Sat

NOTES:

1) All RBSL concentrations in mg/L for ground water or mg/kg for soil.
2) RBSLs for volatilization hazards from all contaminants of concern are based on future land use considerations.
3) These pathways are to be considered incomplete for releases of waste oil, as all determined RBSLs for this product are greater than the highest expected concentration in pure product.
4) >Sol: The selected risk level is not exceeded for all possible dissolved levels.
5) >Sat: The selected target level is not exceeded for all possible saturated levels in soil.

Look-Up Table 8-8

Enclosed Space Vapor Inhalation Exposure Pathways
Commercial Exposure; Building Present

Media	Subsurface Sediments	Vertical Interval between Contamination and Structure	CHEMICALS OF CONCERN						
			Benzene	Toluene	Ethylbenzene	Xylenes	n-Hexane	MTBE	TEH (as diesel oil)
Ground Water	Sands	<3 feet	18.2	>Sol	>Sol	>Sol	>Sol	1470	>Sol
		3 - 6 feet	33.4	>Sol	>Sol	>Sol	>Sol	3000	>Sol
		>6 feet	36.8	>Sol	>Sol	>Sol	>Sol	3580	>Sol
	Silts/Clays	<3 feet	2.08	>Sol	>Sol	>Sol	3.83	332	>Sol
		3 - 6 feet	5.49	>Sol	>Sol	>Sol	10.0	906	>Sol
		>6 feet	7.65	>Sol	>Sol	>Sol	>Sol	1280	>Sol
Subsurface Soils	Sands	<3 feet	0.030	21.4	37.2	67.3	1.21	2.34	17,400
		3 - 6 feet	0.908	>Sat	>Sat	>Sat	36.8	71.0	>Sat
		>6 feet	1.83	>Sat	>Sat	>Sat	74.0	143	>Sat
	Silts/Clays	<3 feet	0.033	26.3	44.5	84.3	1.21	2.28	22,400
		3 - 6 feet	1.01	>Sat	>Sat	>Sat	36.7	69.3	>Sat
		>6 feet	2.03	>Sat	>Sat	>Sat	73.7	139	>Sat

NOTES:

1) All RBSL concentrations in mg/L for ground water or mg/kg for soil.
2) RBSLs for volatilization hazards from all contaminants of concern are based on a structure within the source area.
3) These pathways are to be considered incomplete for releases of waste oil, as all determined RBSLs for this product are greater than the highest expected concentration in pure product.
4) >Sol: The selected risk level is not exceeded for all possible dissolved levels.
5) >Sat: The selected target level is not exceeded for all possible saturated levels in soil.
6) RBSLs for benzene soil contamination in contact with an enclosed space may be below detection limits for most approved laboratory methods. This particular exposure pathway shall be considered clear if soil analytical results are non-detect at laboratory detection limits acceptable to the Department. The Department will provide guidance on acceptable detection limits at a later date.

Look-Up Table 8-9

Enclosed Space Vapor Inhalation Exposure Pathways
Commercial Exposure; No Building Present

			CHEMICALS OF CONCERN						
Media	**Subsurface Sediments**	**Depth to Contaminant Mass (from Ground Surface)**	**Benzene**	**Toluene**	**Ethylbenzene**	**Xylenes**	**n-Hexane**	**MTBE**	**TEH (as diesel oil)**
Ground Water	**Sands**	**<3 feet**	**182**	>Sol	>Sol	>Sol	>Sol	**14,700**	>Sol
		3 - 6 feet	**334**	>Sol	>Sol	>Sol	>Sol	**30,000**	>Sol
		>6 feet	**368**	>Sol	>Sol	>Sol	>Sol	**35,800**	>Sol
	Silts/Clays	**<3 feet**	**20.8**	>Sol	>Sol	>Sol	>Sol	**3320**	>Sol
		3 - 6 feet	**54.9**	>Sol	>Sol	>Sol	>Sol	**9060**	>Sol
		>6 feet	**76.5**	>Sol	>Sol	>Sol	>Sol	**12,800**	>Sol
Subsurface Soils	**Sands**	**<3 feet**	**0.299**	**21.4**	>Sat	>Sat	**12.1**	**23.4**	>Sat
		3 - 6 feet	**9.08**	>Sat	>Sat	>Sat	>Sat	**710**	>Sat
		>6 feet	**18.3**	>Sat	>Sat	>Sat	>Sat	**1430**	>Sat
	Silts/Clays	**<3 feet**	**0.332**	**263**	>Sat	>Sat	**12.1**	**22.8**	>Sat
		3 - 6 feet	**10.1**	>Sat	>Sat	>Sat	>Sat	**693**	>Sat
		>6 feet	**20.3**	>Sat	>Sat	>Sat	>Sat	**1390**	>Sat

