New Jersey Department of Environmental Protection

Site Remediation Program

Soil Investigation Technical Guidance

Site Investigation/Remedial Investigation/ Remedial Action (SI/RI/RA)

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Version 1.0

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SOIL INVESTIGATION TECHNICAL GUIDANCE

1. INTENDED USE OF GUIDANCE DOCUMENT

This technical guidance is designed to help the person responsible for conducting remediation to comply with the New Jersey Department of Environmental Protection (Department) requirements established by the Technical Requirements for Site Remediation (Technical Rules), N.J.A.C. 7:26E. Because this technical guidance will be used by many different people that are involved in the remediation of a site, such as Licensed Site Remediation Professionals (LSRPs), Non-LSRP environmental consultants, and other environmental professionals, the generic term "investigator" will be used to refer to any person that uses this the technical guidance to remediate a contaminated site on behalf of a remediating party, including the remediating party itself.

The procedures for a person to vary from the technical requirements in regulation are outlined in the Technical Rules at N.J.A.C. 7:26E-1.7. Variances from a technical requirement or departure from technical guidance must be documented and adequately supported with data or other information. In applying technical guidance, the Department recognizes that professional judgment may result in a range of interpretations on the application of the technical guidance to site conditions.

This technical guidance supersedes previous Department guidance issued on this topic, pursuant to N.J.S.A. 26:10C-16, and was prepared with stakeholder input. The entire committee consists of the following:

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1.1 Purpose

The purpose of this document is to provide technical guidance on the investigation of contamination in soil at the site investigation (SI), remedial investigation (RI) phases, and verification sampling for remedial action (RA) phases of a remediation pursuant to the Technical Requirements for Site Remediation. In particular, this document will provide the following:

- background for the need to investigate contaminants in soil
- different approaches to achieve compliance with the soil investigation requirements in the Technical Rule
- recommendations for sampling frequencies to properly delineate soil contamination
- assistance in the evaluation and use of soil sampling at Site Remediation Program sites

2. OVERVIEW

This document provides the investigator with the technical guidance to conduct soil sampling and analysis in order to complete a site remediation. This could entail sampling and analysis to determine if contamination is present at the site above an applicable Department remediation standard (the site investigation), delineation of soil exceedances (the remedial investigation) and verification sampling and analysis for confirming that the soil has been successfully remediated (verification sampling for the selected remediation action). Please note that the when the term “sampling” is used in this document it typically means both sampling and analysis.

The remediation process requires that, when a site or AOC is known to be or is suspected of being contaminated, an investigation of the area must be conducted. The first step of this process, after the preliminary assessment (PA) phase, is the site investigation (SI). During a SI, sampling is conducted in areas where the highest contaminant concentrations are suspected to be present, to determine the type and concentration of the contaminants. If it is determined through the SI that contamination is present above the Department’s remediation standards, then delineation of the contamination is required followed by a remedial action.

Contamination is delineated through a remedial investigation (RI). The purpose of the RI is to gather enough information about the contamination, the media and the site, to determine the appropriate course of action required to remediate/mitigate the contamination. Typically, a remedial action is conducted after the RI has been completed; however, there are circumstances when the remedial action may take place prior to the completion of the RI. As part of the remedial action, confirmatory sampling is typically conducted to ensure that the contamination has been successfully remediated. However, if contamination has been satisfactorily delineated prior to the remedial action, depending on the remedy, confirmation/verification sampling may not be necessary.

3. SITE INVESTIGATION – SOIL

3.1 Site Investigation – Soil Objective

The objective of the soil sampling program in the SI phase is to assess if any contaminants are present in an AOC above any of the applicable soil remediation standards (N.J.A.C. 7:26D) or if no further action (investigation or remedial action) is required. If any contamination above an applicable remediation standard is present at the site, then further action (investigation or a remedial action) is required. One goal of the SI is to bias samples towards suspected or known areas of highest contamination.

3.2 General Site Investigation Soil Considerations

This section discusses general concepts that are common to most SIs and are necessary steps for planning and executing a successful SI.

3.2.1 Relation of the SI to the Site Remediation Process

The SI provides information necessary to determine 1) if contaminants are present in concentrations above Soil Remediation Standards (N.J.A.C. 7:26D), 2) the compounds or classes of compounds present, and 3) preliminary information on the horizontal and vertical extent of the contamination, hydrogeology and other site characteristics.

If contamination above the applicable Soil Remediation Standards (N.J.A.C. 7:26D) is detected, the SI information is used to develop an approach for completing the RI. For many sites, the SI represents the first time that an environmental investigation is being conducted, and there is no previous knowledge of site-specific conditions. Therefore, it is important to maximize the amount of information collected in the course of the sampling activities. In some instances, it may not be necessary to separate the SI from the RI; for example, when visibly contaminated soils are encountered and it is evident that the extent of the contamination must be delineated. In addition, there may be instances when a limited investigation will be conducted and sampling will be reserved for post-remedial action verification. This occurs in cases where an observed release is addressed by soil removal and sampling is conducted at the end to verify achievement of remediation standards.

If the SI does not reveal the presence of contamination above applicable Soil Remediation Standards, the SI data collected should be adequate to conclude that no further action is required at the particular area of concern (AOC) being investigated.

3.2.2 Data Quality Objectives

SI data should be comprehensive enough to sufficiently evaluate the AOC and determine if further action is required. The Data Quality Objectives (DQO) is the process pursuant to N.J.A.C. 7:26E-2.2 by which it is determined when, where and how to collect samples along with determining the number of samples or measurements, and the desired level of certainty in the investigation results. These considerations are then used to develop a Work Plan that meets the project needs.

The investigator should consider the following in developing project DQOs:

- What are the nature and the characteristics of the AOC being evaluated? Development of a Conceptual Site Model (CSM) – (see the Department's CSM technical guidance document) may be useful in gathering the information for this task.

- What is the hypothesis that needs to be verified, and what might be the action that will be taken after the hypothesis has been verified (e.g., is there an impact and is remediation warranted)?

- What data are necessary to answer the above questions, including what are the remediation standards?

- Define the extent of the investigation. Will the sampling be representative of all or part of the site or AOC? Will it be representative under all conditions?

- Define the decision rule (e.g., if all contamination is below all applicable remediation standards, then no further action is necessary).

- Evaluate and understand the extent to which the analytical methods and sampling protocols provide the answers required by the project objectives.

Document the DQOs in writing, especially for complex sites or where complex decisions may be necessary. The same process applies to development of DQOs for the RI phase.

The U.S. Environmental Protection Agency (USEPA) has developed in-depth guidance for the development of DQOs (United States Environmental Protection Agency Guidance on Systematic Planning Using the Data Quality Objectives Process EPA QA/G-4 EPA/240/B-06/001 February 2006). Use of this guidance is at the professional discretion of the remediating investigator.

