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Ms. Laurie Kauffman
U.S. Nuclear Regulatory Commission
Division of Nuclear Materials Safety
475 Allendale Road
King of Prussia, PA 19406-1415

Subject: Former United Nuclear Corporation Facility
71 Shelton Avenue, New Haven, CT
Final Status Survey Plan

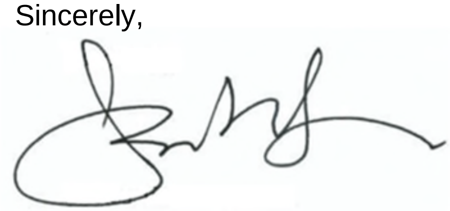
Dear Ms. Kauffman:

General Electric (GE) is pleased to submit the Final Status Survey Plan (FSS Plan) for review and comment by the Nuclear Regulatory Commission (NRC). This FSS Plan was prepared to address post-remedial actions performed by GE at the 71 Shelton Avenue property (Site).

Within the attached FSS Plan, GE references the previous remedial action activities conducted by Cabrera Services, Inc. (Cabrera) in 2011 and 2012. The FSS documentation authored by Cabrera will be submitted to the NRC under a separate cover.

With the exception of the lower brick walls along the western end of former Building 6H, the above-slab building structure at the Site has been deconstructed and transported off-site for disposal. Within the former Building 3H footprint, UNC has successfully removed building the floor slab, building and equipment foundations, and trenches and piping (per the Cleanup Plan) in preparation for implementation of the first phase of the Site FSS Plan. The remediation contractor is currently in the process of removing these same elements within the eastern portion of former Building 6H in preparation for the implementation of additional phases of the Site FSS Plan.

Sincerely,



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Enclosure:
Final Status Survey Plan – Former United Nuclear Corporation, Naval Products Facility, New Haven, Connecticut

General Electric Company

FINAL STATUS SURVEY PLAN

Former United Nuclear Corporation

Naval Products Facility

New Haven, Connecticut

[3/10/2020]

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SOP 09 Procedure for Shallow Soil Sampling
Example of Visual Sample Plan Report

ACRONYMS AND ABBREVIATIONS

CAD	computer-aided design
cm^2	centimeters squared
DCGL or DCGLw	Derived Concentration Guideline
$DCGL_{EMC}$	Derived Concentration Guideline for elevated measurement comparisons
Dpm	disintegrations per minute
dpm/100 cm^2	disintegrations per minute per 100 square centimeter area
DQO	Data Quality Objective
EMC	elevated measurements comparison
EPA	United States Environmental Protection Agency
FSP	Field Sampling Plan
FSS	Final Status Survey
GPS	Global Positioning System
GWS	gamma walkover scan
H_0 the	null hypothesis
LBGR	lower boundary of the gray region
Lc	Critical level
M	meters
M^2	meters squared
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	minimum detectable concentration
µCi/m^2	microcuries per square meter
NaI	sodium iodide
pCi/g	picocuries per gram
pCi/L	picocuries per liter
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control

ROC	radionuclides of concern
ROD	Record of Decision
SAP	Sampling and Analysis Plan

1 INTRODUCTION

On behalf of the United Nuclear Corporation (UNC), Arcadis US, Inc. (Arcadis) has prepared this Final Status Survey Plan (Plan) for building deconstruction, and off-site removal and disposal of building debris and underlying soil (as needed) from the former United Nuclear Corporation (UNC) Naval Products Facility, located at 71 Shelton Avenue in New Haven, Connecticut (site). The site was part of a larger complex called the H-tract.

1.1 Background

The site dates to 1914 and was used by the Winchester Corporation. Olin Mathieson Chemical Corporation – Winchester Western Division (Olin) for manufacturing. Olin operated the site as a contractor from April 1956 to May 1961 and obtained an AEC (later NRC) license in October 1960 for fabrication and manufacture of highly enriched reactor fuel. The site was transferred to UNC in May 1961 and UNC operated the site under a new license from June 1961 to April 1976. The site was decontaminated and decommissioned from 1973 to 1976. On April 22, 1976 NRC removed the H tract, including building 3H and 6H from the license. The site was released for unrestricted use in accordance with Regulatory Guide 1.86 (surficial contamination) and external dose (as low as reasonably achievable). In 1989 to 1990, the NRC initiated a Terminated Sites Review Project to ensure that formerly licensed facilities by the AEC and/or the NRC were terminated in accordance with current NRC criteria for release for unrestricted use. The NRC contacted UNC, which was acquired by GE in 1997, concerning the residual uranium. GE agreed to undertake remediation of the site.

Additional characterization was completed at New Haven in 1996 and 1997. The analysis of soil samples shows a small number of areas that contained enriched uranium exceeding the 1981 NRC soil acceptance criteria (30 pCi/g total uranium). UNC prepared a Decommissioning Plan in order to remediate the areas identified during the sampling effort and it was submitted to the NRC for approval in 1998. Additional subsurface characterization was performed in 2003 and submitted to the NRC for approval in May 2005. In 2006, an addition Final Status Survey (FSS) Plan was written to verify that the concentration of radiological constituents at the site did not exceed the release criteria from the Decommissioning Plan.

In April 2011, NRC and UNC discussed the remediation and decommissioning of the former facility and the release of the property and surrounding area. In September 2011, UNC commenced remediation activities and completed most of the work described in the decommissioning plan by July 2012. During the cleanup activities, UNC identified additional soil areas that exceeded 30 pCi/g of uranium and initiated an FSS sampling program applying NUREG-1575, Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM; United States Environmental Protection Agency [USEPA] 2000). In July 2012, UNC submitted an addendum to their 1998 decommissioning plan (UNC, 2012) that used a dose-based release criterion (the Derived Concentration Guideline Level [DCGLw]), which was accepted by the

NRC in May 2013. The DCGLw was subsequently revised to meet the State of Connecticut's dose standard (19 millirems per year [mrem/year] versus 25 mrem/year). The final DCGLw for soil was 435 pCi/g total uranium the DCGLw for surfaces remained that from NRC Regulatory Guide 1.86.

