EPD Stakeholder Input Request
Land Protection Branch
Draft Area Averaging Guidance

The Georgia Environmental Protection Division (EPD) Land Protection Branch (LPB) has developed the attached draft guidance document:

Area Averaging Approach to Soil Cleanups

This document will be applicable for use in Georgia under a variety of regulatory frameworks including RCRA, CERCLA, Hazardous Site Response Act, Voluntary Remediation Program Act, and Georgia Brownfield Act.

As part of the guidance development process, LPB is soliciting input from the public and impacted organizations regarding this document. Feedback will be accepted through December 14, 2018 by mail or by e-mail at the following addresses. You may also call with questions. Depending on the feedback received, EPD will revise and finalize the document or provide a forum for further stakeholder input:

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EPD will be participating in a workshop hosted by Georgia Industry and Environmental Coalition on December 4, 2018 at the Southern Company Gas offices in Atlanta. This workshop will include a presentation and roundtable discussion on the topic, thereby affording an additional option for individuals to learn more and to provide feedback.

External Review DRAFT

GEORGIA
DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION

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Area Averaging Approach to Soil Cleanups

October 4, 2018

Note: This is an external review draft to assist stakeholders in providing feedback as part of a guidance development process. Final agency approval of this document is pending.

ACKNOWLEDGEMENTS

The following Environmental Protection Division (EPD) staff members participated in the development of this guidance document:

- Kevin Collins (Response & Remediation Program)
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- Mauri Centis (Hazardous Waste Corrective Action Program)
- Shanna Alexander (Risk Assessment Program)
- Robin Futch (Formerly with the Response & Remediation Program)

Additional EPD staff and management participated in the technical review of this document.

REGULATORY APPLICABILITY

This guidance document can be applicable for use under site specific exposure scenarios at sites regulated under the programs of the Land Protection Branch (LPB) at which soil removal actions are being performed as corrective actions in accordance with the following statutes and the corresponding rules:

- Federal Resource Conservation and Recovery Act (RCRA)
- Federal Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)
- Georgia Hazardous Waste Management Act, O.C.G.A. 12-8-60 *et seq.*
- Georgia Hazardous Site Response Act (HSRA), O.C.G.A. 12-8-90 *et seq.*
- Georgia Voluntary Remediation Program (VRP) Act, O.C.G.A. 12-8-100 *et seq.*
- Georgia Brownfield Act, O.C.G.A. 12-8-200 *et seq.*

The above-referenced statutes are administered by the LPB programs listed below:

- Hazardous Waste Corrective Action Program
- Hazardous Waste Management Program
- Response & Remediation Program
- Risk Assessment Program

DISCLAIMER

This document is intended to provide guidance to stakeholders regarding the use of area averaging within the Land Protection Branch. This document reflects the current thinking of the referenced programs regarding the subjects discussed herein. Comments are welcome at any time. This document may be revised in the future based on comments and/or new information. This document does not create or confer any rights for or on any person or operate to bind the public. An alternative approach to those discussed in this document may be used if the approach satisfies the requirements of applicable statutes and regulations. The use of trade names does not constitute endorsement by EPD.

TABLE OF CONTENTS

List of Tables and Figures

ACRONYMS AND ABBREVIATIONS

ASTM	American Society for Testing and Materials
BGS	Below Ground Surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	Chemical of Concern
CRG	Confidence Response Goal
CSM	Conceptual Site Model
DQO	Data Quality Objective
ED	Exposure Domain
EPC	Exposure Point Concentration
EPD	Georgia Environmental Protection Division
EU	Exposure Unit
HSRA	Hazardous Site Response Act
IC	Institutional Control
ITRC	Interstate Technology and Regulatory Council
KM	Kaplan-Meir
MDC	Maximum Detected Concentration
OSWER	Office of Solid Waste and Emergency Response
PAHs	Polycyclic Aromatic Hydrocarbons
PNNL	Pacific Northwest National Laboratory
RAGS	Risk Assessment Guidance for Superfund
RALs	Remedial Action Levels
RCRA	Resource Conservation and Recovery Act
RRP	Response and Remediation Program
RRS	Risk Reduction Standard
UCL	Upper Confidence Limit
UEC	Uniform Environmental Covenant
U.S. EPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
VRP	Voluntary Remediation Program (VRP)
VSP	Visual Sampling Plan

1. INTRODUCTION AND PURPOSE

There are various corrective actions that can be employed at a site in order to achieve remedial action objectives for soil. An area averaging approach is a viable and self-implementing option in which to achieve a risk-based cleanup value at a site and meet the established remedial action objectives.

The area averaging approach to soil cleanups can be defined as treating or removing soils with the highest contaminant concentrations such that the average (95% upper confidence limit (UCL) of the average) concentration remaining onsite after remediation is at or below the cleanup level (U. S. EPA, 2005). This approach does differ significantly from the typical "not-to-exceed" approach to soil cleanup, but due to cost considerations and other factors facilities may consider this alternative approach to demonstrating compliance. In many instances, implementation of an area averaging approach involves a combination of removal actions and statistical data evaluation. The averaging approach is designed to leave some degree of contaminant concentrations in the soil above what would be considered the "not-to-exceed" level from the traditional sense, but implementing cleanup levels as area averages does not rule out the identification and removal of "hot spots" and/or those areas that warrant remedial action with a focus on risk drivers. When applied accurately, the quality assurance and control measures typically entrained within the statistical methods can be used to efficiently and economically test for attainment of cleanup standards, as they allow for specifying and controlling the probabilities of making decision errors (U. S. EPA, 1994).

The area averaging approach is a viable and self-implementing option that may be used to demonstrate compliance with the direct exposure criteria for soil. However, multiple considerations must be taken into account when determining whether this approach is applicable for a given site. Consequently, it is recommended that the regulatory compliance officer for the site be contacted when considering an area averaging approach to a soil cleanup.

