UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

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MEMORANDUM

SUBJECT: Determining Groundwater Exposure Point Concentrations, Supplemental Guidance

FROM: Dana Stalcup, Acting Director
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Office of Superfund Remediation and Technology Innovation

TO: Superfund National Policy Managers, Regions 1 - 10

Purpose

The mission of the Superfund program is to protect human health and the environment consistent with the Comprehensive Environmental Response, Compensation and Liability Act, as amended, and as implemented by the National Oil and Hazardous Substances Pollution Contingency Plan. This memorandum transmits *Determining Groundwater Exposure Point Concentrations*, which is attached, and is to be used in the remedial investigation and feasibility study process (e.g., assessing baseline health risks, evaluating risks of remedial alternatives) and five-year reviews of selected remedies.

Background

During the October 2011 to February 2013 period, a workgroup comprised of members of two EPA forums, the OSWER Human Health Regional Risk Assessors Forum (OHHRRAF) and the Ground Water Forum (GWF), deliberated about how to determine groundwater exposure concentrations. As a result of a consensus-driven process, the attached guidance document was prepared, vetted, and finalized.

Objective

The attached guidance has been developed to reduce unwarranted variability in the exposure assumptions used by Regional Superfund staff to characterize exposures to human populations in the baseline risk assessment. Other cleanup programs in the Office of Solid Waste and

Emergency Response (OSWER) are welcome and encouraged to adopt this guidance, much as they have historically adopted other aspects of the *Risk Assessment Guidance for Superfund* (RAGS).

Implementation

The attached guidance is based on: the *Supplemental Guidance to RAGS: Calculating the Concentration Term* (Publication 9285.7-081); and the updates provided in *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (Publication 9285.6-10). The attached guidance supplements these documents by adding a recommended approach for calculating the groundwater exposure point concentration. Procedures recommended in this directive are consistent with the intent of these previous guidance documents on the subject.

The guidance can be found at www.epa.gov/oswer/riskassessment/superfund_hh_exposure.htm
Please contact Richard Kapuscinski at (703) 305-7411 if you have questions or concerns.

Attachment

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United States Environmental Protection Agency
Office of Solid Waste and Emergency Response

OSWER Directive 9283.1-42, February 2014

Determining Groundwater Exposure Point Concentrations

Disclaimer: *This document presents current technical and policy recommendations of the U.S. Environmental Protection Agency (EPA). This guidance document does not impose any requirements or obligations on the U.S. Environmental Protection Agency (EPA), the states, or the regulated community. Rather, the sources of authority and requirements for addressing groundwater contamination are the relevant statutes and regulations. Decisions regarding a particular situation should be made based upon statutory and regulatory authority. EPA decision-makers retain the discretion to adopt or approve approaches on a case-by-case basis that differ from this guidance document, where appropriate, as long as the administrative record supporting its decision provides an adequate basis and reasoned explanation for doing so.*

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List of Acronyms

ARARs: Applicable and/or Relevant and Appropriate Requirements

CERCLA: Comprehensive Environmental Response, Compensation, and Liability Act

DQO: Data Quality Objective

EPA: U.S. Environmental Protection Agency

EPC: Exposure Point Concentration

GW CSM: Groundwater Conceptual Site Model

GWF: Groundwater Forum

MCL: Maximum Contaminant Level

MDL: Method Detection Limit

NAPL: Non-aqueous phase liquid

OHHRRAF: OSWER Human Health Regional Risk Assessment Forum

OSWER: Office of Solid Waste and Emergency Response

QAPP: Quality Assurance Project Plan

QL: Quantitation Limit

RAGS: Risk Assessment Guidance for Superfund

RCRA: Resource Conservation and Recovery Act

RL: Reporting Limit

RSL: Regional Screening Level (http://www.epa.gov/region9/superfund/prg/)

SAP: Sampling and Analysis Plan

UCL: Upper confidence limit

VOC: Volatile organic contaminant

Definitions[1]

Commingled Plume: A commingled plume exists where groundwater contaminant plumes from two or more discrete releases have mixed or encroached upon one another.