The majority of the areas that were remediated and evaluated met the criteria for unrestricted radiological release. However, during the FSS of the South Trench (a concrete utility trench located along the south side of the building) soil samples were collected from drainage holes in the floor. Subsequent radiological investigations discovered that radioactive contamination had migrated through some of the drainage holes in the floors of the South trench and other utility trenches. A characterization survey (Cabrera, 2015), debris cleanup inside Building 3H/6H, and a supplemental radiological characterization survey (Cabrera, 2018) were performed to further characterize/remediate the Site. These investigations have found that further work was required to remediate the contamination inside and beneath Building 3H/6H.

Based on the history, characterization studies and the physical condition of the building it was decided to deconstruct the building and remove the debris and a portion of the underlying soil (as needed). From September 2019 to March 2020, much the above grade portion of the buildings and underlying soils were removed and transported offsite for disposal. This included the walls, roof, lights, struts, beams, glass and other above ground building structures. The building foundation including at-grade and sub slab portions include slabs, interior and perimeter foundation walls to a depth of approximately 1 foot below slab bottom, and approximately 1 foot of soil from underneath the finished slabs were also removed. As of this writing, remediation excavation is ongoing on the 6H foundation / soil. The South trench, North Trench, and Lateral Trench were deconstructed. Abandoned utility and conduits, concrete walls and floors along with underlying soil were removed.

1.2 Purpose and Objective

This Plan discusses the background, objectives, activities, and monitoring required to complete the Final Status Surveys (FSSs) to demonstrate that the property has achieved conditions associated with unrestricted future use.

1.3 Project Organization

The Final Status Surveys will be implemented at the site, on behalf of UNC, by a team of engineering consultants, health physicists, technical staff, and field support who possess the necessary skills and experience to perform the specific components of the work described in this plan.

1.4 Health and Safety

Health and safety procedures will be followed to permit FSS activities to be conducted without adverse impacts to worker health and safety. These procedures will comply with the applicable

portions of the Health and Safety Plan (HASP) and the Radiation Safety Program (RPP) currently guiding the deconstruction.

2 DATA QUALITY OBJECTIVES

Data Quality Objectives (DQOs) are qualitative and quantitative statements that establish a systematic procedure for defining the criteria by which data collection design is satisfied in order to make determinations regarding remediated properties. The DQOs at UNC include:

- Clarifying the project problem.
- Identifying the decision.
- Defining the data necessary for achieving the end use decisions.
- Defining the study boundaries
- Determining the appropriate method of data collection; and
- Specifying the level of decision errors acceptable for establishing the quantity and quality of data needed to support the project decisions.

The overall quality assurance (QA) objective for this project is to develop and implement procedures for obtaining and evaluating data that meet the DQOs to ensure or confirm that the required remediation is accomplished. Specifically, radionuclide data will be generated to demonstrate that the site properties have achieved the remediation criteria. QA procedures are established to ensure field measurements, sampling methods, and analytical data provide information that is comparable and representative of actual field conditions, and that the data generated are technically defensible.

2.1 State the Problem

This FSS will be used to demonstrate that the residual radionuclide concentrations following remediation comply with concentration and exposure-based criteria per the decision documents. The objective of FSS activities is to obtain data of enough quality and quantity to support an evaluation of the criteria for the properties. Compliance will be satisfied using guidance found in MARSSIM (EPA, 2000). Compliance will be demonstrated using:

- Walkover gamma surveys
- Soil samples

2.2 Inputs into the Decision

Walkover gamma surveys over 100% of the survey unit areas will be conducted to assure no elevated spots are within the survey units. Residual area radioactivity levels of HEU will be determined by quantitative means (soil samples). Quantitative surveys provide representative data from each survey unit for comparison to the Derived Concentration Guideline Level

(DCGLw). The results from laboratory analyses of volumetric samples and gamma counts from field surveys will be used to drive decisions.

Statistical test will be used to determine whether specific survey units are suitably free of residual radioactivity. Uranium isotopes, U-234, U-235, U-238 are naturally occurring and are present in the environment. The background soil concentration was previously determined using an onsite reference area in 1993. (AAA/IEM 2006). The background concentration, based upon 16 samples, was 3.43 picocurie per gram. The background concentration is a small fraction of remedial criterion, thus should not adversely impact analysis results. This allows the Sign rather than the Wilcoxon Rank Sum (WRS) test to be used. The Sign statistical test will be used to compare each survey unit directly with the DCGLw. (See Section 4.4 for further details)

2.2.1 Radionuclides of concern

The radionuclides of concern (ROCs) that were considered during the DCGLw determination for the FSS are total uranium (containing uranium-234 [U-234], uranium-235 [U-235], and uranium-238 [U-238]). Thorium was dismissed as a ROC because the historical usage of thorium on-site was limited.

2.2.2 Derived concentration guideline level

A DCGL is a derived radionuclide activity concentration that corresponds to a dose-based release criterion. The NRC initially established an original release criterion of 30 picocurie per gram total uranium for the site (SECY 81-576). This criterion was used by Cabrera to evaluate residual radioactivity in the 2011-2012 decommissioning effort. After discovering residual radioactivity exceeding this criterion a new site-specific release criterion was requested based on the potential pathways to man. The doses were calculated using RESRAD and the results for 25 millirem/year (mrem/yr) submitted to NRC. The final DCGLw was reduced based upon the State of Connecticut dose limit of 19 mrem/year to a member of the public. (AAA/IEM 2008). The updated remedial concentration (DCGLw) for the site was established as 435 pCi/g total uranium (UNC 2012). Where the total uranium is the sum of the concentration of U-234, U-235, and U-238. Due to analysis methodology limitation, when gamma spectroscopy was used to quantify the total uranium, the U-234 was estimated as 27 times the U-235 concentration.