3.2.3 Accessibility and Access

There may be instances when sampling at an AOC may not be practical or possible due to access or health and safety considerations; for example, when public utilities interfere, buildings are present or active process areas are present, etc. In those cases, alternative assessment methods may be necessary. Depending on the contaminants of concern (COC) and the CSM (see CSM technical guidance), it may be possible to collect a ground water sample downgradient of the investigated AOC, if the suspected contaminants are mobile and there are no other overlapping sources. However, whatever the alternative approach used, pursuant to N.J.A.C. 7:26E-3, the AOC must be investigated in a manner that confirms the presence or absence of contaminants.

If the AOC is not under the control of the remediating party (e.g., off-site property, easement) the person responsible for the remediation will need to obtain access to that AOC in accordance with N.J.A.C. 7:26C Subchapter 8. Access negotiations may be protracted, and should be taken into consideration when developing the project schedule. The investigator may also need to consider whether the SI should be immediately followed by the RI and select appropriate investigation methods and decision points, including but not limited to the use of field screening methods and expedited analyses.

3.2.4 Sampling Program Design

Considerations in Developing the Sampling and Analysis Plan

The SI sampling program should be developed based on the understanding of the following factors:

- size, location and setting of the AOC
- potential COCs, their physical and chemical properties, and the potential for migration or transformation in the environment
- history of releases and remedial actions
- level of understanding of the conditions at the AOC, such as contaminant distribution, physical characteristics of the suspected source area, and hydrogeologic conditions
- potential receptors
- CSM
- site-specific DQOs

AOC HISTORY
It is critical to understand the history of AOC, including past releases and remedial actions

Consider the size of the AOC in determining the number of samples to collect. For adequate characterization, a larger AOC will typically require more samples than a smaller AOC. The actual number of samples will depend upon the judgment of the investigator. The investigator should consider factors such as the following:

- Type of operations at the AOC and how they might have affected contaminant occurrence and migration. Changes in operations over time that may have resulted in multiple points of release. Construction activities that may have displaced or redistributed impacted soils. Under these conditions, more samples may be needed to properly screen the AOC.

- Potential receptors and the need to screen for pathways and impacts during the SI process. If it appears that overland transport to surface drainage, surface water bodies, etc., might have occurred based on factors such as topography and historical information, one or more targeted samples could provide valuable information.

- The nature of potential contaminants and how they might behave when released to the environment. If contaminants are mobile, likely to be guided by site stratigraphy, or have special properties (like high specific gravity), a greater number of samples might be required.

- Project DQOs. For example, if it is known that the AOC has been impacted and the investigator is only interested in confirming the range or magnitude, then a limited number of samples may be sufficient.

If the geometry of the AOC is not well understood, it may be necessary to use screening tools to better define the limits of the AOC before proceeding with the sampling program. There are various tools for areal survey. Discreet sampling and analysis may be used in an SI, depending upon site conditions and DQOs. Selection and use of the appropriate techniques is at the professional judgment of the investigator.

When a source area has not been identified and under certain conditions, such as a documented presence of buried drums, tanks, subsurface features or confirmed ground water contamination, the SI may include a geophysical survey. However, a geophysical survey may not be necessary if, for example, the presence of a tank is identified with adequate certainty from the PA and the remediating party plans to remove the tank immediately. The investigator should consider the conditions of the AOC and the potential remedial actions, and make appropriate decisions that will yield a protective outcome in a timely and cost-effective manner.

The investigator should rely on the PA to select proper analytical parameters. If a PA has not been conducted (such as for an AOC-specific investigation), the investigator should undertake sufficient diligence to understand the history of the AOC prior to development of the SI sampling plan. Analytical parameters should be appropriate for the AOC processes and chemicals used. For example, if the primary chemicals used at the AOC can be transformed over time through natural processes (e.g., biodegradation) or anthropogenic events (e.g., fire), the selection of analytical parameters should consider those facts. Follow the requirements of N.J.A.C. 7:26E-2.1.

3.3 Field Sampling Approach

The Field Sampling Approach should be based on the information gathered that supports sampling to determine whether the AOC is contaminated above remediation standards and further remediation is needed, or that there is no contamination above remediation standards and no further remediation is required. "It is important that the purpose of the sampling and associated DQOs be identified before fieldwork begins" (New Jersey Department of Environmental Protection Field Sampling Procedure Manual 2005 (FSPM)). Samples should be biased towards suspected or known areas of highest impact. This information should be obtained from the PA data (if a PA was conducted), field screening data, and field observations, etc. For example, use a record of a point discharge location, observations of stressed vegetation, disturbed soils, geophysical anomalies, etc., to bias sampling locations. If sample locations cannot be biased, then use of a random or a grid pattern sampling scheme may be appropriate. A random pattern may be more suitable when the AOC appears to be homogeneous, while a grid pattern may be more appropriate when the AOC appears to be heterogeneous. In all cases, consider the site-specific DQOs when selecting a sampling strategy and document the decision logic in the appropriate report.

The FSPM is the primary reference for planning and executing field sampling programs. The Department publishes periodic updates and revisions to the FSPM. For this reason, the investigator should record the manual version being used at the time of the field program. Other references may be used to supplement the FSPM on an as needed basis.

There are a variety of manual and mechanized sampling devices that can be used to obtain the necessary soil samples. If borings are used for sample collection, drill all borings and wells in accordance with the Subsurface and Percolating Waters Act, N.J.S.A. 58:4A-4.1 et seq. (including permitting requirements) and the Regulation, Well Construction and Maintenance; Sealing of Abandoned Wells, N.J.A.C. 7:9D. While the boring is being drilled, it is necessary to identify the subsurface materials, consider their hydraulic and geochemical behavior, and determine when and how to continue or terminate a boring. For example, clay-rich soils can impede the vertical flow of ground water and dissolved phase contaminants, and drilling through such a soil type into underlying granular soils can create a path for contaminant migration and cross-contamination of previously non-impacted soils. It is for this reason that the investigator needs a thorough understanding of the location and thickness of a confining layer before installing any borings or wells into the next aquifer.

Use test pits to obtain a greater cross-section view of the subsurface than the one typically obtained with a boring. Follow the specific safety requirements (e.g., Occupational Safety and Health Administration excavation standard) for safe excavations (29 CFR 1910 & 1926). Upon completion of the test pit, return the materials removed in the opposite order they were excavated.

If contaminated materials are returned to the borehole or test pit, then the investigator will address the presence of this contamination as part of the remedial action work plan (RAWP). Comply with all applicable state and federal regulations if soil cuttings are collected for disposal.

Select sampling intervals using one or more of the following criteria:

- direct reading instruments
- observations of odor, color
- evidence of contamination
- changes in lithology
- characteristics and properties of suspected COCs

Surface Samples:

Collect surface soil samples after all inconsequential surface debris (e.g., vegetation, rocks, etc.) has been removed from the surface. Initial characterization soil sampling, with the exception of Area Specific Requirements and soil to be analyzed for volatile organic compounds (VOCs), should be collected from zero to 6 inches below grade. Additional sampling of soil below the zero to 6-inch interval or those specified in the Area Specific Requirements may be needed where the surface has been re-graded, or physical evidence indicates the possible presence of deeper contamination. Consult the Department FSPM for detailed protocols regarding sample collection in general but particularly with regard to collecting soil samples being analyzed for VOCs, as the sampling protocol for these compounds requires careful collection procedures, which are detailed in the FSPM.