Comprehensive Environmental Response, Compensation, and Liability Act: The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as the Superfund law, was enacted by Congress on December 11, 1980 and amended by the Superfund Amendments and Reauthorization Act (SARA) on October 17, 1986. It is a United States federal law designed to clean up sites contaminated with hazardous substances. (http://www.epa.gov/superfund/policy/cercla.htm)

Contaminant Plume: A groundwater contaminant plume is a three-dimensional, dynamic (i.e., may vary temporally), potentially irregular distribution of contaminants dissolved or suspended in groundwater. The shape and size of a plume depends on the geologic framework, groundwater flow system, type and concentration of contaminants, and variations in the contaminants' release history. For the purposes of groundwater exposure point concentration (GW EPC) calculations, a groundwater contaminant plume is defined as the volume of groundwater with contaminant concentrations exceeding risk-based tapwater Regional Screening Levels (RSLs) and/or Maximum Contaminant Levels (MCLs) or other applicable criteria.

Contaminant Source: A contaminant source (source area) is a three-dimensional zone of high contaminant concentrations resulting from a release of contaminants to the environment and from which contaminants may migrate.

Core/center of the plume: The three-dimensional core/center of the plume is defined as the zone of highest concentrations of each contaminant within a delineated groundwater plume. See Figure 1.

Exposure Point Concentration (EPC): As defined generally for EPA's cleanup programs, the EPC is intended to be a conservative estimate of the average chemical concentration in an environmental medium (EPA 2002). For the purposes of this document, the environmental medium is groundwater.

Groundwater Conceptual Site Model: A groundwater conceptual site model (GW CSM) is a multi-dimensional qualitative and quantitative representation of the groundwater flow and solute transport system. The GW CSM conveys what is known or suspected about contaminants of potential concern, locations of probable contamination sources, release mechanisms and timing, potential migration pathways, and potential (current and future) receptors. The GW CSM uses a concise combination of written and graphical work products (e.g., maps, cross sections, diagrams) to provide a site-specific description of the migration and fate of contaminants with respect to possible receptors and the geologic, hydrologic, biologic, geochemical, and anthropogenic factors that control contaminant distribution. A robust GW CSM is a comprehensive, clear, internally consistent, multi-dimensional understanding of site conditions and processes, including the temporal variability of conditions and processes at the site. Like

[1] Definitions are provided for the purposes of this guidance.

CSMs utilized in other arenas (e.g., risk assessment), the GW CSM is a dynamic tool and is reevaluated, refined, and revised as new site information is collected.

Human Health Risk Assessment: A human health risk assessment (HHRA) is the process to estimate the nature and probability of adverse health effects in humans who may be exposed to chemicals in contaminated media, now or in the future. EPA begins the HHRA with a planning and scoping phase which is then followed by the four steps: hazard identification, dose-response assessment, exposure assessment, and risk characterization. Risk Assessment Guidance for Superfund, Part A (RAGS Part A) provides guidance on the human health evaluation activities that are conducted during the baseline risk assessment at Superfund sites (EPA Human Health Risk Assessment website: http://www.epa.gov/risk_assessment/health-risk.htm).

Method Detection Limit: The method detection limit (MDL) is a laboratory/method/instrument capability value and varies by laboratory and instrument. It is the minimum concentration of an analyte that can be identified, measured and reported with 99% confidence that the analyte concentration is greater than zero. This is a statistical determination of precision; accurate quantitation is not expected at this level. As a result, this value is not usually specified for a specific project, so it is usually not reported in the data.

Non-Aqueous Phase Liquids: Non-aqueous phase liquids (NAPLs) are liquids that, like oil, are immiscible in water. There are two classes: light NAPLs (LNAPLs), such as gasoline, are less dense than water and will tend to float on the water table; dense NAPLs (DNAPLs), such as the common solvent trichloroethylene, are denser than water and tend to sink once they reach the water table.