2.2.3 Study Boundaries

The areas under consideration of the FSS include the soils under the footprint of the buildings 3H and 6H, a 20-foot buffer along the building, the soils under the north and south trench, and the soil surface of the property. All concrete and debris above building 3H and 6H footprint was (removed with approximately one foot of surface soil (for 6H are being removed at this writing).

2.3 Data Collection Method

The concentration of residual radioactive materials in the survey units will be determined by direct surface radioactivity measurements (gamma walkover survey) and volumetric sampling and analysis of surface soils.

2.4 Define Acceptable Limits on Decision Errors

The decisions necessary to determine compliance with the soil cleanup criteria are based on precise statistical statements called hypotheses. These hypotheses will be tested using data from a survey unit. The state that is presumed to exist is expressed as the null hypothesis (H_0). For a given null hypothesis, there is a specified alternative hypothesis (H_a) that is an expression of what is believed to be the state of reality if the null hypothesis is not true.

2.4.1 Null and Alternative Hypotheses

For the Sign test, the hypotheses selected for the FSS are as follows:

Null Hypothesis (H_0):

The median concentration of the residual radioactivity in the survey unit is greater than the $DCGL_W$.

Versus:

Alternative Hypothesis (H_a):

The median concentration of the residual radioactivity in the survey unit is less than the $DCGL_W$.

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These hypotheses were chosen because the burden of proof is on the H_0. Therefore, the survey unit will not be released until proven to meet the cleanup criteria. The measured median concentration in the survey unit must be less than the $DCGL_W$ in order to pass.

These hypotheses also were chosen because contamination below the $DCGL_W$ is measurable. Releasing a survey unit that requires additional remediation is an unacceptable alternative. Statistically based decisions will be utilized for evaluating the release criteria. Statistical acceptability decisions, however, are always subject to error. Two possible error types are associated with such decisions. These are discussed below.

The first type of decision error, called a Type I error, occurs when the H_0 is rejected when it is actually true. A Type I error is sometimes called a “false positive.” The probability of a Type I error is usually denoted by α. This error could result in higher potential doses to future site occupants than prescribed by the dose-based criterion. For the UNC site, the maximum Type I error rate has been set at ά= 0.05.

The second type of decision error, called a Type II error, occurs when the H_0 is not rejected when it is actually false. A Type II error is sometimes called a “false negative.” The probability of a Type II error is usually denoted by β. The power of a statistical test is defined as the probability of rejecting the H_0 when it is false. It is numerically equal to $1-\beta$. Consequences of Type II errors include unnecessary remediation expense and project delays. For UNC site, the Type II error rate will be $\beta=0.05$

2.4.2 Relative Shift

The lower boundary of the gray region (LBGR) and the target values for α and β are selected during the DQO process. For FSS planning purposes, the LBGR is set to one half the DCGLw. The width of the gray region (DCGL - LBGR) is a parameter that is central to the Sign Test. This parameter also is referred to as the shift, Δ. The absolute size of the shift is actually of less importance than the relative shift Δ/σ, where σ is an estimate of the standard deviation of the measured values in the survey unit. The relative shift, Δ/σ, is an expression of the resolution of the measurements in terms of measurement uncertainty. The value of the relative shift is used to calculate the number of samples required to demonstrate that a survey unit has met the applicable release criteria.

2.5 Release Criteria

The objective of FSS activities is to obtain data of sufficient quality and quantity to support an evaluation of the criteria for the properties. In order to release the site, it must be adequately demonstrated that the average radiological residual concentrations on surfaces and in the soil do not exceed the DCGLw criteria.

3 SURVEY UNITS

All areas of a site will not have the same potential for residual contamination and will not need the same level of survey coverage to establish release criteria. MARSSIM defines survey units for areas with higher potential for contamination that require a higher degree of survey effort. Section 2.2 of MARSSIM provides the following definitions.

- Non impacted areas: Areas that have no reasonable potential for residual contamination
- Class 1 Areas: Impacted areas that have, or had prior remediation, a potential for contamination (based upon site operating history) or known contamination above the DCGLw.
- Class 2 Areas: Impacted areas that have, or had prior remediation, a potential for contamination or known contamination but are not expected to exceed the DCGLw.
- Class 3 Areas: Impacted areas that are not expected to contain any residual radioactivity or are expected to contain levels of radioactivity that are a small fraction of the DCGLw.

All impacted soil areas were subdivided into separate survey units based upon contamination potential. Survey units were originally assigned based upon the 2006 Final Status Survey Plan. Additional areas were classified based upon the Supplemental Characterization Survey (Cabrera 2018). MARSSIM recommends limiting survey unit sizes for soils as follows:

- Class 1 up to 2,000 m^2
- Class 2 2,000 to 10,000 m^2
- Class 3 no limit

Based by previous remediation efforts and historical records the following areas were survey units were identified. The size and shape of the survey units presented section 3 are estimates. After remediation activities are completed formal survey will be performed, identifying the exact coordinates of each location. The coordinates will be uploaded into a GIS map to obtain exact survey unit size and boundaries.

3.1 Class 1

Five areas on the UNC Site were identified as Class 1.

3.1.1 Building 3H

Building 3H from Column 31 to 48 is approximately a 1,480 m^2 area on the northeastern side of the site. This area includes the soils under the Decon Pit, Rectifier Room, and X-ray Reading Room. Most of these areas were decontaminated during the 2011 and 2012 remedial actions and evaluated under the 2018 Supplemental Characterization Survey (Cabrera 2018). According to the 2018 Remedial Action Completion Report (Cabrera 2018) Final Status Survey operations in the Decon Pit included a 100% GWS, collection of 10 systematic surface soil samples, and collection of four biased surface soil samples. Systematic and biased soil sample results for the Decon Pit did not exceed the DCGLw. In like manner, Final Status Survey operations in the X-Ray Read Room included a 100% GWS, collection of 21 systematic surface soil samples, and collection of 73 biased surface soil samples. Systematic and biased soil sample results for the X-Ray Read Room did not exceed the DCGLw. Despite this previous FSS evaluation, the removal of floor and subsurface soils, exposes new material to the environment. Thus, this area needs to be reevaluated under the current FSS Plan.