Subsurface Samples:

In most instances, samples should be collected from just above the water table, top of competent bedrock, or ten feet below ground surface, whichever is encountered first. However, there are cases where sampling below the water table may be appropriate, such as to determine whether there are exceedances to the direct contact soil remediation standards, and when the source of the contamination is known or suspected to be located below the water table (e.g., leaking USTs or buried waste). Also, if contaminants with specific gravity >1 are known or suspected, it may be necessary to extend the borings beyond the general limits specified above to collect soil, ground water or free-phase contaminant samples, as needed to characterize the site. The Department's Ground Water Investigation Technical Guidance addresses investigation of ground water. If dense nonaqueous phase liquid (DNAPL) is suspected, the borings should extend to the first confining unit. Avoid drilling through the confining layer to guard against DNAPL migration. If drilling through the confining unit is necessary, employ proper isolation techniques as mandated by Department regulation. Conduct a thorough review of any site and regional geologic information prior to proceeding with drilling through the confining zone.

In addition to the above sampling interval, samples should also be collected from intervals where contamination is suspected based on field observations. If surface soil samples are not being collected separately, a soil sample should be collected from the initial depth interval retrieved from the boring.

Field Logistical Problems

If more or less than a six-inch increment is sampled because of poor sample recovery or other field logistical problems, provide an explanation in the report.

Field Screening (Real Time Measurement Technologies)

The investigator may elect to utilize real time measurement technologies, such as field portable analytical equipment, rapid screening immunoassay, X-ray fluorescence tools, Laser Induced Fluorescence, Membrane Interface Probes, geophysics, etc. These tools can be very efficient in expediting a well-designed SI program. Real time measurement technologies may also be utilized as part of an expedited site characterization program. However, the analytical error associated with these methods can be greater than that of fixed laboratory methods. Depending on DQOs, it may be necessary to calibrate these methods against site-specific standards (split samples). Typically, ten percent of the samples may be split for analysis by a certified laboratory, but depending on the total number of samples and the expected variability of COC concentrations, more or fewer samples can be collected. Splitting samples for calibration or verification may be particularly important when proposing to remove an AOC from further consideration. N.J.A.C. 7:26E-2.1(b) provides the regulatory requirements for use of field screening at a contaminated site.

3.4 Munitions and Explosives of Concern

Treat all Munitions and Explosives of Concern (MEC) or Material Presenting a Potential Explosive Hazard (MPPEH) encountered on sites under assessment or investigation as extremely dangerous. Report the presence and/or the potential presence of MEC and/or MPPEH immediately pursuant to N.J.A.C. 7:1E-5. MEC can be unexploded ordnance, discarded military munitions, or munitions constituents in sufficient amounts or concentrations to pose an explosive hazard.

Basic safety is paramount. Take all precautions to prevent injury. If the PA supports that the site had a munitions-related history under Department of Defense or private ownership, the investigator should suspect that buried explosive hazards are present. It is advisable to hire a MEC consultant to assist in determining the presence/absence of buried MECs in any area subject to intrusive investigation, such as borings or test pits. Additional guidance for investigation of areas with the potential to contain MEC and MPPEH can be found in U.S. Army Corps of Engineers EP 75-1-2, Munitions and Explosives of Concern (MEC) Support During Hazardous, Toxic, and Radioactive Waste (HTRW) and Construction Activities.

Munitions and Explosives

If evidence of munitions or explosives is observed during the sampling program, immediately cease all activities, secure the site and call the Department Hotline 1-877-927-6337

If MEC or MPPEH are encountered or it is suspected that they have been encountered, do not touch the object. Follow the 3Rs: RECOGNIZE, RETREAT AND REPORT. Mark the location, keep people out of the area and report it. The site is now considered a potential munitions response site. Contact the Department Hotline (call center) at 1-877-927-6337 and tell the operator there is a "potential explosive hazard". The Department call center will reach out to the appropriate local and state authorities to provide assistance. Keep the area secure until qualified help arrives. If immediate danger exists, call 911 prior to calling the Department Hotline.

3.5 Documentation

Good documentation is critical for the purpose of both providing a legally defensible record of the field program, and to maintain and transmit data for future assessment and interpretation. This is typically done using field log books, as they represent the primary legal record and source of documentation for site activities. The field log books record summaries of all field activities so that an average person can understand the chain of actions, events, and decisions (including who, what, when, where, and why).

FIELD BOOK BEST PRACTICES

- Permanently bound book
- Single project per field log book
- Pages are sequentially numbered
- Do not remove pages from the book
- Entries are date and time specified
- Weather conditions are noted
- Field personnel and visitors are identified
- Field activities are summarized

When soil borings are drilled and samples are collected, organize the information in the form of a boring log. It is best that the log be recorded in the field book. Other options (such as data collection forms or electronic logging equipment) are also acceptable, if data integrity is maintained and the information becomes part of the permanent project record. The log should describe soil types and soil materials, field instrument measurements, depth to ground water, if ground water is encountered, soil mottling (if present), presence of odor, vapors, soil discoloration, and free and/or residual product. Describe and classify soils according to one of the standard systems (e.g., Burmister, Unified, or United States Department of Agriculture). See Chapter 6 the FSPM for more information about soil classification. Once a system is selected, that system should stay consistent through the duration of the remediation. Further information regarding standard soil classification systems may be found in the FSPM. Use similar recording procedures when test pits are conducted. Electronic data capture systems provide great operating efficiency and collect data that can be easily processed for further analysis and presentation.

Record the location of the samples so that results can be interpreted in their proper spatial context. There are many ways to record sample locations, including measurement from permanent landmarks, using global positioning system equipment (with appropriate accuracy), or employing the services of a State of New Jersey Licensed Surveyor. The Department has developed guidance and standards for the capture of location data in "Mapping and Digital Data Standards" (July 1997). This matter is also discussed in Chapter 10 (Documentation) within the FSPM. The FSPM provides guidance on Logging, Field Log Books, Documenting Sampling Points, Photo-Documentation and Sample Collection Paperwork.

3.6 Technical Guidance for Site Investigations - Area Specific

The following sections offer general technical guidance on how to sample specific AOCs. These recommendations apply to common/typical situations that may be encountered. Sampling should generally be conducted based on section 3.3 above (Field Sampling Approach). In some instances, these guidelines may not be technically appropriate and the investigator should use professional judgment in deciding when alternate sampling strategies may be more effective in detecting contamination that might otherwise go undiscovered.