Due to the complexities of applying the area averaging approach, a workgroup consisting of technical personnel from the Response and Remediation Program (RRP), Hazardous Waste Corrective Action Program, Hazardous Waste Management Program, and the Risk Assessment Program developed this guidance to aid in performing and evaluating this approach to soil cleanups. This guidance provides general guidelines on how to achieve compliance with the applicable soil cleanup levels when utilizing an area averaging approach, and will assist users in the accurate and consistent application of the area averaging concepts across the various cleanup programs throughout the Land Branch. The specific objectives of this guidance include the following:

1) Establish the applicability of an area averaging approach.
2) Provide general guidance for developing an area averaging approach for soil cleanups that is consistent with the expectations of the Division in its oversight role.
3) Provide a general overview of the various statistical methods, tools, and resources that can be applied when estimating the exposure point concentration (EPC) term (i.e., the

concentration of a given chemical in a given medium at a location of potential contact with a specified receptor).

Typically a certain degree of statistical expertise is needed to perform and evaluate the statistical methods used when applying this approach; therefore, it is assumed that the users of this guidance possess a working knowledge of general statistics and statistical applications.

2. APPLICABILITY

Determining the applicability and plausibility of an area averaging approach is typically completed as part of the conceptual site model development phase of site cleanup. If a random exposure scenario is plausible at a specific site, and the cleanup objective(s) is not driven by a leach-based exposure scenario, area averaging may be considered a viable approach for surface and subsurface soil cleanup. For information on risk-based exposure and compliance scenarios related to soil leaching please see the EPD Soil Leaching Guidance.

Although most area averaging scenarios are associated with the removal of one primary chemical of concern (COC), it is worth noting that the successful implementation of the averaging approach will require a demonstration that the cumulative cancer and non-cancer risks are in compliance with soil criteria for sites with multiple COCs. Details associated with the determination of cumulative risks are included in the Georgia Risk Assessment Guidance.

According to the applicable regulations, area averaging of surface and/or subsurface soils can be considered an option for soil cleanups. However, it is important to consider the possibility that the exposure scenarios for subsurface soils and resulting cleanup criteria can be non-random and generally based on site-specific exposure scenarios, such as the construction/utility worker with a definitive work area/depth over a defined period of time. Therefore, EPD recommends that area averaging be applied only to those exposure domains (EDs) where routine surficial contact occurs, as the exposure concentrations are intended to be average "site-related" concentrations routinely contacted by a receptor. Should a site choose to utilize the area average approach for subsurface soils, an appropriate ED must be established to demonstrate that exposure to subsurface soils within this area is spatially random. Specifically, the data acquired to support the selection of an ED must account for the nature and extent of the release, the depth of the expected exposure, the vertical heterogeneity typical of subsurface environments, and the exposure pattern (i.e., randomness, frequency, duration, etc.) associated with a potential receptor. It should be noted that since utility and construction work tend to vary in location, depth, and duration, it may be impractical (at some sites) to 1) establish an accurate ED specific to these activities, and 2) acquire the necessary supporting data, versus addressing the health and safety concerns associated with this exposure pathway through site-specific institutional controls (i.e., land disturbance restrictions in an environmental covenant). It is recommended that the regulatory compliance officer be consulted prior to implementing a subsurface area averaging approach.

Considering that a significant amount of area averaging cleanups will pertain to the use of area averaging for surface soil, the following information is referenced in support of the definition of surface soils for the area averaging approach:

- Section 2.2.1 of the U.S. EPA Region 4 SESDPROC-300-R3 states that surface soils are generally classified as soils between the ground surface and 6 to 12 inches below ground surface (bgs).
- Section 12-8-102 of the VRP Act states, "the soil exposure domain for routine surficial contact with site soils is…from the ground surface down to a depth of two feet."
- Section 391-3-19-.07(8)(d)2 of the Rules for Hazardous Site Response (Rules) states that the Type 3 risk reduction standards (RRS) defines surface soils as soil within one foot of the land surface.

It should be noted that while the VRP Act specifies surficial soil as being between the surface and a depth of two feet, HSRA, RCRA, and the referenced U.S. EPA guidance and other federal and state guidance documents generally classifies a narrower range of soil (0-6 inches and 0-1 foot) as surface soils depending on the type of contaminant. This disparity is in part due to the consideration that a higher level of direct contact exposure to undisturbed soils will most likely be to contaminants in the top couple of inches of soil. For example, samples for contaminants like metals, polycyclic aromatic hydrocarbons (PAHs), dioxin, and pesticides should typically be collected in the top 3 to 4 inches of soil, and samples for most organics, particularly volatile organic compounds (VOCs) samples should be collected at a depth of 9-12 inches for surface soils (U.S. EPA, 2014). There may be some variations in the definition of surface soils among EPD Programs when implementing a surface soil investigation and cleanup; however, it is highly recommended that the data be separated into the 0-1 foot and 1-2 foot intervals in order to demonstrate no discernable disparity between these soil horizons.

Based on the guidance available to the EPD at the time that this document was developed, the following documents should be considered as primary resources when developing and evaluating the area averaging approach:

- Interstate Technology and Regulatory Council, November 2016. Geospacial Analysis for Optimization at Environmental Sites, Available online: http://gro-1.itrcweb.org/
- Interstate Technology and Regulatory Council, February 2012. Incremental Sampling Methodology. Available online: http://www.itrcweb.org/ism-1/pdfs/ISM-1_021512_Final.pdf
- U.S. EPA, 2005. Office of Emergency and Remedial Response, Peer Review Draft Guidance on Surface Soil Cleanup at Hazardous Waste Sites: Implementing Cleanup Levels, April, Available online: http://www.epa.gov/sites/production/files/documents/guidance-cleanup-April-05.pdf

The following additional documents contain pertinent and relevant information regarding the quality and quantity of site characterization data and statistical methods necessary to conduct area averaging at hazardous waste sites.

- U.S. EPA, 1992. *A Supplemental Guidance to RAGS: Calculating the Concentration Term*.

- U.S. EPA, 2002. *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites.*
- U.S. EPA, 2005. *Guidance on Surface Soil Cleanup at Hazardous Waste Sites: Implementing Cleanup Levels*.
- U.S. EPA, 2015. ProUCL Version 5.1 User Guide.
- U.S. EPA, 2015. ProUCL Version 5.1 Technical Guide.