3.1.2 South Trench Column 31 to the End of Building 3H

South Trench between Column 31 to end of Building 3H is approximately 417 m^2 area runs along the southeastern edge of the site to the eastern property edge. During previous characterization activities it was discovered that radioactive contamination had migrated through a few of the drainage holes in the floors of the utility trenches. The drainage holes created a preferential pathway for residual uranium to be washed into the underlying soils during routine

operations at the site. Also, there is potential contamination as a results of subsurface abandon pipes and conduits throughout this trench. The walls and base of the concrete making up the trench pass the FSS for surficial contamination as reported in the RCRA (Cabrera, 2018). This area will be evaluated as a Class 1 survey unit under this FSS Plan.

3.1.3 South Trench Column 1 to Column 31

South Trench between Column 1 to Column 31 is approximately 860 m^2 area on the southeastern edge of the site to Shelton Avenue. The drainage from the drainage holes in this area came from the largely uncontaminated Building 6H. With the exception of the area near the original Chemistry Laboratory, the activity this section of the utility trench is likely to be less contaminated than the section south the Building 3H. Only two drainage holes at column 26 and 27 indicated greater than 435 pCi/g via grab samples from the holes. This area will be evaluated as a Class 1 survey unit under this FSS plan.

3.1.4 Building 6H from Column 17 to Column 31

Building 6H Center is between Column 17 to Column 31 approximately 1,593 m^2 property in the middle of the building. During the 2016 survey this area was largely uncontaminated. The north trench runs along the northern edge of this survey unit. While the lateral trench runs along the western side. Cleanup activity removed pipes and conduits from the north and lateral trench. While previous FSS found this area satisfactory, the current cleanup activities have exposed new subsurface material to the environment, therefore, this area will be evaluated as part of the current FSS Plan.

3.1.5 Building 6H from Column 1 to Column 17

Building 6H between Column 1 and Column 17 contains the original Chemistry Laboratory. This survey unit is approximaetly1,448 m^2 and is bounded by Shelton Avenue to the West, the lateral trench to the east, and the south trench to the south. Historical reports suggest that several pipes segments in the Chemistry Laboratory indicated elevated activity and potential internal contamination. These pipes travels both along the walls and below grade and could have contributed to residual contamination. Cleanup activities removed theses pipes and the soils below the laboratory. This area will be evaluated as a Class 1 survey unit as part of this FSS Plan.

3.2 Class 2

3.2.1 Ten-Foot Buffer Area

A ten-foot buffer around the footprint of the building was presented in the Cleanup Plan and identified as an impacted area. At that time, it was not expected that the area would require excavation and therefore was classified as a Class 2 area. Excavation revealed structures

directly adjacent to the building footprint within this buffer zone. Once remediation is complete the size and boundary of this area will be established, and survey points calculated.

3.3 Class 3

There are two Class 3 survey unit on this site the site of the previous Haul Road and Laydown Area.

3.3.1 Haul Road

The Haul Road is a 135 m^2 triangular segment of property located in the southeastern corner of the site. This area was surveyed in 2016 including 100% gamma walk over survey, 4 biased soil samples, and 3 systematic samples. All measurements were below the DCGL. While previous FSS reported this area as clean, due to the small number of measurements obtained in 2016, this area will be reevaluated to ensure residual contamination does not exist.

3.3.2 Laydown Area

The Laydown Area is a rectangular area from the northern side of Building 3H to the property edge. This 1,083 m^2 area was surveyed in 2016. The 2016 survey event included 100% gamma walk over survey, 22 systematic surface soil samples, and four biased surface soil samples. The systematic and bias samples did not exceed the DCGLw for the site and was disposed as clean in the 2018 Remedial Action Completion Report. During the more recent cleanup activities, this area was used as storage area for intermodal containers (IMCs) and equipment. While contamination is not anticipated to be present, it will be surveyed as part of this FSS plan.

3.4 Non-Impacted

The non-impacted areas are areas that are not expected to have residual contamination. These areas have either been reported as clean in the 2018 Remedial Action Completion Report FSS or previous FSS.

3.4.1 Buildings 9H, 10H, 11H

In 2016 borings were performed in the area of the footprint of the former Building 9H Offices, Building 10H Hot Waste Processing and Building 11H Metallurgy Laboratory. Soil samples from these areas did not indicate any intervals with radioactivity exceeding background levels. The highest concentration of activity reported from this area was 3.25 pCi/gram total uranium, which is far less than the 435 pCi/gram site DCGLw. Therefore, this area was disposed as clean in the 2018 Remedial Action Completion Report. (Cabrera 2018). This area was used to store intermodal containers and constructed equipment. A gamma walk over survey will be performed to ensure residual contamination does not exist

3.4.2 Argyle Street Sewer

In 1997 inspection indicated that residual HEU existed inside of the inactive sewer that traversed the adjacent property line along Argyle Street. (ORISE 1997) In 2012 ORISE personnel conducted independent surface scans of the sewer line. The surface scans were indistinguishable from background radiation. The Argyle Sewer and adjacent soils was removed in 2011 and 2012 and replaced. The FSS conducted included 100% gamma walk over survey, 22 systematics surface soil samples, and the collection of 42 biased soil samples. Composite volumetric samples were collected from overburden material (0-10 feet depth) along the sewer. Also, sand and soil material and sludge from the Argyle Street sewer were collected. The Sign Test was used to evaluate the sample results and the Argyle Street Sewer was disposed as clean in the 2018 Remedial Action Completion Report. (Cabrera 2018). Therefore, no further actions are required for the Argyle Street Sewer.