The sampling parameters should be based on the history of the AOC. If the history of the AOC is unknown or unclear, then initial sampling parameters should include Target Compound List plus TICs/Target Analyte List (TCL + TICs/TAL), hexavalent chromium, petroleum hydrocarbons, and pH, which may be scaled back once the COCs are fully characterized.

3.6.1 Above Ground Tanks

Above Ground Tanks with shell or bottom in direct contact with soil in the past or present
Conduct boring locations around the perimeter of the tank (and within former tank footprint if removed), biasing the locations to expected areas of contamination based on field observations (such as soil discoloration, odors, etc.), field screening (see the FSPM), and history of leaks, spills, repairs and/or replacement. Conduct at least one boring in the expected downgradient ground water flow direction from the tank. Conduct additional borings beneath piping joints, valves and other areas where spills or leaks would most likely occur, and in low areas where contaminants from spills and/or leaks may accumulate. Collect soil samples from each boring pursuant to section 3.3 of this guidance. If, based on professional judgment, only surface samples are necessary to determine contamination is present (or not present) above applicable standards, sampling locations should be biased as indicated above.

Above Ground Tanks Elevated Over Unpaved Soil
Collect soil samples at elevated tanks (that is, the shell or bottom is not and has never been in contact with the ground) when there is physical or documentary evidence of discharges, when soil discoloration is observed, when field monitoring or other evidence indicates that a discharge has occurred, or when the area has been covered so the soil is not visible.

Collect soil samples from below tanks which store or may have stored hazardous substances, hazardous wastes, or pollutants that do not cause obvious soil discoloration (such as volatile organics), in the area most likely to be contaminated, including without limitation, joints, valves or former leak or rupture areas along with low areas where contaminants from spills and/or leaks may accumulate. If soil samples cannot be obtained from below the tank because soils are not accessible to sampling equipment, locate a boring as near as possible to the tank. Sample the boring in accordance with section 3.3 above.

<u>Above Ground Tanks Over Paved Surfaces</u>
If a tank is located over a paved surface where there are stained soils adjacent to the paved surface or if the potential contaminant would not cause discoloration (volatile organics), or if there is a history of spillage or other evidence that a discharge has occurred, collect soil samples as follows:

Tanks without Containment
Collect soil samples adjacent to paved surfaces. Sampling frequency should be based on professional judgment. The following sampling frequency is recommended for situations when there are no field indicators to allow for sample bias:

- Collect a minimum of one soil sample per side where there is exposed soil for sides up to 30 feet in length.
- Collect one additional soil sample per side for every additional 30 feet in length.
- For very long paved surfaces (greater than 100 feet), a reduction in frequency may be considered based on professional judgment.

Locate each sampling point immediately adjacent to the pad and biased toward the expected location of greatest contamination and in low areas where contaminants from spills and/or leaks may accumulate.

If a paved surface shows evidence of deterioration that may allow contaminant contact with the soil, or its surface has been modified (repaved), or aerial photographs or site history indicate potential for previous discharges to the soil, collect soil samples beneath the paved surface at a frequency of one per 900 square feet of surface area to characterize soils below the paved surface. Sampling locations should be biased toward the suspected location of greatest contamination based on low points, drainage patterns, discoloration or other field indicators.

Tanks with Containment
In addition to the sampling indicated above, sample the appropriate media at the point of discharge from any containment system if the system discharges or may have discharged to soil, ground water or surface water. The specific situation will dictate the appropriate sample frequency and media to be sampled.

3.6.2 Piping

<u>Above Ground Piping</u>
Collect soil samples beneath piping runs biased to where there is evidence of a discharge such as soil discoloration, stressed vegetation or elevated field instrument readings. If the potential contaminant would not leave behind evidence of a discharge or there are no field indicators to bias sampling, collect soil samples based on locations of joints, dispensers, valves, unpaved surfaces, and other potential discharge areas.

<u>Below Grade Piping</u>

Evaluate below grade piping to identify any past or present discharges using soil samples located immediately below the piping, but no farther than two feet from the piping. Conduct sampling unless the system has always had secondary containment with leak detection and no discharge history.

Collect a minimum of one soil sample for total piping length up to 15 feet. Collect an additional soil sample for each additional 15 linear feet of piping or portion thereof in excess of 15 feet to 50 feet of piping length. Sampling locations should be biased to include joints, dispensers, and other potential discharge areas.

Piping runs within two feet of another pipe run may be considered a single pipe run. Collect soil samples for multiple pipelines midway between/among the lines, or biased toward any pipe for which evidence of a discharge exists. For pipes that are separated by a distance greater than two feet horizontally, collect soil samples below each pipe.

For total piping lengths in excess of 50 feet, sampling frequency may be reduced based upon professional judgment.

In certain situations where access for the collection of soil samples is limited and/or where piping is relatively new, video inspection using an in-line surveillance camera may be conducted as an alternate means of evaluating piping integrity.

3.6.3 Loading and Unloading Areas

Sample the exposed soils at loading or unloading areas associated with tanks at a minimum rate of one sample per fill connection or valved discharge point.

For loading or unloading points located over impervious cover, conduct sampling using the same protocols as for pads (see below) 3.6.5.

3.6.4 Rail Lines, Spurs and Sidings

Follow recommendations in Section 3.6.3 for all loading and unloading areas.

<u>Active Rail Lines</u>
Active rail lines leading to the loading and unloading areas are assumed to be contaminated for the purpose of the SI. To prove otherwise, conduct sampling consistent with the "Inactive Rail Lines" section below.

<u>Inactive Rail Lines</u>
Sampling is needed to characterize soils associated with rail lines that are intended to be taken out of service or have already been taken out of service. Collect samples for the entire length of the siding from the loading/unloading area to the property line where the line joins the regional rail system. Collect a soil sample at a frequency of one sample per 100 feet of rail line (minimum of one sample). Reduction of sample frequency for rail lines greater than 500 feet in length is appropriate. Include PAHs (polycyclic aromatic hydrocarbons), PCBs, and target analyte list

(TAL) metals in the sample analysis. Target samples to areas of stressed vegetation, low elevations and/or visually impacted areas.

If a siding has been used for long-term storage of rail cars, expand the analytical parameters to include Target Compound List plus TICs/Target Analyte List (TCL + TICs/TAL), hexavalent chromium, petroleum hydrocarbons, and pH,unless specific information about the contents of the tank cars historically stored at the siding can be obtained. Collect samples at a frequency of one per 100 feet (minimum of two samples).

3.6.5 Pads and Storage Areas

Pads

Pads should have a minimum of one sampling location per side adjacent to exposed soil for sides up to 30 feet long. For sides greater than 30 feet long, collect sample(s) from one additional sample location for each additional 30 feet of length.

Locate each sampling point immediately adjacent to the pad and biased toward the expected location of greatest contamination based on low points, drainage patterns, discoloration, stressed vegetation, field instrument measurements or other field indicators.

Collect soil samples beneath the pad if a pad shows evidence of deterioration that may allow contaminant contact with the soil beneath the pad, or its surface has been modified (repaved), or aerial photographs or site history indicate potential for previous discharges to the soil. Sample frequency should be one per 900 square feet of surface area to characterize soils below a pad up to 300 feet in perimeter with a minimum of one sample.