Quality Assurance Project Plan: A Quality Assurance Project Plan (QAPP) is developed to document the planning, implementation, and assessment procedures for a particular site, as well as any specific quality assurance and quality control activities that are needed. The data are evaluated to determine whether the objectives in the QAPP have been met and the data is of adequate quality for further evaluation. The establishment of data quality objectives (DQOs) is a critical component of the process and assuring that data is collected in a manner that will allow its use in the calculation of the GW EPCs.

Quantitation Limit: The quantitation limit (QL) is the minimum concentration that can be reported as a quantitative value for an analyte in a sample, typically a reference sample. This concentration can be no lower than the concentration of the lowest calibration standard for that analyte. It generally is specified in advance for a specific project. EPA generally establishes the Project QL prior to sample analysis through the identification of Data Quality Objectives in the Quality Assurance Project Plan (QAPP). The Project QL ideally is 3-10 times lower than the Screening Level, when technically feasible. Laboratories with a laboratory QL at or below the Project QL generally are selected to perform the analyses. The Laboratory QLs for the Contract Laboratory Program are found at http://www.epa.gov/superfund/programs/clp/target.htm and are called "Contract Required Quantitation Limits" in that reference.

Piezometer: A type of well whose primary purpose is to measure the elevation of the water table or the groundwater pressure head at a point in the subsurface (i.e. the potentiometric surface). Generally piezometers have a relatively small (less than 1 inch) diameter and are not designed to obtain groundwater samples for chemical analysis. Monitoring wells differ from piezometers in that they are designed so that groundwater samples can be obtained and are larger than piezometers (typically larger than 1.5 inches in diameter), although sampling devices have been developed that allow groundwater samples to be obtained from smaller diameter wells.

Potable: Water designated as a drinking water source.

Remedial Investigation: A remedial investigation (RI) serves as the mechanism for collecting data to characterize site conditions, determine the nature of the waste, assess risk to human health and the environment and conduct treatability testing to evaluate the potential performance and cost of the treatment technologies that are being considered.
http://www.epa.gov/superfund/cleanup/rifs.htm

Reporting Limit: A reporting limit (RL) is a sample-specific quantitation limit that has been adjusted for dilutions, moisture content, or other sample-specific factors. This value is the quantitation limit actually achieved in the analysis. The RL may be the same as the quantitation limit that was set as the goal for project planning. Often, however, it will be higher than the quantitation limit for samples with high concentrations of contaminants or a matrix that interferes with the analysis. This is the value that normally appears on the data sheet for data reporting.

Sampling and Analysis Plan: A Sampling and Analysis Plan (SAP) is a project proposal that describes how the assessor will address a specific situation. Typically, it details the project goals and purpose, sample locations, sample frequency, parameters measured, field and laboratory, protocols, etc. The SAP must meet the DQOs outlined under the QAPP. SAPS also describe how the data will be managed and used and how data quality will be evaluated SAPs may refer back to the programmatic QAPP for the QA/QC protocols.

Screening Level(s): Screening Levels are chemical-specific concentrations for individual environmental contaminants may warrant further investigation or site cleanup. Screening Levels for establishing data quality objectives for groundwater sampling and for delineating plume extent include: Maximum Contaminant Levels (MCLs) as established by the Safe Drinking Water Act program by EPA's Office of Groundwater and Drinking Water in the Office of Water and Regional Screening Levels for residential tapwater. Other applicable criteria (e.g., promulgated State Drinking Water Standards) are considered on a site-specific basis.

Site Team: For purposes of this document, a site team is typically composed of the Project Manager, Hydrogeologist, Ecological Risk Assessor, Human Health Risk Assessor, and other scientists as needed.