3. DATA REQUIREMENTS

Key terms to be defined when applying the area averaging approach include exposure domain (ED), exposure unit (EU), exposure point concentration (EPC), and “hot spot” or “source material”. These key terms of the area averaging approach, along with general limitations and criteria, can be defined and used according to the following sections of this guidance.

3.1 Exposure Domain

The ED, for purposes of this guidance document, will be defined as the geographic area within which a receptor comes in contact with a contaminated soil during the exposure duration. Each ED can then be subdivided into smaller EUs based on site specific characteristics. Please see the Figure 1 below for a modified illustration (U.S. EPA, 2005).

The ED can be further described as an area where human or ecological receptors may come into contact with contaminants in soil on a regular basis (U.S. EPA 1989), the size and location of which may depend on known or anticipated uses of the site (ITRC, 2012). Within this established ED, the receptor is assumed to be equally exposed to all parts of the area by moving randomly across the area. The assumption of equal exposure to any and all parts of the ED is a reasonable approach (U.S. EPA, 1992) which allows a spatially averaged soil concentration to be used to estimate the true average concentration contacted over time (ITRC, 2012).

Information justifying the size and placement of the ED should be included as part of the development of Data Quality Objectives (DQOs) and Conceptual Site Models (CSMs). Justification should also include an explanation as to how the size of the ED is appropriate for the receptor being considered. If the ED is larger than the area of anticipated exposure, the average for the area will not accurately reflect exposure. For example, an adult-sized ED may be larger than that of a child; therefore, a cleanup strategy based on an area average for an adult may not be protective of a child (U.S. EPA, 2005).

3.2 Exposure Unit

EDs may be subdivided into or comprised of smaller EUs. EUs may be defined as equally sized and spaced volume areas established within the EDs, or they may be based on irregular features of the site which define contaminant transport mechanisms or potential human health/ecological exposure. For example, EUs may be based on an understanding of the contaminant distributions in or around the source, or based on the boundaries between different geologic formations with differing contaminant transport or exposure characteristics. For these reasons, the EUs can be utilized to define the removal action areas that may be needed to reduce the EPC to below the established compliance standard (ITRC, 2012). Please see the Figure 1 below for a modified illustration (U.S. EPA 2005) of the ED and EU.

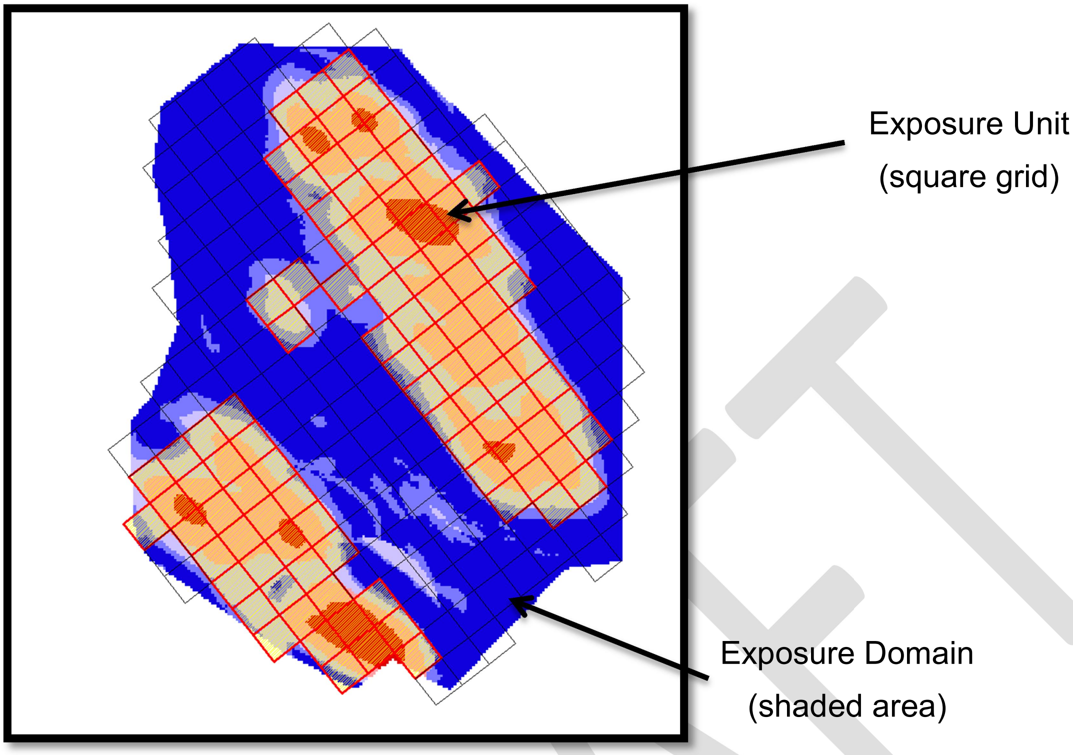

Figure 1: Sample Exposure Domain and Exposure Unit

3.3 Exposure Point Concentration

For the purpose of determining compliance with a numerical soil cleanup standard, compliance averaging for a contaminant will involve determining the 95% upper confidence limit (UCL) for the mean of the contaminant concentrations in soil. As defined in *Risk Assessment Guidance for Superfund: Volume III – Part A* (U. S. EPA, 2001), an EPC is the average concentration of a chemical (within an ED) to which receptors are exposed. This value is commonly calculated as the 95% UCL of the arithmetic mean and is often used to demonstrate compliance with the direct exposure cleanup criteria. EPD has discretion in accepting other methods (e.g., area weighted-averaging, concentration distributions, bootstrapping, etc.) for computing the EPC. However, EPD should be consulted prior to employing any of these alternative statistical methods.

For discrete sampling approaches, U.S. EPA guidance provides methods for calculating the EPC term for normal and lognormal datasets (U. S. EPA, 2015). EPD recommends using ProUCL for most statistical evaluations (http://www.epa.gov/land-research/proucl-software). The statistical methods available in the ProUCL program also allow for incorporation of non-detect values in determining EPCs. The EPC will often be one of the primary criteria for determining the type and magnitude of the remediation effort for a contaminant release. The successful derivation of a valid EPC will require the following:

1) A complete characterization of the vertical and horizontal extent of contamination released to the ED;
2) Definition of the ED and exposure depth; and
3) Collection of a statistically valid data set for each proposed ED.