Bermed Pads and Pads Surrounded by Impermeable Cover

In addition to the pad sampling indicated above, sample the appropriate media at each drainage discharge point. The specific situation will dictate the appropriate media to sample and parameters for analysis.

Storage and Staging Areas over Permeable Cover

Sample frequency should be one per 900 square feet of surface area to characterize soils below a storage or staging area up to 300 feet in perimeter with a minimum of one sample.

3.6.6 Surface Impoundments Including but not Limited to Lagoons, Fire Ponds, Waste Ponds, Waste Pits, Storm Water Detention Basins, Excavations, Natural Depressions or Diked Areas

For active surface impoundments with impermeable liners, which may be damaged because of sample collection, verify liner integrity by physical inspection and/or evaluation of monitoring well water quality data associated with the surface impoundment, if available.

Sediment and surface water sample locations should be biased towards inflow/outflow areas and areas where sediments may be expected to accumulate. Take core samples for contaminant analysis and fully characterize sediment type, thickness of sediment layers, and vertical extent of sediment. Sample individually distinct layers of sediments thicker than six inches, as evidenced by color, particle size, or other physical characteristics.

3.6.7 Drainage Systems

Floor Drains
Collect soil/sediment and water samples from the discharge point for any floor drain or collection system that may have ever discharged to soil, ground water or surface water. If the point of discharge is unknown, conduct tracer tests (for example, use dye or smoke) to determine the discharge point. Collect a soil sample adjacent to each floor drain. The depth of each sample should be at the invert of the drain.

Document the drainage system integrity by representative soil sampling at potential leak areas. Conduct video inspection, hydrostatic test or pressure tests of the collection system for large systems to assist in the selection of representative sample locations.

Roof Leaders
Collect soil/sediment samples at the discharge points of roof leaders if storage units or process operations have vented to the roof. Give careful consideration to the analysis and evaluation of the data. For example, PAHs may be the result of degradation of roofing products and not related to the AOC.

Swales and Culverts
For swales or culverts that may have received discharges or runoff from other AOCs, collect soil/sediment samples where runoff/discharges enter the swale or culvert. If flow could have scoured soil/sediments, collect surface water and/or sediment samples at the downgradient deposition area(s).

Storm Sewer and Spill Containment Collection Systems
Collect surface water and/or sediment samples within manholes, catch basins, sumps, or other structures where contaminated runoff or discharges enter the drainage system. Conduct soil sampling through the use of adjacent soil borings around catch basins, manholes, sumps or other structures which received or may have received hazardous substances, hazardous wastes, or pollutants, unless confirmed to be structurally sound (after cleaning and inspection). Sample a single boring located within two feet of the downgradient side of the structure at a depth corresponding to the bottom of the structure. Additional sample(s) may be necessary based on the characteristic of the contaminant (i.e., DNAPL) or field screening. Give careful consideration to analyzing and evaluating the data. For instance, runoff from parking lots may contain contaminants unrelated to an AOC.

Collect appropriate soil/sediment samples from systems which contain dry weather flow (that is, five days following the most recent rainfall) at the discharge point of the system if the system discharges to a surface water body and analyze for contaminants from AOCs that discharge into the system.

3.6.8 Waste and Wastewater Treatment Systems

Discharge and Waste Disposal Systems and Areas (including Boiler and Compressor Discharge)
The sample frequency should be at least one sample for every 900 square feet for areas up to 300 feet in perimeter.

Above Ground Treatment Systems
Sample tanks associated with above ground treatment systems using the same protocols for above ground tanks.

Below Grade Wastewater Treatment Systems
For septic tanks, separators, neutralization pits, and other flow through systems, collect two samples from within the tank, one aqueous and one sludge sample for analysis. For residential dwellings where there are between 1 and 4 families, if it can be documented that the septic tank only received domestic wastewater throughout the entire history of its use, then no sampling is recommended.

Septic Disposal Fields
Conduct at least one boring per 900 square feet of field area with a minimum of four borings per disposal field. Locate borings within two feet of the downgradient edge of the bed area in active disposal fields. Angle the borings, if possible, so that samples are taken below the infiltrative surface and directly below laterals within abandoned fields. Locate borings to include the first five feet of the infiltrative surface and space the samples so they are representative of the entire disposal field. Take soil samples at a depth corresponding to zero to six inches below the bottom of the infiltrative surface. For residential dwellings where there are between 1 and 4 families, if it can be documented that the septic tank only received domestic wastewater throughout the entire history of its use, no sampling is recommended.

Cesspools, Seepage Pits and Dry Wells
Collect one representative sample of liquid, if present, and sludge/sediment in each pit for laboratory analysis. Collect soil samples, within two feet of the suspected downgradient side of the structure at a depth corresponding to the bottom of the structure.

3.6.9 Landfills

See separate technical guidance for SI and RI issues regarding landfills.

3.6.10 Underground Storage Tanks

See separate technical guidance for sampling recommendations regarding USTs that are remaining active, being removed, or being closed in place.

3.6.11 Potentially Contaminated Areas Away from Process Areas not Otherwise Addressed

Collect soil samples biased toward suspected areas of the greatest contamination. If there is no basis for biasing, then random sampling of these areas is recommended as follows:

- Grid the area to be sampled and give each grid node an identification number.
- Base the grid nodes chosen for sampling on the numbers selected from a random number chart.
- Sample areas of less than 10 acres at a rate of at least one sample for every two acres.
- For areas greater than 10 acres, a reduced frequency may be appropriate.
- Collect the soil sample from the surface (zero - six inches).

If the sampling effort is targeted for potential historic pesticide use, additional sampling instructions can be found in the Department's Historic Pesticide Task Force Recommendations document.

3.7 Receptor and Ecological Evaluation

When assessing the sampling results from the SI, the requirements for a receptor and an ecological evaluation may be triggered and should be conducted in accordance with the Technical Requirements for Site Remediation N.J.A.C. 7:26E, and the Department's ecological evaluation guidance document and receptor evaluation form.

3.8 Notification of Discharge

If at any point during the investigation of a site, a discharge occurs, contamination is identified that has been caused by a discharge not already known by the Department, or immediate environmental concern conditions are identified, the Department is to be notified pursuant to N.J.A.C. 7:26E-1.4.

4 NATURAL BACKGROUND INVESTIGATION – SOIL

During the course of an investigation, there may be contaminants found in the soil at a site or AOC which exceed an applicable soil remediation standard but which may be naturally occurring. The regulatory requirements for determining natural background levels are provided in the Technical Requirements for Site Remediation **N.J.A.C. 7:26E**-3.8. The following technical guidance provides the protocols recommended by the Department to assist in determining whether the noted concentrations of a specific contaminant in soil would be considered naturally occurring.