Superfund: Superfund is the name given to the environmental program established to address abandoned hazardous waste sites. It is also the name of the fund established by the Comprehensive Environmental Response, Compensation and Liability Act of 1980, as amended (CERCLA) (EPA Superfund website: http://www.epa.gov/superfund/about.htm, August 21, 2013).

Superfund Sites: Sites included in the Superfund Program. (http://www.epa.gov/superfund/)

1.0 Introduction

Human health risk assessments conducted at sites investigated in accordance with the Comprehensive Environmental Response, Compensation and Liability Act of 1980, as amended (CERCLA) and the Resource Conservation and Recovery Act, as amended (RCRA) require estimates of the contaminant concentrations in various media to which humans are currently exposed or are reasonably expected to be exposed in the future. Where contaminated groundwater at a site is designated as potable, currently or in the future, an estimate of the exposure point concentration for groundwater (GW EPC) is needed. As defined here, a GW EPC is a conservative estimate of the average chemical concentration in groundwater at a potential location and point in time. This guidance outlines a recommended approach for estimating a GW EPC for use in evaluating risk posed by reasonable maximum exposure conditions at sites with contaminated groundwater and is intended to improve the quality and consistency of calculating EPCs for groundwater in risk assessments performed at EPA's Superfund and RCRA corrective action sites. This recommended approach is based on the *Supplemental Guidance to RAGS: Calculating the Concentration Term* (Publication 9285.7-08I) and updates provided in *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (Publication 9285.6-10), but adds a recommended approach for calculating the GW EPC. Procedures recommended in this guidance are consistent with the intent of these previous guidance documents on the subject.

The OSWER Human Health Regional Risk Assessment Forum (OHHRRAF) and the US EPA Ground Water Forum (GWF) joined together to prepare this document. The OHHRRAF consists of US EPA human health risk assessors who develop and promote scientifically defensible and nationally consistent methods for conducting human health risk assessments and who provide risk managers at CERCLA and RCRA corrective action sites with information needed to make and communicate transparent, reasonable, and protective decisions. The GWF is a group of EPA groundwater technical specialists representing US EPA's Regional Superfund and RCRA offices, responsible for the identification and resolution of groundwater issues impacting the remediation of sites. These two forums are referred to as "the Forums" throughout the remainder of this guidance.

This guidance presents current technical and policy recommendations of the EPA's Office of Solid Waste and Emergency Response (OSWER). The recommendations herein are not intended to apply or establish a precedent for any other purpose, including the purpose of evaluating completion of groundwater restoration.

The intended audience for this guidance is CERCLA and RCRA risk assessors, hydrogeologists and site project managers. This document does not address vapor intrusion or non-aqueous phase liquids (NAPLs) and is not intended to determine the attainment of Applicable and/or Relevant and Appropriate Requirements (ARARs) and/or cleanup goals. For more information on the vapor intrusion issue, please refer to the following EPA website: http://www.epa.gov/oswer/vaporintrusion/.

2.0 Information Needed to Calculate an Appropriate Groundwater Exposure Point Concentration

Prior to the development of a GW EPC, it is assumed that a site team has been assembled, the Remedial Investigation and human health risk assessment (HHRA) are underway, and a robust GW CSM that clearly defines the plume(s) has been developed. Decisions about the data to be used in EPC calculations ideally are based on the groundwater conceptual site model (GW CSM). In addition, information about well construction, including screened interval, is generally useful for supporting decisions about data sets to use for EPC calculation. Decisions about the data to be used in EPC calculations ideally are based on the GW CSM.

Data used in EPC calculations are most informative if recent and from the core of the plume. It is typically not appropriate to use modeled concentrations in GW EPC calculations; actual sampling data are preferred.

If the GW CSM has identified a seasonal or other temporal influence (e.g. drought patterns, tidal cycles, or changes in patterns of groundwater withdrawal or irrigation) on contaminant concentrations, OSWER recommends using data collected during times of higher detected concentrations in the calculation. Regional hydrogeologists can be consulted to determine if seasonality or other temporal influences are an issue at the site and if so, determine the appropriate sampling and dataset for that site.