NOTES:

1) All RBSL concentrations in mg/L for ground water or mg/kg for soil.
2) RBSLs for volatilization hazards from all contaminants of concern are based on future land use considerations.
3) These pathways are to be considered incomplete for releases of waste oil, as all determined RBSLs for this product are greater than the highest expected concentration in pure product.
4) >Sol: The selected risk level is not exceeded for all possible dissolved levels.
5) >Sat: The selected target level is not exceeded for all possible saturated levels in soil.

Look-Up Table 8-10

Exposures from Contaminated Surface Soils

Chemical of Concern	RBSL (mg/kg)
Benzene	**3.63**
Toluene	**>Sat**
Ethylbenzene	**>Sat**
Xylenes	**>Sat**
n-Hexane	**>Sat**
MTBE	**102**
TEH (as Diesel)	**9520**
TEH (as Waste Oil)	**3173**

NOTES:

1) The fate and transport model used to determine the RBSLs related to exposures from contaminated surface soils combines effects from dermal contact with, ingestion of and inhalation through outdoor air of COCs emanating from these soils.
2) >Sat: The selected target level is not exceeded for all possible saturated levels in soil.

8.4 STEP 4. SELECTION OF NEXT COURSE OF ACTION

The possible outcomes of the Tier 1 evaluation are as follows:

- Site closure;
- Removal/treatment of contaminated surface soils to meet Tier 1 levels (see NDEQ Environmental Guidance Document 03-141: Management of Petroleum Contaminated Materials for disposal direction);
- Tier 2 investigation and assessment; and/or
- Implementation of remedial actions.

Detail of actions that may be required are expressed below:

- If the concentrations for all COCs are less than the RBSLs for all applicable exposure pathways, then no additional actions will normally be required by the Department.

- Where the representative concentrations are at or above any of the RBSLs, other than those concerning the surficial soils pathways, an additional Tier 2 investigation and evaluation will normally be required by the Department for those exposure pathways for which the RBSLs are exceeded.

- For the dermal contact/ingestion/inhalation of surface soil contamination exposure pathways only, if the contaminant concentrations for all COCs are less than the RBSLs, then no additional actions will normally be required by the Department. If the maximum contamination concentrations are greater than the RBSLs for any COCs, the Department will normally require active remediation to address the pathway(s) levels (see NDEQ Environmental Guidance Document 03-141: Management of Petroleum Contaminated Materials for disposal direction).

SECTION 9.0 TIER 2 EVALUATION

9.1 STEP 1: IDENTIFICATION OF DATA NEEDS AND COLLECTION OF DATA

When a site is required to proceed with a Tier 2 assessment, additional contaminant and site data need to be collected. These data are used in the calculation of Tier 2 SSTLs. The information to be collected will be dependent on the exposure pathway(s) being investigated. The data requirements are discussed in Section 6.0.

9.2 STEP 2: DEVELOPMENT OF SITE CONCEPTUAL EXPOSURE SCENARIO

Under the Tier 1 evaluation, a Site Conceptual Exposure Scenario was developed to identify the complete exposure pathways. This scenario must be revised for the Tier 2 evaluation. In most cases, the Site Conceptual Exposure Scenario for Tier 2 will be the same as for Tier 1.