The following recommended basic data requirements may assist in the successful derivation of a valid EPC:

- Generation of a valid data set for the ED is key to the derivation of an appropriate EPC. Consistent with U.S. EPA recommendations in the ProUCL version 5.0 User's Guide (U.S. EPA, 2015) and for practical and cost considerations, EPD recommends a minimum of 10 sample points from a single population, with at least 50% detectable results, to calculate reliable UCL estimates and determine the presence of any outliers occurring within data sets. In cases where a dataset of 10 sample points or more contains less than 50% detected values, the EPC should be based on the maximum detected concentration (MDC) or a nonparametric-based 95% UCL (either Kaplan-Meier (KM) or bootstrapping) EPC should be computed (U.S. EPA, 2013). In cases where the data cannot be approximated by a smooth continuous function, the MDC in the data set should be used to represent the EPC.

- Consideration should be given to the vertical extent of contamination and distribution of contaminants to avoid calculating biased EPCs. It is also important to understand where the highest contaminant concentrations are present onsite. For example, if a release to soil results in elevated concentrations in the top few inches of soil, an EPC calculated using soil data from the top 2 feet of soil would underestimate the current risk from exposure to surface soil. The EPC calculation, when performed, must be based on an appropriate distribution of the data.

- When presenting EPCs, the EPCs should be summarized on a table along with a summary of the data on which the EPCs were based; an example is illustrated in Table 1 below.

Table 1: Sample Chart for Reporting EPCs

Site Name: ABC Waste Disposal
Receptor: Commercial/Industrial Worker

Chemical	Units	Range of Detection Limits	Range of Detected Concentrations	Detection Frequency	Arithmetic Mean	95% UCL	Data Distribution	EPC

3.4 Limitations and General Criteria

Decisions about whether to use area averaging or implement a cleanup as a not-to-exceed level can depend on the amount of site characterization data. When there is adequate data coverage and the EDs/EUs are well defined, an area average approach may be appropriate. However, there are limitations to this particular cleanup approach. Specific examples of where this approach would not be appropriate include, but are not limited to the following:

- In Section 12-8-108(8) of the VRP Act and the Rules for Hazardous Site Response (Rules) Chapter 391-3-19-.07, area averaging does not apply to materials defined as source material and/or free product, and compliance with site-specific cleanup standards that require that source material and/or free product be removed may be satisfied when such material is removed, decontaminated, or otherwise immobilized in the subsurface, to the extent practicable.
- In accordance with Chapter 391-3-19-.07 of the Rules, no soils remaining in place under Type 1, 2, 3, or 4 RRS shall exhibit hazardous waste characteristics of ignitability, corrosivity, or reactivity as defined in 40 CFR 261 Subpart C.
- Extrapolation of data over a large area based on a small number of sample locations is unacceptable, unless it is clearly established that the contaminant distribution across the large area is uniform and accepted by the regulatory authority.
- When unique exposure scenarios exist within the ED and exposure can be considered non-random, such as a community playground, a garden, etc.
- The cleanup level is not derived from a UCL or average post-remediation concentrations (considers factors other than risk);
- The quality of site characterization data is not optimal and given the site conditions (complexity, size, characterization, contaminant distribution), it is not cost-effective to do the necessary sampling and statistical analysis;
- Discrete sampling methodologies must be used to collect the data that will be utilized in the area averaging datasets. However, if the use of an alternative sampling methodology is deemed necessary, site managers should consult the regulatory compliance officer for the site to obtain approval for the use of the proposed method prior to implementing the sampling plan.
- Instances where the party conducting the cleanup does not own the property and does not have express permission from the property owner to allow for potential contaminant concentrations above default regulatory levels to remain in place through an area averaging cleanup approach. This factor would also affect the ability to enact any institutional controls (IC) that may be necessary to maintain the exposure scenarios established through the area averaging approach.

For the general steps associated with the area averaging approach please refer to the flow chart in Appendix A, which illustrates the decision process for determining the viability of applying area averaging. The following is a list of general factors which should be considered when implementing an area averaging cleanup approach:

- *Randomness:* Justification of random exposure throughout the established ED(s) must be provided. Allowing soil contamination to remain in place in areas that are frequented more readily (e.g., child's playground, recreational park, etc.) may result in exposures to unacceptable levels of risk.
- *Quality and Quantity of Site Characterization Data:* Refer to U.S. EPA *Data Quality Objectives Process for Hazardous Waste Site Investigations* (U.S. EPA, 2000) for guidance on what constitutes high quality site characterization data. If there are uncertainties in the site characterization data (e.g., wide concentration ranges), consult with the regulatory compliance officer or implement a not-to-exceed or "bright-line" cleanup approach.
- *Toxicity:* Because soils with concentrations exceeding the cleanup level will be left onsite, it is necessary to demonstrate that those concentrations do not represent acute and sub-chronic health risks. EPD recommends the use of U.S. EPA Region IV Removal Management Levels when considering the acute and subchronic health risks associated with the concentration levels, receptors, current and future site use, and exposure scenarios.
- *Community Acceptance:* Consideration must be given to the potential that the public may not be receptive to an area averaging approach that may leave some impacted soils in place above cleanup criteria.
- *Statistical Expertise:* Implementing an area averaging approach requires a basic understanding and knowledge associated with statistical calculations and the use of statistical computer software.
- *Cost Effectiveness:* In some instances it may be more costly to acquire the amount of data necessary to support an area averaging cleanup approach versus a bright-line removal action and/or use of institutional controls to address exposure risks.