3.4.3 71 Shelton Avenue Site Property

The rest of the property, including the areas along fences, property line retaining wall, and driveways are not expected to contain radioactivity. These areas will be screened during the gamma walk over survey to ensure residual contamination does not exist.

4 SAMPLING

4.1 Gamma Survey

MARSSIM suggests that a gamma scan surveys for Class 1 survey units be performed to cover 100 percent of the accessible areas in each survey unit. Class 2 and Class 3 survey unit scans can be performed over smaller portions of the accessible areas. The purpose of the gamma survey is to identify the potential presence of smaller, discrete area of residual radioactivity.

Gamma walkover surveys (GWS) will be performed to cover 100 percent of all accessible areas in each survey unit classified as Class 1.

GWS for Class 3 units will depend on the size of the survey units and accessibility. However, if possible, Class 3 areas will have a minimum of 50 percent scan coverage. For small areas, the Class 3 surveys will likely approach 100 percent scan coverage.

While MARSSIM does not require non-impacted areas to receive any level of survey because they are not anticipated to have any residual contamination, the non-impacted areas of the site will be gamma surveyed to ensure that there are no areas of unremediated material. The survey coverage will be approximately 75%. Due to accessibility and interferences issues, everything cannot be surveyed.

The GWS will be conducted using a gamma survey system consisting of a 2-inch by 2-inch sodium iodine scintillator (gamma probe Ludlum 44-10) coupled to a ratemeter/scaler (Ludlum 2221 or equivalent). The probe will be held one to three inches above the surface and moved from side to side while moving forward at a rate no faster than 3 feet per second along a transect-a serpentine motion. Transects will be spaced six feet apart and each the length of the survey unit. As the field of view of the probe is about six feet this assure adequate coverage of all areas. The gamma probe and rate meter/scaler are coupled to a GPS (R2 GNSS Receiver GPS system with Terrasinc software) and a screen pen-based computer. All will be linked electronically to support the creation of an electronic file that records the coordinates along with the surface soil exposure rate as the transects are traversed. At the conclusion of the survey the file is uploaded to a computer where ESRI® Geographic Information System (GIS) software will be used to create a spatial representation of the data (count rate).

Gamma exposure count rates will be electronically segregated or "binned" and the bins color coded (e.g., blue coding will represent count rates less than twice background, yellow coding for count rates greater than twice background, red coding for count rates greater than four times background, etc.). The resulting color-coded figure will illustrate the spatial distribution of gamma counts relative to background. Areas with greater than four times background will be further investigated, and representative samples from such areas will be collected for laboratory analysis.

4.2 Number of sample locations

The Sign statistical test will be used to determine whether the site is suitably free of residual radioactivity. The minimum number of systematic sample points required for each unit can be determined using MARSSIM Section 5.5 for guidance.

MARSSIM provides the minimum number of measurement locations (N) required for each survey unit or reference area for selected values of α (Type I error), β (Type II error), and Δ/σ (relative shift). The values were calculated using the equation provided below with an increase of 20% to account for uncertainties in the calculation and to obtain sufficient data points to attain the desired power level for the statistical tests and allow for possible lost or unusable data.

The following equation, which is used to calculate N (see Section 5.5 of MARSSIM), relies on Sign P, the probability that a random measurement from the survey unit exceeds a random measurement from the background reference area by less than the DCGL when the survey unit median is equal to the LBGR above background.

$$N = \frac{(Z_{1-a} + Z_{1-\beta})^2}{4(Sign\ P - 0.5)^2}$$

For UNC the following values were used:

- The $DCGL_w$ for the remaining Site soils is 435 pCi/g total uranium.
- The lower bound of the gray region (LBGR) is the statistical region where the consequences of decision errors are relativity minor and is generally accepted to be equal to one-half of the DCGLw. Thus, LBGR 50% of the DCGLw or 217.5.
- The shift (Δ) is equal to the width of the gray region (DCGL – LBGR). 435 – 217.5 = 217.5
- A standard deviation (σ) of 20 pCi/g (approximately the square root of the DCGLw or one standard deviation) is assumed.
- The relative shift is defined as Δ/σ. 217.5 ÷ 20 = 10.8.
- Per MARSSIM Table 5.4 of gives a Sign P of 1.
- The standard decision error levels α is the acceptable probability of incorrectly concluding the site median is less than the threshold, (0.05) and β is the acceptable probability of incorrectly concluding the site median exceeds the threshold, (0.05) leads to decision error percentile of 1.645 for both from Table 5.2.

$$10.82 = \frac{(1.645\ + 1.645)^2}{4(1 - 0.5)^2}$$

Results in N = 10.82 + 20% = 13.96, rounded up to 14 samples. Thus, the minimum number of systematic samples is 14.

4.3 Sample Collection

As noted in MARSSIM Appendix D, a triangular grid is general more effective in locating small areas of elevated activity. The data points are then positioned throughout the survey unit from a randomly selected starting point and the established sampling pattern. Grids are presumed in a single flat plane. Pacific Northwest National Laboratory Visual Sampling Plan Version 7.12a will be used to determine the location of the sample points. The minimum sampling intensity for all Class 1 survey units will be 14. The number of systematic samples in a survey unit may be increased due to grid edge effects. The locations of the sampling points may shift based on site interferences. No discrete soil samples will be performed on concrete surfaces. Random measurement patterns will be used for Class 3 survey units.

Prior to taking a soil sample, a one-minute gamma count of the location of the sample will be taken with a Ludlum 44-10 2 inch by 2 inch sodium iodine probe coupled to a Ludlum 2221 ratemeter. A Z score will be calculated for each gamma scan survey data point. The Z score describes how many standard deviations above or below the mean a measurement fall. Areas with a Z score equal or greater than 3.0, additional measurements and soil samples will be

required. As a conservative measure, a biased soil sample will be collected at the location where the highest gamma walkover datum point is observed.

During GWS of non-impacted areas of the site, bias samples will be obtained in areas reporting four times the background.