4.1 Sampling for Natural Background in Soil

Conduct sampling for a natural soil background investigation as follows:

- Select a background reference area that has as similar as possible physical, chemical, geological, and biological soil characteristics as the AOC being investigated, but that is not affected by activities on the site. Select the locations of the background samples from areas that have not received contamination, but do have the same basic soil characteristics as the medium of concern at the site. Identify similar soil types using standard classification systems such as Burmister, Unified, or United States Department of Agriculture.

- Collect a minimum of 10 background soil samples from the selected background reference area. Collect the samples from a depth that coincides with the interval of interest or comparable soil horizon to the AOC soil sample.

- Collect background samples at locations unaffected by current and historic site operations as documented by the PA, including aerial photographs. Wherever possible, collect background samples from locations which are topographically upgradient and upwind of contaminant sources.

- Do not collect background samples from the following locations:

  a) parking lots, roads, or roadside areas
  b) areas where potential contaminants were loaded, handled, or stored
  c) waste disposal areas
  d) areas on or near railroad tracks
  e) areas of historic fill material
  f) areas receiving runoff from areas (a) to (e) above or from adjacent sites
  g) storm drains or ditches receiving runoff from the site or adjacent sites
  h) any other AOC

- Collect and analyze background samples using the same methods as were used for AOC samples

4.2 Statistical Outlier Review

Examine the background data set for statistical outliers as follows:

(1) The investigator should verify the statistical assumptions of Normal and Lognormal distributions of the data (USEPA proUCL or other program). If the observed data does not follow the presumptive distribution, then it may be necessary to collect additional background samples or evaluate potential impacts from other site activities (such as discharges or earth moving).

(2) An outlier is defined as a concentration greater than 1.5 times the range of the 25th to 75th percentile, plus the concentration of the 75th percentile. For example, if the 75th percentile concentration in a data set is nine ppm and the 25th percentile is three ppm, subtract three from nine and multiply the result by 1.5. This equals nine ppm. Add the result to the 75th percentile for a concentration of 18 ppm. Any sample point above 18 ppm is considered an outlier. Transform the background sample data to natural logarithms before performing the outlier test because it is assumed that natural background chemical concentrations are log normally distributed; and

(3) An outlier should not be considered part of background unless the chemical concentration is confirmed with the analysis of an additional sample from the outlier location. If the difference between the original and confirmation sample results is no greater than 20 percent, the average concentration of the two samples may be considered the highest background concentration.

(4) Apply the highest contaminant concentration found in the background samples as an upper limit for the contaminant concentrations found on the site. If contaminant concentrations are found at any sampling location on the site exceeding the highest concentration found in the background samples, conduct additional investigation; and

(5) Do not average the samples collected for AOC investigation for background comparisons.

4.2 Alternative Statistical Programs

Alternatively, use the procedures in EPA, ProUCL Version 4.00.05, Technical Guide, EPA/600/R-07/041 (May 2010) to compare site and background area data. If that procedure is utilized, include the data sets and statistical program outputs in an appendix to the RI report.

5 REMEDIAL INVESTIGATION – SOIL

5.1 Purpose

The purpose of the RI with regard to this technical guidance is to fully delineate all soil which contains contaminants above the applicable soil remediation standards. Remedial Investigation of contaminants in soil is to be conducted pursuant to the Technical Requirements for Site Remediation. A RI of the soil is necessary at each AOC where there are contaminants present that exceed any applicable remediation standard. It is recommended that the Conceptual Site Model be used to assist in the selection of the appropriate number and locations of soil samples and to further the goals of the RI. Please note that there are times when it is appropriate to conduct a single-phase remediation where the remedial action is initially conducted and samples are collected following the remediation rather than conducting a SI and/or a RI. An example of such a situation would be if the area of contamination is small, and the extent of the contamination is obvious due to staining. This is a circumstance where, the single phase remediation approach may be more appropriate.

5.2 Goals

The goals of a soil RI are as follows:

- Delineate the horizontal and vertical extent of contaminants in soil at the site to the applicable remediation standard(s).

- Identify potential Immediate Environmental Concern Conditions or otherwise highly contaminated soil

- Identify the migration paths and actual or potential receptors of contaminants. A RI of soil could lead the investigator to other contaminated media such as air, bedrock, sediment, ground water, surface water, and buildings at a contaminated site. Delineation of the extent of contamination noted in these media would also be required pursuant to N.J.A.C. 7:26E-4.1(a)1

- Identify and implement containment and/or stabilization remedies (interim remedial measures) for soil to prevent contaminant exposure to receptors and to prevent the offsite migration of contaminants while determining appropriate remedial actions.

- When the SI or RI soil sampling results exceed Ecological Screening Criteria (ESC) found at http://www.nj.gov/dep/srp/guidance/ecoscreening/ and environmentally sensitive natural resources (ESNR) are on or in the vicinity of the site, further sampling may be necessary to determine if there is a potential or complete pathway from the site to the ESNR. In these circumstances, appropriate sampling should be conducted along migration pathways or within the ESNR itself to determine if contamination is present at concentrations above ESC. For further information, consult the Department's Ecological Evaluation Technical Guidance document.

- Data may also be collected to determine the geometry and composition of the contamination along with data regarding the surface and subsurface characteristics of the site, including, without limitation, the depth to ground water. This data should be obtained to assist in the determination of appropriate remedial actions. Examples of the type of data that may be gathered for this purpose include, without limitation, treatability studies, bench scale studies and pilot scale studies (these studies may be conducted pursuant to EPA 540/2-89/058 "Guide for Conducting Treatability Studies Under CERCLA"). Data collection of this type is typically conducted once the general extent of contamination is known, usually after the first delineation phase.

- Collect soil data when needed to develop permits for any remediation activities.

5.3 Soil Delineation and Restricted Property Use

When the future use of an area under investigation will be restricted and the property owner has agreed to place a deed notice on the property appropriately restricting its use, the horizontal and vertical delineation of the soil contamination may be limited to the non-residential direct contact soil remediation standard as opposed to the typical requirement to delineate to the residential direct contact soil remediation standard. However, as indicated in N.J.A.C. 7:26E-4.2(a), the use of a deed notice does not provide relief from the requirement to delineate to the applicable impact to ground water soil cleanup standard, in the unsaturated soil zone, when the impact to groundwater standard is below the residential or non-residential direct contact soil remediation standard. The delineation must still adequately characterize the magnitude and extent of the contaminants that will remain at the site. There is also a need to determine if soil contamination has migrated off the property at any depth above the residential direct contact soil remediation standard. Delineation samples should be biased to identify highest contaminant concentrations and migration paths of the contaminant. Samples should be biased using professional judgment, based on area history, discolored soil, stressed vegetation, drainage patterns, field instrument measurements, odor and other field indicators.