Once the site has addressed the above noted limitations and general criteria, there are additional technical aspects of the approach that may influence the implementation of the soil cleanup approach. The additional technical aspects that should be considered when implementing an area averaging cleanup approach include the following:

- *Size and structure of the ED:* A site must consider pre- and post-remediation land use and the location of source material and/or hot spots. While established EDs will vary based on site specific characteristics, it can be assumed that for a residential scenario the ED will not exceed 0.5-acre (i.e., the size of a suburban residential lot), consistent with U.S. EPA's *Soil Screening Guidance* (U.S. EPA, 1996). Therefore, the sampling technique would consist of subdividing large residential properties into EUs of 0.5 acre or less. For residential properties that are less than or equal to 0.5 acre, the actual residential lot size is typically designated as the exposure unit. ED's for non-residential scenarios can exceed 0.5-acre in size, and it is recommended that the established criteria, limitations, and resulting EDs for non-residential use be developed on a site-specific basis. It is also important to note that according to the U.S. EPA *Soil Screening Guidance*, the EDs should not be laid out in such a way that they unnecessarily combine areas of high and low levels of contamination to deliberately manipulate the mean (U. S. EPA, 1996). For this reason, non-residential area averaging cleanup approaches are supported by ICs.

- *Sample Size:* It is critical to ensure that the sample size within each ED is sufficiently representative of site conditions. Small sample sizes can translate to large uncertainty in estimates of pre- and post-remediation EPCs and resulting removal criteria. Similarly, over-sampling high concentration areas may fail to represent random movement of receptors and an appropriate sample distribution throughout the ED.
- *Sample Locations:* Sample locations should be compared to both the spacial structure of the impacts and the site related EDs. In addition, the depth of the sample(s) should be evaluated relative to the vertical distribution of the contamination at the site.
- *Decision Statistics:* It is recommended that the distributions and subsequent summary statistics should be computed using the latest version of U.S. EPA's ProUCL software. ProUCL calculates both parametric and non-parametric 95% UCLs and provides recommendations on which 95% UCL to use depending upon distributional assumptions and skewness. The first step in computing a UCL of a population mean is to test the data distribution. ProUCL tests for normal, lognormal and gamma distributions. If the data set does not fit any of the three distributions tested, U.S. EPA guidance recommends non-parametric approaches for estimating sample statistics. If 10 or more samples have been collected, use of the maximum detected concentration as the EPC is a conservative assumption since it assumes that the potential receptors were exposed to the MDC of each contaminant regardless of where that detection occurred within the EU. While it is EPD's recommendation to use the latest version of ProUCL for the statistical evaluations for estimation of the 95% UCL as the EPC, it is acceptable to use other free commercially available statistical software applications when available. (i.e., the SADA application for computing univariate statistics (http://www.sadaproject.net/)). In general, the data sets used for derivation of an EPC should meet or exceed the criteria for determining the number of samples needed as specified in the U.S. EPA: Guidance for Data Usability in Risk Assessment, Part A (U.S. EPA, 1991) (http://rais.ornl.gov/documents/USERISKA.pdf). Consideration should also be given to using U.S. EPA's Systematic Planning Using the Data Quality Objectives Process (U.S. EPA, 2006) for designing a sampling plan to collect data of sufficient quality and quantity to support the goals of the sampling investigation: http://www.epa.gov/sites/production/files/2015-06/documents/g4-final.pdf.
- *Statistical Methods:* Utilizing other methods such as area weighted-averaging, concentration distributions, bootstrapping methods, etc., for computing the EPC should be determined on a site specific basis along with proper justification for employing any of these alternative statistical methods. For example, area-weighted averaging could be useful where data are unevenly distributed or for point-by-point risk calculations through plotting of soil sampling locations as individual exposure units represented by Thiessen polygons.

3.5 Source Material / Hot Spots

As stated in the Limitations and General Criteria section, any identified source material and/or hot spots should not be incorporated into the area averaging cleanup approach. Therefore, it is important to provide a clear definition of source material and hot spots as they pertain to area averaging, and that soil cleanups address any EPD Program-specific requirements regarding source material and hot spots.

According to Section 391-3-19-.02 of the Rules, source material is defined as "any material that includes or contains regulated substances that act or may likely act as a reservoir for migration of regulated substances to groundwater, soil, surface water, or air, or acts as a source for direct exposure". Sources, which are areas of contiguous soil contamination, are delineated by the area and depth of contamination or to the water table, whichever is shallower (U.S. EPA, 1996).

U.S. EPA describes a hot spot as "a small portion of the ED that has very high contaminant levels" (U.S. EPA, 1996) or as "strata that contain high concentrations of the constituent of interest and are relatively small in size when compared with the total size of the materials being sampled" (ASTM D 6009-96 and U.S. EPA, 2002). ITRC's guidance document, Incremental Sampling Methodology Representative Sampling Confident Decisions, generally describes a hot spot as an area of elevated contamination (ITRC 2008). Hot spots may have a significant impact on direct contact exposures. The specific area and magnitude of contamination constituting a hot spot should be agreed on during the project planning and CSM phase (ITRC, 2012).

It is worth noting that Table 3-2, *Hot Spot Table*, of the ITRC's *Use of Risk Assessment in Management of Contaminated Sites* (ITRC, 2008) lists the written definitions and characteristics for hot spots of soil contamination for various states. The written definitions can generally be characterized as either numerical or those with non-quantified characteristics. For example, Alabama defines the term hot spot "in reference to a localized area or areas with concentrations substantially higher than the rest of the exposure domain", and Florida defines the term "in reference to a localized area or areas with concentrations substantially higher than the rest of the site" (ITRC, 2008). While the term "hot spot" is not defined in State regulations, the closest equivalent definition for the purposes of this document would be that of source material.

It is not uncommon for persons developing sampling plans to be instructed to investigate source materials and/or hot spots, which can bias existing data sets that were not developed with the initial intention of area averaging (U.S. EPA, 2013). The sampling plan should consider characterization of hot spots through extensive sampling, field screening, visual observations, or a combination of the above (U.S. EPA, 1989). Note that a hot spot may not always be identified visually (i.e., stained soil, free product) but can be identified by soil sampling results. When evaluating the sampling results for a site, a hot spot is typically identified when making relative comparisons in concentrations throughout the entire site. For instance, statistical outlier tests run with a program such as ProUCL (U.S. EPA, 2015) can be used to identify upper end outliers within the data, which in many instances represent potential hot spots or source material (ITRC, 2012).