If seasonality or other temporal influences are not a site issue, then OSWER recommends using data collected from the latest two rounds of sampling for each selected well. Generally it is recommended to use data collected within the last year so that the data will be representative of current conditions. (Depending on the GW CSM, the amount of time required to be representative of current conditions could be more or less than one year).

Factors to consider when evaluating whether or not data are representative of current conditions include the following:

- Movement – OSWER recommends that groundwater flow rates be considered when determining which data are representative of current conditions (the faster the flow rates, the less representative older data will be) and to evaluate future risks.

- Fate and transport – OSWER recommends that attenuation processes be considered when determining which data are representative of current conditions (the higher the attenuation rates, the less representative older data may be) and to evaluate future risks. For more details on this and other fate and transport issues, consult with a regional hydrogeologist.

Generally, when there is more than one aquifer at a site, OSWER recommends that the aquifers be considered separately when calculating an EPC (i.e., EPC values for each aquifer).

When the monitoring network provides sample concentrations from multiple sample depths at a given location within a plume (e.g., nested, paired, and/or multiport monitoring wells in the same aquifer), OSWER recommends using the highest detected concentration from such samples at each location to calculate the GW EPC for each aquifer (e.g., if there are two samples from different depths in a two-port well in the same aquifer at a given location within the plume footprint, it is recommended that the higher of the two sample concentrations be used in the EPC calculation, along with concentrations from other wells in the aquifer). When there are multiple groundwater contaminants with concentrations that are not proportional, this recommended approach could result in different samples (e.g., sampling depths) being used to characterize exposure concentrations for a given plume.

3.0 Well Types

Several different types of wells may be present on a site. Typically, sampling results from monitoring wells are the only data acceptable for use in the GW EPC calculation. If sampling results from a well type other than a monitoring well are being considered, coordination with the site team is important to assure appropriate use of the data in the calculation of the GW EPC.

a. Monitoring wells: Monitoring wells in the core of the plume are the preferred source for data used in GW EPC calculations for purposes of characterizing a reasonable maximum exposure condition. At any given location, there may be a single well that provides groundwater samples at one depth or there may be groundwater samples from multiple depths (e.g., two paired wells, multiple clustered or nested groups of monitoring wells, or multi-port wells with multiple sampling depths located in a single hole). It is recommended that the monitoring wells used have documentation that they have been properly constructed and maintained.

b. Private (residential) drinking water wells: Groundwater samples from residential wells provide valuable information about current exposure conditions at individual locations; however, reliable information about the construction and/or depths of residential wells is often limited, if available at all. It is recommended that each residential well be evaluated on a well-by-well basis for risk assessment purposes to inform the risk management decision for each individual property. However, residential well data are not included with monitoring well data in a GW EPC calculation for evaluating a reasonable maximum exposure condition.

c. Temporary wells (e.g., hydro-punch): Generally, data from these types of wells are not recommended for use in a GW EPC calculation because the results are not reproducible. There may be some exceptions to this based on site-specific conditions (e.g., absence of any other type of well in the core of the plume). OSWER recommends that use of data from temporary wells be determined on case-by-case basis. If data from temporary wells are used, consultation with the site team is recommended to assure the approach meets project goals.

d. Piezometers: Depending on the details of their construction, data from piezometers may or may not be acceptable for use in GW EPC calculations. Consultation with the site team is recommended prior to using any data from piezometers.