9.3 STEP 3: INPUT PARAMETERS FOR TIER 2 SSTLS

The Tier 2 assessment requires the use of the same models as the Tier 1 assessment. However, site-specific fate and transport parameter values are used to calculate Tier 2 SSTLs, whereas Tier 1 RBSLs were generated using non-site-specific default values.

9.3.1 Physical & Chemical Properties of COCs

The Department uses the same default values for the calculation of Tier 2 SSTLs as used for the generation of Tier 1 RBSLs; values can be found in Table D-1, Appendix D.

9.3.2 Exposure Factors

The Department uses the same default values for residential and commercial exposure factors in Tier 2 as used in Tier 1; values can be found in Table D-3, Appendix D.

9.3.3 Toxicity Values & Target Risk Limits

The Department uses the same default toxicity values and target risk limits for carcinogenic and non-carcinogenic health effects in Tier 2 as in Tier 1; values can be found in Table D-2, Appendix D.

9.3.4 Fate & Transport Parameters

The Department allows the use of representative site-specific values for fate and transport parameters for Tier 2 that were not allowed at the Tier 1 level. These variables are labeled as “Site-Specific” under the “Tier 2 Value” column in Table D-4, Appendix D.

9.4 STEP 4: CALCULATION OF TIER 2 SSTLs

Tier 2 SSTLs are calculated by the Department for selected POCs using computational software developed by the Department.

9.5 STEP 5: CALCULATION OF REPRESENTATIVE CONCENTRATIONS

The SSTLs are compared to the representative contaminant concentrations discussed in Section 7.7. The representative concentrations are either the maximum or average contaminant concentrations, depending on the exposure pathway being examined.

9.6 STEP 6: SELECTION OF THE NEXT COURSE OF ACTION

The possible outcomes of the Tier 2 evaluation are as follows:

- Site closure
- RP notified of Proposed Cleanup Levels and request for submittal of a remedial action plan to address cleanup.

Details of actions that may be required are expressed below:

- If the concentrations for all COCs are less than the SSTLs for the applicable exposure pathways, then no additional actions would normally be required by the Department.

- Where the representative site concentrations are above any of the SSTLs for an exposure pathway, active cleanup to the SSTLs will normally be required. Remedial actions will proceed as detailed in Title 118 Appendix B, Steps 9 – 11.

- The use of engineered controls may be considered to eliminate actual or potential exposures.

SECTION 10.0 REFERENCES

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Salhotra, A. M., personal communication, February 26, 2002.

Todd, D. K., 1980, Ground Water Hydrology, John Wiley & Sons, New York, p. 28.

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GLOSSARY

applicable exposure factors - data used to calculate some allowable intake concentration of a chemical of concern into the body, including such factors as body weight, exposure duration, ingestion rate, etc.

biodegradation - the reduction in total mass and concentration of chemicals of concern due to the biological processes by bacteria in the environment.

chemical of concern - specific constituent of petroleum that the Department has identified for evaluation due to its toxicological effects.

commercial - refers to land use or exposure factors under conditions that cannot be defined as "residential" where receptors are potentially exposed to COCs.

direct exposure pathway - exposure pathway where the point of exposure is in the source area, without a release to any other medium (e.g., dermal contact with contaminated surface soils).

enclosed space - structure (e.g., residence with basement) of limited access allowing for the potential collection and concentration of contaminant vapors in the structure's breathing space.

exposure pathway - the course a chemical of concern travels from the source area(s) of a release to a potentially exposed receptor, comprised of a release source (e.g., LUST), a transport medium or media (e.g., ground water), a point of exposure (e.g., a water well) and an exposure route (e.g., ingestion of contaminated ground water).

fate and transport model - an estimate of contaminant concentration with time and distance based on a quantitative estimate of chemical mobility and persistence, developed using pre-set or site-specific information in conjunction with analysis of transport mechanisms such as advection, dispersion, and diffusion and/or a quantitative estimate of biodegradation processes.

free product - measurable (≥0.01 feet) petroleum product that is present as a non-aqueous phase liquid (i.e., liquid not dissolved in ground water).