While data evaluation is one way in which to identify potential hot spots or source material, the following general components/criteria may also be applied to determine/define hot spots or source material (ITRC, 2012):

- Areas with stained soil, known contamination, or obvious releases;
- Areas where contaminants were suspected to have been stored, handled, or disposed;
- Areas where sufficient sampling evidence indicates elevated concentrations in a specified location relative to the surrounding soil over a significant volume of contaminated media, and;
- Areas of soil contamination associated with known F-listed and K-listed waste material in accordance with 40 CFR 261.31 & 261.32.

3.6 Sampling Recommendations and Sampling Plan

One of the fundamental benefits of an area averaging approach is that this type of soil cleanup approach allows for the acquisition of data that will support decision making about an area or volume of material that is impractical or impossible to analyze in its entirety. Consequently, the representativeness of the sample data set becomes vital to the area averaging approach, as potential errors may result from collecting small volumes of samples meant to represent a much larger volume of contaminated soil. Therefore, the development of a focused soil sampling plan is a critical component of the area averaging approach, and can make or break the usefulness of this particular soil cleanup approach from a regulatory standpoint (ITRC, 2012).

For example, the majority of the sites in Georgia tend to have a fairly heterogeneous soil composition, which in some cases can lead to large variability in data sets from areas that may have traditionally been expected to be fairly uniform. Heterogeneities at very small, seemingly inconsequential, spatial scales can create the impression that large hot spots are present when discrete sampling is used. However, it is just as likely that heterogeneity can cause true hot spots to be missed, even though a sample was taken from within the boundaries of a hot spot. This is one reason why it is very important to have these hot spot areas adequately characterized horizontally and vertically to support the development of the CSM for the site. At sites that are heterogeneous in nature it becomes very important to ensure that the sampling plan accounts for the variability in not only site conditions but soil conditions as well (ITRC, 2012).

Considering that there are some sites that may complete their cleanup in a different program from where they may have originated, it is common for sampling plans to be developed without a clear picture of how the data will be used. Inadequate sampling designs commonly indicate that "representative samples" will be collected, but often there is no indication of what the samples are supposed to be representing (ITRC, 2012). Typically, a sampling plan with a low number of discrete samples does not produce a very accurate or precise estimate of the mean because such an approach does not account for heterogeneity and may not accurately represent large-scale contamination trends, particularly at larger sites/EDs. While the direct solution to this particular issue is to collect more data, it is worth noting that collecting the number of discrete samples sufficient to make a defensible area averaging decision at a site may at times be precluded by cost considerations (ITRC, 2012).

It is recommended that the following points be taken into account when developing or evaluating a soil sampling plan for an area averaging approach at a site:

- If possible, the plan should be developed early in the site assessment process, but not so early that a basic CSM has not been completed. For additional information on the development of CSMs, see ASTM E1689-95 (2014) Standard Guide for Developing Conceptual Site Models for Contaminated Sites.
- Default sampling plans should include the collection of data from discrete grab soil samples, collected in accordance with the U.S. EPA Region 4 Science and Ecosystem Support Division Soil Sampling Operating Procedure SESDPROC-300-R3 (August 21, 2014). Consult with the regulatory compliance officer prior to implementing alternate sampling methodologies.
- The plan should at a minimum incorporate the information discussed in the prior Sections (Applicability and Data Requirements), and include a soil sampling rationale to demonstrate that a sufficient amount of soil samples have been, or will be collected in order to develop a data set that is representative of the ED for all constituents of concern. Specific consideration should be given to establishing vertical sampling intervals (i.e., separating out the data from the 0-1-foot and 1-2-foot surface soil ranges).
- An appropriate sampling rationale and associated sampling plan should be used to justify that the contaminant concentration in a representative sample is an accurate and precise estimate of the true contaminant concentration in the representative sampling grid/EU. For example, the EU that is established, within the ED, for a residential ½-acre site may generally be a 25-foot x 25-foot grid. With this default sampling rationale for a ½-acre residential ED, approximately 35 sample locations would contribute to the calculation of the ED EPC. While it may be understood that residential scenarios tend to require more conservative sampling strategies, establishing EUs and associated sampling strategies for non-residential use scenarios may yield less conservative EUs and sample spacing throughout the ED(s).
- If no hot spots/source material were identified in the CSM phase, it is recommended that the sampling plan avoid concentrating or localizing sample locations around specific areas of concern, as this tends to represent a hot spot/source material release scenario rather than the assumed random distribution of contamination throughout the ED that is typical of an area averaging approach to site cleanup, i.e. will the strategy include the removal of the entire EU(s) or an alternate approach.
- It is recommended to discuss the removal action strategy for EPC exceedances with the regulatory compliance officer.
- Incorporate a sampling strategy for evaluating fill material that complies with the EPD "Guidance for Demonstrating Completion of Soil Removal Actions at Corrective Action Sites in Georgia" (https://epd.georgia.gov/land-protection-branch-technical-guidance).

Should a facility need additional assistance in establishing an EU (sample grid) size, ED size, or number of samples collected from each, the DQOs sample sizes module (Chapter 12) of ProUCL is a useful software tool (U.S. EPA, 2015).

3.7 Software/Modeling Recommendations

For basic statistical evaluations of the data sets used in the area averaging approach, EPD recommends the use of U.S. EPA Office of Research and Development ProUCL Version 5.1.00 (http://www.epa.gov/land-research/proucl-software).

Visual Sample Plan (VSP) is a freely available software from the Pacific Northwest National Laboratory (PNNL) at http://vsp.pnnl.gov/ (12-2017 / Version 7.10). VSP is useful for taking into account different standard deviation and population distributions in calculating the number of samples needed to achieve specific confidence requirements in a sample population. VSP can utilize variograms to determine a range and an associated confidence in the range, and should the confidence not meet a certain criteria it can indicate that additional sampling points are needed.

Should a geostatistical methodology be used in support of the area averaging approach, ArcGIS Pro 2.1 (https://www.esri.com/en-us/arcgis/products/arcgis-pro/overview) with the Geostatistical Analyst Package, or similar licensed and available software may be used to evaluate the data presented.