4.0 Data Quality and Other Issues to be Addressed when Calculating the Groundwater Exposure Point Concentration

In addition to well type, which is addressed in Section 3.0, the following are some factors to consider when evaluating data for inclusion in a data set for GW EPC development:

a. Detection/reporting limits – OSWER recommends that Quality Assurance Protection Plans (QAPPs) be reviewed to ensure that the laboratory can achieve detection/reporting limits that are below Maximum Contaminant Levels (MCLs) and/or tapwater Regional Screening Levels (RSLs). OSWER also recommends that sample quantitation limits be reviewed to ensure that they achieved these data quality goals. If the detection limit is elevated due to interference for a hazardous substance that is known to be site-related, then OSWER recommends that re-analyzing or re-sampling be considered.

b. Sampling methods – Sampling methods should be assessed to ensure they meet the data quality objectives (DQOs) identified in the site-specific Sampling & Analysis Plan (SAP).

c. Turbidity – OSWER recommends that turbidity levels be stable and be as low as possible (generally less than 5 -10 NTUs) prior to sampling. If turbidity levels cannot be stabilized or adequately reduced by longer purging time and/or lowered pumping rates during purging and sampling, OSWER recommends that additional well development (and potentially well replacement) be considered/undertaken before collecting a sample.

d. Filtered vs. unfiltered samples – Unfiltered data are recommended for use in EPC calculations. From *US EPA Risk Assessment Guidance, Part A (1989)*, "If unfiltered water is of potable quality, data from unfiltered water samples should be used to estimate exposure." In the rare exception that use of filtered data is needed, it must be agreed upon by the site team.

e. Type of contaminant – Some additional considerations should be made based on the type of contaminant including fate and transport processes for volatile organic compound (VOC) breakdown products, NAPL, metals, the potential presence of contaminants of emerging concern (e.g., 1,4-dioxane), etc.

f. Non-detects - Non-detects are frequently an issue at sites. Consultation with the site team and use of software like ProUCL should be used to address this issue.

5.0 Method to Develop GW EPCs for Use in the Risk Assessment

There often is a dichotomy between the data needs for site characterization, which focuses on the nature and the extent of the contamination, and the data needs for a GW EPC calculation, which focuses on the core (or center) of the contamination plume. For the GW EPC, the assessors need adequate characterization of the entire plume to be able to identify the core of the plume (distinguished by higher concentration levels compared to the lower levels of the plume fringe).

Multiple discrete plumes may be present at a site due to releases from individual sources. OSWER recommends that each plume be evaluated individually for a unique EPC. For sites that have commingled plumes from multiple sources and/or separated and distinct plumes that may commingle under stress conditions, the aggregate risk needs to be evaluated based on the consideration of the combined effects, when appropriate, from each contaminant present.[2] The risk assessment needs to include information regarding the analysis and calculations.

There are various approaches available to calculate a GW EPC. This guidance provides one approach to calculating GW EPCs that is expected to be appropriate for a majority of sites. There may be cases where regional policies and/or site-specific conditions require certain methods be used that differ from the default method described here. Before selecting the approach for a site-specific situation, consultation within the regional site team is recommended to assure that project goals are met.

OSWER generally recommends that monitoring wells within the core/center of the plume[3] be used to calculate the GW EPC for each contaminant. Data from a minimum of 3 wells in the core of the plume is generally recommended for this calculation. OSWER recommends that the GW EPC be calculated as the 95% Upper Confidence Limit (95% UCL) of the arithmetic mean concentration for each contaminant addressed in the risk assessment. A statistical software

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[2] When a single contaminating chemical is present in groundwater, the noncancer health risk can be characterized by calculating the noncancer hazard quotient (HQ). When multiple chemicals are present in groundwater, the HQ estimates for each chemical are aggregated (as a simple sum), based upon the assumption that each chemical acts independently (i.e., there are no synergistic or antagonistic toxicity interactions among the chemicals), after segregating the chemicals by toxic effect to derive separate hazard index (HI) values for each effect.

The carcinogenic risks can be characterized by calculating the excess cancer risk over a lifetime (LCR) and, if multiple chemicals are present, aggregating the LCR estimates for each carcinogen (as a simple sum), based upon the assumption that each chemical acts independently.