5.4 Soil Delineation Procedures

Accomplish delineation by one or more of the following:

5.4.1 Delineation Using Collected Data

Once it has been determined that contamination exists in soil above a remediation standard(s), the extent of the contamination must be determined in accordance with N.J.A.C. 7:26E-4.1(a)1. The typical approach to delineate contaminants in soil is to select step-out sample locations that surround the previous sample location exceeding the standard. Use of a three-dimensional sampling approach is recommended. This approach relies on professional judgment when determining the sample locations and frequency, and should be based on a thorough understanding of the CSM. "A Conceptual Site Model describes the expected source of the contaminant and the size and breadth of the area of concern, identifies the relevant environmental media and the relevant fate and transport pathways, and defines the potential exposure pathways." (EPA 2002). Other variables to be considered are as follows:

- soil properties that affect contaminant migration (for example, texture, layering, moisture content)
- physical and chemical nature of the contaminant under investigation (for example, solubility, density, volatility, reactivity)
- manner in which the contaminant is understood to have been released (for example, surface spill, leachate generated through above ground or buried waste, leaking underground tank or pipe)
- timing and duration of the release
- amount of contaminant understood to have been released (EPA 2002)

The above factors should be considered when determining how far to step-out from the point of discharge/exceedance, which direction(s) to step out, and how deep to sample both when laterally stepping out from the origin of the contamination, and when delineating vertically. The same logic would again apply when conducting subsequent step-outs. This iteration would theoretically continue until a decreasing trend is established and the furthest sample indicates that contaminant concentrations are below the appropriate standard(s).

Other sampling approaches include probabilistic sampling techniques. These techniques are typically used when there is no clear understanding of the sources of contamination and the contaminants do not leave visual signs that allow for biased sampling. A probabilistic sampling approach may be used to characterize historic fill, determine mean concentrations of a contaminant within a specified boundary, or evaluate fall-out from stack emissions in a specified area. Some examples of probabilistic sampling include the following:

- **Adaptive Cluster Sampling –** starts with randomly selecting sampling locations within a grid layout in an area of concern. Once the initial samples are collected and analyzed, the number and location of the next set of samples will be conducted around the samples that exceed the chosen parameters. This process will continue in an iterative fashion until there are no longer any exceedances of the chosen parameters. This type of sampling is similar to the step-out approach described above. It is a useful approach for locating hotspots and delineating contaminant boundaries when there is a general lack of an understanding of source locations.
- **Ranked Set Sampling –** is a hybrid of random set sampling and judgmental sampling where a set of random locations are selected. The field investigator will select a subset of those locations based on observation and professional judgment to obtain the most representative samples. In addition, the use of less expensive field tests may be utilized to assist selection of samples to be laboratory analyzed.
- **Stratified Sampling –** use when there is a defined difference between sub-populations within a sampled group, for example, sampling stratified layers of soil.
- **Composite Sampling –**several samples are combined to create one sample that is representative of the larger population of samples. This method is routinely used for characterizing soils for disposal or reuse, in accordance with NJDEP guidance. For the purposes of an RI, the Department does not typically accept this approach as it does not indicate spatial or temporal variability in contaminant concentrations. However, there may be

instances where a modification of this approach, referred to as incremental sampling, may be considered acceptable.

Investigators interested in using these statistical sampling approaches may obtain further information from the EPA 2002 document.

These approaches require that presentation of sample data indicate contamination is below the applicable remediation standard. This may be accomplished during the remedial investigation phase, after a remedial action has been implemented, or at any point in between these two phases.

5.4.2 Field Screening Methods

In accordance with N.J.A.C. 7:26E-2.1(b)2, field screening methods are not to be used to verify contaminant identity or clean zones. However, where 10 or more samples are required for initial characterization sampling at an area of concern, field screening methods listed below may be used to document that up to 50 percent of sampling points within the area of concern are not contaminated.

- NJDEP FSPM
- NJDEP Site Remediation Program's Field Analysis Manual
- Field Measurements (EPA/530/UST-90-003),
- the Field Screening Methods Catalog (EPA/540/2-8 8/005)

Other field screening methods may be used if use of the selected method enables the investigator to meet the sampling objectives and technical rationale for using the selected sampling method is provided in the applicable report.

5.4.3 Delineation Through Extrapolation

A contaminant gradient may be established by showing that contaminant levels decrease as follows:

- ten percent or more between the initial characterization sample and each of two sequential delineation samples;
- a factor of five or more between the initial characterization sample and a single delineation sample; or
- a reasonable combination of laboratory samples and field instrument readings.

Once a contaminant gradient has been established, the approximate limits of contamination may be reasonably estimated by extrapolation to complete the RI. However, when a contaminant gradient is used to estimate the limits of contamination, the extent of contamination above the applicable unrestricted use remediation standard still needs to be confirmed using laboratory analyses prior to the completion of a remedial action.

5.4.4 Delineation Below the Water Table

If a vertical soil contaminant gradient has not been established to the water table:

- For contaminants having water solubility greater than 100 milligrams per liter between 20 to 25 degrees Celsius, saturated zone soil shall be delineated for residual product pursuant to N.J.A.C. 7:26E-2.1(a)14, and for direct contact soil cleanup criteria; and

- Delineate other contaminants below the water table to direct contact soil cleanup standards. It should be noted that since this sample is reported on a dry weight basis, the results would be biased high.

5.4.5 Use of the Triad Approach

Traditionally, the Department has been a proponent of the Triad approach. However, under the Site Remediation Reform Act framework, some of the roles and stakeholder relationships envisioned by Triad (see http://www.itrcweb.org/Documents/SCM-3.pdf; http://www.epa.gov/tio/download/char/epa542f07001.pdf; Triad web page) have been changed.

In the past, implementation of the Triad approach involved Department case management team's active coordination of the various stakeholders under the "systematic project planning" component. When the work is conducted under the oversight of a LSRP, it is imperative that this person understand the process, and arrange for the proper participation of the appropriate stakeholders. Since Triad is often used in Brownfield projects, the remediating party should engage the Department and any other stakeholders in a timely fashion.

In addition, there are various technical components that require detailed attention, including use of properly certified analytical services (and adherence to Department certification requirements), and using qualified staff to perform highly technical data analysis functions (such as geostatistics). The flow of data in real-time requires proper planning for data management and communication to the stakeholders. The LSRP must exercise caution in interpreting the data to ensure that sites are properly characterized and to select and implement an appropriately protective remedy.

6 REMEDIAL ACTION TECHNICAL GUIDANCE FOR VERIFICATION SAMPLING OF SOIL

6.1 Purpose

The purpose of the remedial action technical guidance for verification sampling of soil is to provide assistance in developing sampling designs for soil to confirm the remedial action has met its objective of mitigating soil contamination to the appropriate remediation standards pursuant to N.J.A.C. 7:26E-5. To make such a determination, the number, location and type of samples collected need to be representative of the soil conditions at the site or AOC based on the SI/RI sampling or known site/AOC use. The remedial action verification-sampling plan that is developed will depend on the remedial action that is selected. For instance, if the contaminated soil is being excavated, then the sampling will focus on the soil remaining in the excavation. Whereas, if the contaminated soil is being treated, then post-remediation confirmatory sampling should be conducted in the impacted zones that were remediated to ensure the remediation was effective.