Volumetric discrete soil samples will be taken in accordance with approved sampling procedure (see attached). Generally, a single soil sample will be obtained from the surface at each sample location. The sample will consist of the collection of 400 to 500 grams of soil, homogenized, and shipped to an off-site laboratory.

Sample will be analyzed for U-238, U-235 and U-234 by alpha spectroscopy method DOE A-01-R and U-235 and U-238 (Th-234) by gamma spectroscopy method DOE GA-01-R. Gamma spectroscopy U-234 will be estimated by multiplying the U-235 result by 27.

4.4 Survey Unit Evaluation – Sign Test

Because the background natural concentration of uranium is less than 1% of the site's DCGLw, all measurements will be evaluated using the Sign Test (MARSSIM section 8.3.2). The Sign Test's null hypotheses (H_0) is the median concentration of residual radioactivity on the site will be greater than the DCGLw. This is assumed to be true unless the statistical test indicates that it should be rejected. The Sign Test is applied as outlined in the following steps from MARSSIM.

Assume the set of results from the sample analysis for total uranium is {Xi} where i = 1 to 15. This set will be evaluated as follows:

1. List the set of measurements
2. Subtract each measurement Xi, from the DCGLw to obtain the differences: Di = DCGLw – Xi, i=1,15
3. Discard each difference that is exactly zero and reduce the sample size by the number of such zero measurements.
4. Count the number of positive differences. The result is the test statistic S+. Note that a positive difference corresponds to a measurement below the DCGLw and contribute evidence that the survey unit meets the release criterion.
5. Large values of S+ indicate that the null hypothesis, that is the survey unit exceeds the release criteria (DCGLw), is false, The value of S+ is compared to the critical value; for 15 samples the critical value is 11 (MARSSIM Appendix I Table I3, ά =0.05), If S+ is greater than the critical value, 11 for this case, the null hypothesis is rejected.

Note that if all the samples are less than the DCGLw no further evaluation is required as the survey unit will always pass the Sign test.

5 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

5.1 QA/QC

Activities associated with this FSS shall be performed in accordance with written procedures and approved protocols in order to ensure consistent, repeatable results.

5.2 Field Instruments

Instruments and equipment used will meet the required detection sensitivities. Instruments will be operated in accordance with either written procedures or manufacturer's manuals. Current calibration will be kept onsite for review and inspection used during the survey. The records will include at minimum:

- Equipment name, model, and serial number
- Manufacturer
- Date of calibration
- Calibration due date

Instruments will be maintained and calibrated to the manufacturer's specifications to ensure traceability, sensitivity, accuracy, and precision.

Prior to and after daily use, instruments will be QC checked by comparing the instruments response to a designated gamma source and background radiation. QC source checks will consist of one-minute integrated counts with the designated source position in a reproducible geometry, performed at the designated location. Background checks will be performed in an identical fashion with the source removed. The results of the background and QC checks will be recorded in a field logbook. Prior to the start of initial surveys, this procedure will be repeated at least five times to establish average instrument response.

Instrument response to the designated QC check source will be plotted on control charts and evaluated against the average established at the start of the field activities. A performance criterion of +/– 2 sigma of this average will be used as an investigation action level. A performance criterion of +/– 3 sigma of this average will be used as a failure level requiring corrective action. Results exceeding this criterion will be investigated and appropriate corrections to instrument readings will be made if the response is affected by factors beyond personnel control, such as large humidity or temperature changes. The instrument(s) in question will be removed from service while investigations and corrective actions are in progress.

Instrument response to background will be used to establish a mean background response for each instrument, to monitor gross fluctuations in background activity, and to evaluate detector response.

During QC checks, instruments used to obtain radiological data will be inspected for physical damage, current calibration and erroneous readings in accordance with applicable protocols. Instrumentation that does not meet the specified requirements of calibration, inspection, or response check will be removed from operation. If the instrument fails the QC response check, any data obtained to that point, but after the last successful QC check will be considered invalid due to faulty instrumentation.

5.3 GPS Requirements

A reference location will be established for the GPS system. At the start of the field effort the average easting and northing GPS position data will be used to establish the average response of the GPS system. During subsequent routine checks, GPS position data will be compared to the established averages and recorded in the field logbook. Measurements differing by more than one meter from this average will be investigated and corrective actions will be implemented, if possible.

5.4 Laboratory

All laboratory analyses will be performed by an approved/certified laboratory. The laboratory shall analyze method blanks, matrix spike samples, laboratory control samples and replicates at the minimum frequencies specified in the QAPP.

6 REFERENCE

AAA/IEM, 2008 Integrated Environmental Management, Inc. Derived Concentration Guideline Levels for Decommissioning the former UNC Manufacturing Facility, New Haven, Connecticut. AAA Environmental, Inc./Integrated Environmental Management, Inc. June 16, 2008.

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Oak Ridge Institute for Science and Education (ORISE), 1997. ORISE. Radiological Scoping Survey of Buildings 3H and 6H at the Former UNC H-Tract Facility, New Haven, Connecticut. January 1997.