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

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

indirect exposure pathway - an exposure pathway with at least one intermediate release to any media between the source area and point of exposure (e.g., ingestion of contaminated ground water at a water well, generated from contaminated soils located in the upgradient direction of ground water flow).

Individual Excess Lifetime Cancer Risk (IELCR) - the target risk level for a carcinogenic chemical of concern (as in 10^{-6}) used to quantify risk in the RBCA process or establish risk-based screening levels.

Look-Up Table (LUT) - table containing Tier 1 RBSLs used for comparison to contaminant concentrations found during the Tier 1 site assessment.

monitoring well – a water well installed in accordance with Nebraska HHSS Title 178 within or straddling the ground water table for the purpose of collecting ground water samples for analysis.

monitoring (sampling) point – either a monitoring well, borehole, or similar structure (e.g., direct push boring, soil gas point) used for the collection of various environmental media (i.e., ground water, soil, soil vapor) for analysis.

natural attenuation - the reduction in total mass and concentration of chemicals of concern with distance and time due to processes such as biodegradation, diffusion, dispersion and absorption.

point of compliance - location between a source area and a potential point of exposure where concentrations of chemicals of concern must be at or below the determined target levels in the media of concern.

point of exposure - point at which a chemical of concern may come into contact with or be taken into an actual or potential receptor.

receptor - any human who is or may be adversely affected by a petroleum release.

Remedial Action Class - one of three pollution occurrences defined for categories of ground water (or overlying soils) in Nebraska, dependent on the degree (or potential) of use of ground water as drinking water, and further defined in NDEQ Title 118 **-** Ground Water Quality Standards and Use Classification.

residential - refers to land use or exposure factors used to describe or characterize receptors that are potentially exposed to COCs in at least one of the following environments: residences, ground-level or basement apartments, or other similar domiciles, and sensitive population centers, including but not limited to daycare centers, schools, hospitals, or nursing homes.

risk assessment - an analysis of the potential for adverse health effects caused by a chemical of concern, used to determine the need and type of remedial action and/or to develop site-specific cleanup levels.

risk-based corrective action (RBCA) - a streamlined approach to petroleum release corrective actions in which exposure and risk assessment practices are integrated with traditional corrective actions to ensure that appropriate and cost-effective remedies are selected that are protective of human health and the environment.

risk-based screening level (RBSL) - initial corrective action target concentration for a chemical of concern for the first tier of risk assessment, calculated from simple and conservative fate and transport models and pre-set site conditions.

site-specific target level (SSTL) - corrective action target concentration or final cleanup level for a chemical of concern developed during the second tier of risk assessment, calculated from the same fate and transport models used to develop an RBSL, using site-specific information.

source area - either the location of liquid or residual petroleum hydrocarbons from a point source release or the location of the highest soil and ground water contaminant concentration of the chemicals of concern as determined by the site assessment.

subsurface soils - those unconsolidated materials located within the unsaturated zone at a depth greater than three feet below ground level.

surface soils - those unconsolidated materials located within the unsaturated zone at a depth between zero and three feet below ground level.

target risk limit - level of concern used in exposure equations for carcinogens (e.g., a 10^{-6} IELCR) or non-carcinogens (e.g., a HI=1) to calculate an allowable intake of a chemical of concern into the body.

Tier 1 assessment - a risk-based analysis to develop non-site-specific values (RBSLs) for direct and indirect exposure pathways utilizing conservative factors and fate and transport models for various potential exposure pathways, where the values will apply to all releases that fall within specific categories.

Tier 2 assessment **-** a risk-based analysis applying the direct exposure factors established under a Tier 1 evaluation at the point(s) of exposure developed for a specific site and development of SSTLs for potential indirect exposure pathways at a POE based on site-specific conditions.