For links to available free software for processing and analysis of spatial data used in conjunction with geostatistical software please go to the EPA Region V FIELDS (Field Environmental Decision Support) Team website:

https://response.epa.gov/site/doc_list.aspx?site_id=7313.

Additional information regarding various geostatistical software is available from ITRC in the web-based “Geostatistics for Remediation Optimization” guidance (http://www.itrcweb.org/).

4. AREA AVERAGING METHODOLOGY

In general, site managers tend to use one of the following three statistical methods when demonstrating that cleanup levels are met through an area averaging approach:

- Iterative truncation;
- Confidence response goal (CRG); and
- Geostatistics

Iterative truncation is a simple method based on the identification and removal of soils with the highest contaminant concentrations in order to achieve an EPC that is at or below the desired cleanup-level for the site. The CRG method is a more statistically complex method that utilizes the mean and standard deviation of contaminant concentrations, along with the established cleanup levels. The third noted method utilizes geostatistical methods to process spatially correlated data, such as sites where contaminant concentrations reveal clear spatial patterns of highly impacted zones surrounded by marginally impacted areas with gradually decreasing contaminant concentrations. This type of spatially correlated data is suitable for geostatistical analyses; however, this method tends to require specialized software and advanced statistical knowledge.

Additional information on these methods and others can be found on the ITRC "Geospatial Analysis for Optimization at Environmental Sites" website (https://gro-1.itrcweb.org/) and in the ASTM STP 1283 (1996). Also, Table 2 at the end of this Section summarizes the three primary methods that are likely to be used for area averaging demonstrations.

4.1 Iterative Truncation Method

Iterative truncation is a simple method based on the identification and removal of soils with the highest contaminant concentrations in order to achieve an EPC that is at or below the desired cleanup level for the site. Iterative truncation is used for non-spatially correlated data and it assumes that each sample is an uncorrelated data, and unbiased representation of a remediation area within the ED.

In general, a site manager should consider the following important factors when determining whether iterative truncation is an appropriate method to use at a site: sampling size is sufficient, sampling design yields a representative distribution of measurements within the exposure unit, and assumptions about post-remediation distribution of concentrations are reasonable.

As indicated, iterative truncation involves removing (truncating) high values in the sample concentration measurements and calculating a hypothetical post-remediation EPC. For this reason, it is inappropriate to use composite samples. Each iteration entails replacing the next highest value with ½ the detection limit value or the arithmetic mean concentration of clean fill, which as a general rule of thumb can be a minimum of 1 sample per 250 yds^3 (California

EPA, 2001). It is recommended that the amount of fill material samples to be collected be determined by coordinating with the regulatory compliance officer for the site prior to implementation, as the amount may vary depending upon the fill material characteristics, background information on the borrow area, and volume of fill material required. Each iteration will involve the calculation of a new EPC that is compared to the cleanup level. At the end of the process, the estimated post-remediation EPC should be at or below the desired cleanup level, and a soil concentration will be set at which all the soils above that concentration have been removed, also referred to as a RAL.

4.2 Confidence Response Goal (CRG) Method

The CRG method is used to calculate a cleanup goal associated with a specific EU and for all practical purposes is the same as a Remedial Action Level (RAL). This cleanup goal is a not-to-exceed concentration that will ensure that the area average concentration of the soil left in place at the selected EU is at or below the established cleanup level. The basic premise of this method is that the CRG can be expressed as a function of the mean and standard deviation of contaminant concentration, and the cleanup level. The average post-remediation concentration is calculated from the pre-remediation distribution that is truncated at the CRG, and a second superimposed distribution that represents the concentration of a contaminant in clean fill. The average concentration of the post-remediation distribution is a weighted average of the portion of the pre-remediation distribution with concentrations below the CRG and the concentration of the clean fill which replaces all pre-remediation concentrations that exceed the CRG. Additional discussion and references to this method can be found in the U.S. EPA *Draft Guidance on Surface Soil Cleanup at Hazardous Waste Sites* (U.S. EPA, 2005).

Although potential remedial cost savings may be associated with the use of the CRG method, risk managers should be aware of the need for statistical expertise in applying the method correctly and the difficulty in communicating the results to the public and gaining community acceptance.

4.3 Geostatistical Methods

While non-spatial methods assume that the contaminant concentrations within an EU are uncorrelated, at many sites contaminant concentrations reveal clear spatial patterns, where highly impacted zones are surrounded by marginally impacted areas with gradually decreasing contaminant concentrations.

Geostatistical methods are statistical procedures designed to process spatially correlated data and interpolate between known data points. The presence of spatially correlated data is quite common at hazardous waste sites because of structured patterns in the distribution of contamination. For example, sites impacted by migration of contaminants from a concentrated localized source, such as an unlined lagoon for liquid waste storage, might exhibit spatial patterns of contamination. Contaminant concentrations in and around the lagoon may be higher than those at greater distances from the lagoon.

Spatial correlation also arises because sampling data are sometimes collected in a biased fashion and may be clustered around hot spots of contamination. In such areas, soil samples can be influenced by the same phenomena and are therefore not independent. This poses some difficult questions/problems from the perspective of spatial data analysis:

- What data are truly representative of the entire site and should be used for variography or for developing distributional models?
- What data are redundant or create bias?
- Has contamination been characterized adequately?

These questions are frequently encountered, especially in the initial phases of a project that has not undergone thorough pre-planning (ASTM, 1996).

This type of spatially correlated data is suitable for geostatistical analyses. While geostatistics can accommodate biased data, excessive bias can provide misleading results. For example, geostatistical interpolation would over-estimate the extent of the impacted area in a situation where a highly sampled hot spot is surrounded by un-sampled non- impacted areas. Geostatistics is not a solution, only a tool. It cannot produce good results from bad data, but it will allow one to maximize that information (ASTM, 1996).

There are a few more common geostatistical methods that can be helpful when implementing this type of cleanup approach at a site. The most typical geostatistical methods are known as kriging or co-kriging. These methods are used to extrapolate and estimate concentration gradients based on the spacial correlation. Common applications of kriging in environmental and geotechnical engineering include: delineation of contaminated media, estimation of average concentrations over exposure domains, as well as mapping of soil parameters and piezometric surfaces (Rouhani, 1996). These methods can also be used to develop excavation limits based on the estimated concentrations rather than having excavation limits to known sample locations. These methods require specialized software, expertise in statistical methods and advanced GIS capabilities, the details of which are beyond the scope of this document.