MARSSIM *Multi-Agency Radiation Survey and Site Investigation Manual* NUREG-1575, Rev 1 (2000)

Visual Sampling Plan *A Tool for Design and Analysis of Environmental Sampling* Version 7.12a Pacific Northwest National Laboratory (2020)

TABLES

Table 1 - Survey Units

Survey Unit	Classification	Approximate Size (meter^2)[1]	Description
Building 3H Column 31 to 48	1	1,480	Includes Decon Pit, Rectifier Room, Xray Reading Room
Building 6H Column 17 to 31	1	1,593	Includes Lateral and North Trench
Building 6H Column 1 to 17	1	1,448	Includes Chemistry Laboratory, North Trench
South Trench Column 31 to SE corner of Building 3H	1	417	Includes weep holes from Building 3H
South Trench Column 1 to 31	1	860	Includes weep holes from Building 6H and Chemistry Laboratory
10 Foot Buffer Area	2	Unknown	10 foot boundary around Building 3H and 6H, may contain below grade structures.Class 1 or calss two areas may be established.
Haul Road	3	135	
Laydown Area	3	1,083	

Note 1 - Estimated

Table 2 – Classification of Survey Units

Room	Survey Unit Classification	Description
71 Shelton Bulk Property	Non impacted	Area outside of site activities: along fences, borders, grass, driveway, and sidewalks
Argyle Street Sewer	Non impacted	Previously dispositioned as clean under RACR 2018[1]
Building 3H	1	Subsurface soils
Building 6H	1	Subsurface soils
Building 9H/10H/11H	Non impacted	Previously dispositioned as clean under RACR 2018[1]
Chemistry Laboratory	1	Subsurface soils
Decon Pit	1	Subsurface soils
Haul Road	3	Previously dispositioned as clean under RACR 2018[1] but reevaluating based upon site activities
Laydown Area	3	Previously dispositioned as clean under RACR 2018[1] but reevaluating based upon site activities
North Trench	1	Subsurface soils
Rectifier Room	1	Subsurface soils
South Trench	1	Subsurface soils
10 Foot Buffer	1 or 2	Subsurface soils
Xray Reading Room	1	Subsurface soils

Note 1 - Cabrera 2018 Remedial Action Completion Report Site Decommissioning Former UNC Manufacturing Facility. November 2018

Table 3 - Sampling Requirements

Survey Unit Classification	Class	Statistical Test	Scanning	Sampling	Direct Measurement
Impacted	Class 1	Yes	100% Coverage	Systematic	Systematic
Impacted	Class 2	Yes	50% Coverage minimum	Systematic	Systematic
Impacted	Class 3	Yes	50% Coverage minimum	Random	Random
Non-Impacted	N/A	No	75 - 100% Coverage	Bias	No