6.2 Single Phase Remediation

When single-phase remediations are conducted, (where the remedial action is conducted concurrently with sampling to delineate the contamination and to confirm contaminant removal), sampling shall comply with the delineation/verification sampling guidance in 6.3 below.

6.3 Confirmation Sampling

To show the effectiveness of a remedial action pursuant to N.J.A.C. 7:26E-5.2(a)3, conduct confirmation sampling and analyses as indicated below. Please note that RI samples may be used in place of post-excavation sampling if the investigator determines they are sufficient to delineate the AOC to the applicable remediation standard. This is a viable approach and has the benefit of determining more exact volume estimates of soil needing remediation for remedial action planning purposes.

6.3.1 Confirmation Sampling for Soil Excavations

Conduct all sampling pursuant to the soil technical guidance for SIs and RIs above and pursuant to N.J.A.C. 7:26E-3 and 4. Use of a CSM is recommended to assist in the selection of the appropriate number and location of confirmation soil samples.

If an excavation is conducted, the minimum post remediation sampling frequency should be as follows:

- Select a sidewall sample location for every 30 linear feet of sidewall or other appropriate spacing based on the configuration of the excavation to demonstrate horizontal compliance with the remediation standards. Collect samples at the top and bottom of each sidewall to demonstrate vertical compliance with the remediation standards. Additional samples may be needed at other depths in a sidewall to demonstrate vertical compliance with the remediation standards. Bias sidewall sample locations and sample depths for each sidewall to the highest concentration based on field screening, depth of discharge, data from SI and RI sample locations, type and characteristics of contaminant, and other indicators of potential contamination. Adjust sample depths based on the depth at which contaminants were discharged (surface versus subsurface) and the type and characteristics of the contaminants that will affect contaminant fate and migration.

- Take one sample from the excavation bottom for every 900 square feet of bottom area. Bias bottom samples within each 900 square feet to the highest concentration based on field screening, data from SI and RI sample locations, type and characteristics of contaminant, and other indicators of potential contamination.

6.3.2 Confirmation Sampling for In-Situ Soil Remediation

If in-situ remediation is conducted, the minimum post-remediation sampling frequency should be one sample per 900 square feet of contaminated area biased to the highest contaminant concentration identified prior to remediation. Where the contaminated zone exceeds two feet in depth, take one additional sample per 900 square feet of contaminated area for each two feet of depth. For very large areas, sampling frequency may be reduced. If a specific patented technology is being used, the technology vendor licensed to implement the technology may also have a recommended sample frequency that may be considered. If sampling frequency is reduced from the recommended one sample per 900 square feet, indicate this within the Remedial Action Report Form submitted to the Department with the Remedial Action Report. Conduct the sampling after the appropriate time period in which the in-situ remediation technology is designed to reduce the contaminant concentration to or below the appropriate remediation standard. Conduct a sufficient number of rounds of sampling in order to verify treatment objectives based on the technology implemented.

In the sampling and analysis program consider any potential by-products of the treatment process. For example, chemical oxidation may change the valence state of metals such as trivalent chromium to (soluble) hexavalent chromium, pentavalent arsenic to (soluble) trivalent, etc. Consider byproducts of organic compound treatment and sample accordingly. As a general practice, document the changes in soil redox and general chemistry conditions. Consider these issues when developing a verification sampling plan for in-situ remediation technologies.

If the perimeter sampling had not delineated the extent of contamination prior to the in-situ remedial action during the RI phase, then verification sampling should also include perimeter sampling to clearly define the boundaries of the remedial action and ensure that it has remediated all contaminated soil that exceeded applicable remediation standards.

6.3.3 Confirmation Sampling for Ex-Situ Soil Remediation

If ex-situ treatment is conducted, analyze the treated materials according to the proposed end use of the treated soils. For on-site reuse, follow the Department's Alternative and Clean Fill Guidance for SRP Sites document. For off-site disposal, follow Department requirements and receiving specifications for the facility.

6.3.4 Confirmation Sampling Biased to Highest Contaminant Concentration

Post-remediation sample locations and depth should be biased towards the areas and depths of highest contamination identified during previous sampling episodes, unless field indicators such as field instrument measurements or visual contamination identified during the remedial action indicate that other locations and depths may be more heavily contaminated. In all cases, post-remediation samples should be biased toward locations and depths of the highest expected contamination. Sample analysis should be for the contaminants of concern as well as any potential degradation products or byproducts that would result from the natural degradation and the specific remediation technology used.

6.3.5 Sampling to Confirm Estimated Gradients

If the extent of contamination above the applicable residential soil remediation standard was estimated during the RI, confirm the extent of contamination above the applicable residential soil remediation standard by sampling at those points where compliance with the applicable standard is expected prior to the completion of a remedial action or the execution of a deed notice. Sample analysis should be for the contaminants of concern as well as any potential degradation products or byproducts that would result from the natural degradation and the specific remediation technology used.

6.4 Fill Material/Soil Re-use On Site

In addition to the requirements at N.J.A.C. 7:26E-5.2(b), consider the Department's Alternative and Clean Fill Guidance document when alternative or clean fill will be used as part of a remedial action.

7 REFERENCES

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USEPA, 2006. Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA/240/B-06/001, February 2006.

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Appendix A

Acronyms

ACRONYMS

AOC	area of concern
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CSM	conceptual site model
DNAPL	dense nonaqueous phase liquid
DQO	data quality objective
ESC	ecological screening criteria
ESNR	environmentally sensitive natural resources
FSPM	Field Sampling Procedures Manual
GIS	Geographic Information Systems
HASP	Health and Safety Plan
ITRC	Interstate Technology and Regulatory Council
LSRP	Licensed Site Remediation Professional
MEC	munitions and explosives of concern
MPPEH	material presenting a potential explosive hazard
N.J.A.C.	New Jersey Administrative Code
NJDEP	New Jersey Department of Environmental Protection
N.J.S.A.	New Jersey Statutes Annotated
PA	Preliminary Assessment
PAH	polycyclic aromatic hydrocarbons
RAWP	Remedial Action Work Plan
RI	Remedial Investigation
SI	Site Investigation
TCL/TAL	target compound list/target analyte list
USEPA	United States Environmental Protection Agency
UST	underground storage tank
VOC	volatile organic compound

Glossary:

Systematic Project Planning: A planning process that lays a scientifically defensible foundation for proposed project activities. Systematic project planning usually includes identification of key decisions to be made, the development of a conceptual site model to support decision making, and an evaluation of decision uncertainty along with approaches for managing that uncertainty in the context of the conceptual site model. If the collection of environmental data from representative populations is desired to support decision making, then sampling, analytical, and relational uncertainties in the data-generation process must be managed. Systematic planning is an iterative process that continues throughout the life cycle of a project. (http://www.triadcentral.org/Brownfields/gloss/index.cfm)