[3] Sometimes the project team will be interested in quantifying risks in contaminated areas that are beyond the center of the plume. This may occur when, e.g., there are overlapping plumes, there are actual receptors located in certain parts of the plume, or there are other site-specific considerations. Therefore, in such cases, it may be necessary to evaluate risks in other parts of the plume, *in addition to* the center of the plume."

package such as ProUCL can be used to calculate a 95% UCL. It is generally desirable to use at least 10 data points for each contaminant (e.g., 5 wells and 2 rounds of data representative of current conditions equate to 10 data points) to compute a 95% UCL. If the 95% UCL is greater than the maximum detected concentration, OSWER recommends that the GW EPC default to the maximum detected concentration for that contaminant. If less than 3 wells are within the core of the plume, OSWER recommends that maximum detections be used as the EPC for that contaminant. It is recommended that the uncertainty of using so few data points be discussed in the Risk Characterization portion of the risk assessment, specifically the uncertainty section of the risk assessment.

The recommended averaging of concentration data from multiple monitoring wells is intended to apply solely for purposes of the baseline risk assessment. The recommendations herein are not intended to apply or establish a precedent for any other purpose, including the purpose of evaluating completion of groundwater restoration.

6.0 Summary

This guidance recommends an approach for calculating the GW EPC at Superfund and RCRA corrective action sites for use in human health risk assessments. The recommended approach is to calculate a 95% UCL on the arithmetic mean based on data from the core of a contaminant plume and to use that value (or the maximum value if the 95% UCL exceeds the maximum value) to represent the GW EPC for potentially exposed individuals. This approach is expected to be appropriate for a majority of sites.

7.0 References and Citations

U.S. Environmental Protection Agency (EPA). 2013. Human Health Risk Assessment website. Available: http://www.epa.gov/risk_assessment/health-risk.htm.

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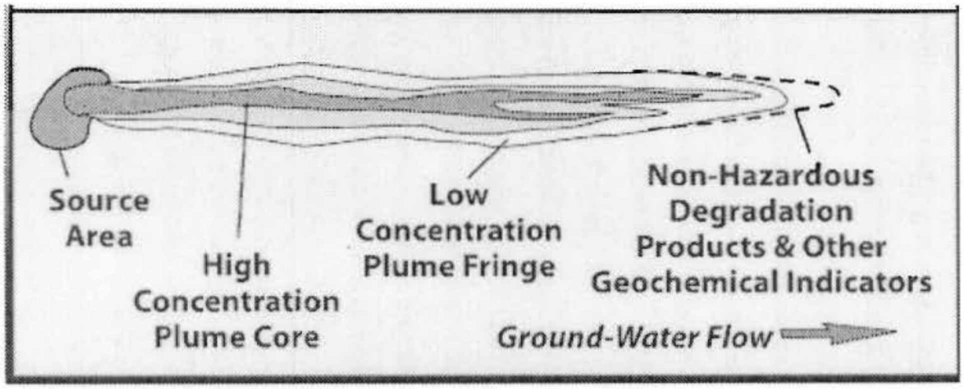
U.S. Environmental Protection Agency (EPA). 2002. *Supplemental Guidance to RAGS: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites.* Publication Number 9285.6-10. Office of Solid Waste and Emergency Response. December.

U.S. Environmental Protection Agency (EPA). 1992. *Supplemental Guidance to RAGS: Calculating the Concentration Term.* Publication Number 9285.7-08I. Office of Solid Waste and Emergency Response. May.

U.S. Environmental Protection Agency (EPA). 1989. *Risk Assessment Guidance for Superfund (RAGS) Volume 1: Human Health Evaluation Manual (Part A).* Publication Number EPA/540/1-89/002. December.

FIGURE 1



Idealized Plan View of a Groundwater Contaminant Plume for Purpose of Distinguishing the "Core" from Fringe Areas