Table 2. Recommended Statistical Methods For Implementing Cleanup Levels As Area Averages

Iterative Truncation Method Pros: • Simple; no statistical expertise needed. Cons: • Very sensitive to highest contaminant concentrations in the sample; if the highest sample concentrations are not representative of the highest concentrations at the site, the resulting RAL may not be protective. Cautions: • Inappropriate for use with composite data. • Inappropriate for use with spatially correlated data. • If sampling data are biased such that higher concentration areas are over-sampled, the resulting RAL will be unnecessarily low.
Confidence Response Goal Method Pros: • Less sensitive than iterative truncation to the representativeness of the highest sample concentrations. • Accounts for different statistical distributions of contaminant concentration data. Cons: • May entail some statistical expertise. • Difficult to communicate results to public, due to mathematical complexity. Cautions: • Inappropriate for use with composite data. • Inappropriate for use with spatially correlated data. • If sampling data are biased such that high concentration areas are over-sampled, the resulting RAL will be unnecessarily low.
Geostatistical Method Pros: • Can be used with spatially correlated data. • Can be used with biased sample data (e.g., over-sampling of hot spots). • Can reduce the amount of excavation by only digging to estimated concentration gradients rather than known sample locations Cons: • May entail geostatistical expertise and specialized software. • More costly and time consuming than non-spatial methods. Cautions: • Consider the value of the information gained from geostatistical approach to ensure that the anticipated benefits justify the costs.

5. CONCLUSIONS

As indicated within this guidance document, the area averaging approach, under certain circumstances, can provide an appropriate method for verifying that the risk associated with direct exposure to site soils has been sufficiently addressed through corrective action. While site managers are encouraged to carefully review the contents of this document to assist with the determination of the applicability of the area averaging approach, the final decision to apply this approach should be made in consultation with the EPD compliance officer and/or project manager. Additionally, sufficient justification for the use of area averaging, in accordance with this guidance document, and a detailed description of its implementation should be presented in the appropriate report for EPD review and approval.

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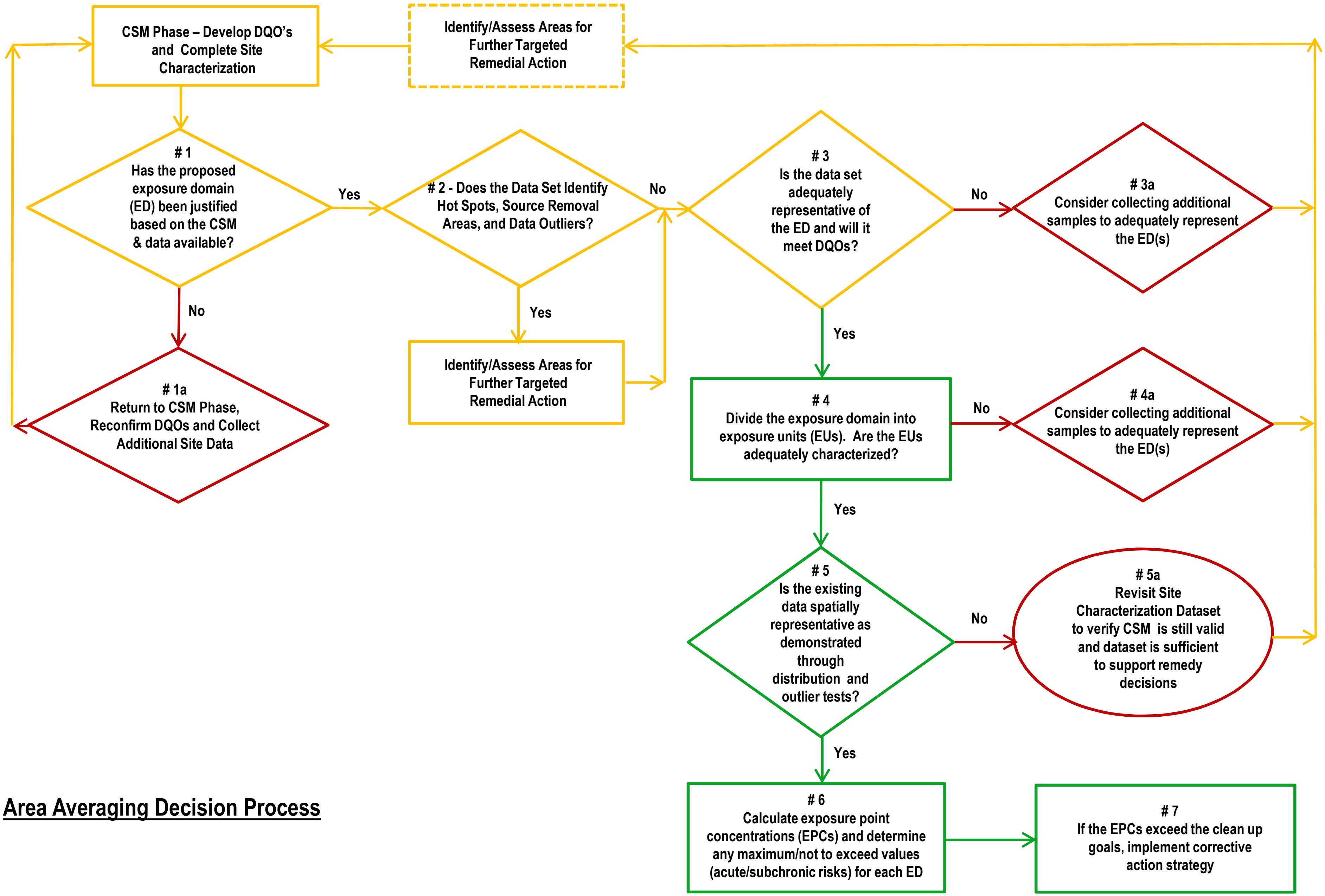
Is Area Averaging Applicable to the Data Set and Should It be Considered?



Area Averaging Decision Process