FIGURES

Figure 6.1 - UNC New Haven Site – 71 Shelton Avenue, New Haven, Connecticut

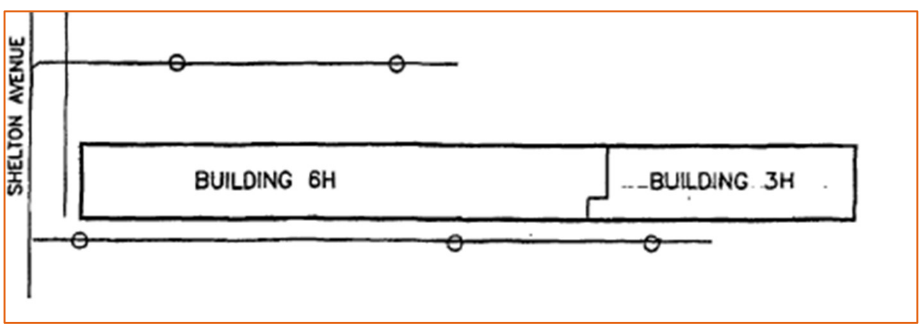

Figure 6.2 – UNC Buildings Sketch

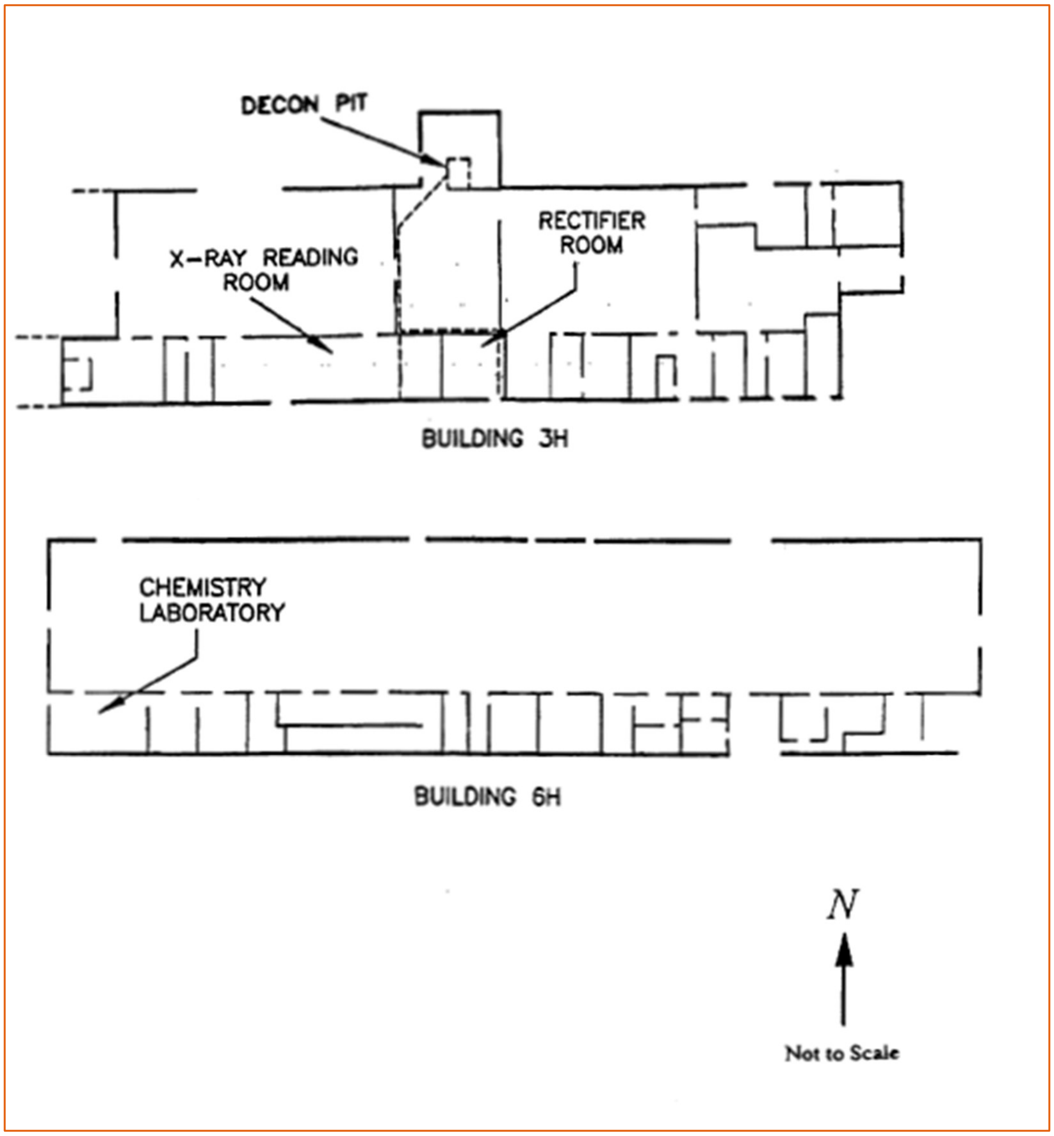

Figure 6.3 - Building 3H and 6H

Figure 6.4 - Survey Units with Sample Points

Survey Unit Color Codes for visual ease.

Green	Building 3H Column 31 to 48
Yellow	Building 6H Column 17 to 31
Pink	Building 6H Column 1 to 17
Brown	South Trench Column 31 to SE corner of Building 3H
Blue	South Trench Column 1 to 31
Orange	Haul Road
Purple	Laydown Area
Not Identified	10 Foot Buffer Area
Not Identified	Remaining Site Property

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ATTACHMENTS

SOP – 09 Procedure for Shallow Soil Sampling

PROCEDURE FOR SHALLOW AND DEEP SUBSURFACE SOIL SAMPLING

SOP#: WGGM-09

Rev: 9

Rev Date: May 2016

SOP VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
9	May 2016	All	Update entire SOP	Michael Barone

APPROVAL SIGNATURES

Prepared by: Lisa Szegedi ______________________ Date: 5/5/2016
Lisa Szegedi, Technical Lead

Reviewed by: Michael Barone ______________________ Date: 5/5/2016
Mike Barone, Project Manager

1 SCOPE AND APPLICATION

Introduction

This guideline is to provide information on soil sampling to be conducted at the Welsbach/General Gas Mantle Site.

Definitions

Soil Samples. Environmental samples of potentially contaminated soil, where soil is defined as a layer of weathered, unconsolidated material; often defined as containing organic matter and being capable of supporting plant growth.

Grab Sample. A discrete soil sample representative of a specific location at a given point in time.

Transfer Device. Any instrument or vessel that contacts the sample during collection or transport (e.g., stainless steel trowel).

Auger. An auger consists of a T-handle attached to a stainless steel bucket (which generally has a 3-to 4-inch diameter) with an attached cutting edge that is twisted downward into the soil. The stainless steel bucket allows for collection of subsurface soils during augering.

2 EQUIPMENT LIST

1. Ludlum model 44-10 2” x 2” NaI gamma scintillation detector
2. Ludlum model 44-9 Pancake G-M detector
3. Ludlum model 12 ratemeter
4. Ludlum Model 43-5 zinc sulfide (ZnS(Ag)) detector
5. Ludlum Model 2221 scaler/ratemeter or Ludlum Model 2350 data logger
6. 5-gram En Core® samplers
7. En Core® T-handle
8. Laptop computer
9. Digital camera
10. Global positioning system (GPS)
11. Stainless steel augers
12. T-handle and drill rods
13. Stainless steel bowls
14. Stainless steel trowels, scoops, and spatulas
15. Geoprobe Rig or equivalent
16. Tripod Rig or equivalent
17. Geoprobe Large Bore Soil Sampler (“Macrocore”)
18. Standard Geoprobe Acetate Liners
19. Disposable gloves
20. Plastic zip-lock bags

21. Plastic garbage bags
22. Measuring tapes
23. Polyethylene sheeting
24. Aluminum foil
25. MiniRAE 10.6 eV photoionization detector (PID)
26. 8-oz glass sample jars
27. Topsoil or potting soil
28. Paper towels
29. Sample coolers
30. Ice

3 PROCEDURE

Guidelines

Soil types at a hazardous waste site can vary considerably, both at the site surface and in the underlying strata. Soil variations affect the rate of contaminant migration via surface runoff and windblown transport of particulates, and affect the rate of contaminant migration downward through the soil. Sampling of the soil horizons above the ground water table can detect contaminants before they have migrated into the water table, and can help to quantify the amount of contaminants sorbed within the aquifer that have the potential to contribute to ground water contamination.

Most of the methods employed for soil sampling at hazardous waste sites are adaptations of techniques long employed by foundation engineers and geologists. For this site, the shallow subsurface soil samples will be collected using hand augers or a manually installed Geoprobe Core Barrel. Subsurface soil samples will either be collected with a Geoprobe 54LT rig, or equivalent.

SAMPLING PROTOCOL

1. Special Precautions for Sampling:

The following general precautions should be taken when sampling:

a. Prior to entering the property, confirm with the person present (owner, tenant, landlord, etc.) that access to the property was granted.

b. Health and Safety Plan protocols will be followed. As needed, road cones, caution tape or other appropriate means may be used to identify the exclusion zone. A 25 foot exclusion zone will be established around heavy equipment operation. This zone may be extended as determined to be protective by the SSHO or FTL.

c. A clean pair of new, disposable gloves will be worn each time a different location is sampled and each time a new interval is sampled within the same auger/borehole. Gloves will be donned immediately prior to sampling.

d. Sample containers for source samples or samples suspected of containing high concentrations of contaminants will be placed in separate plastic bags immediately after collection and decontamination of the outside of the container.

e. All field personnel and field instruments will be frisked out with a Pancake G-M detector prior to leaving the sampling location. If radiological contamination is detected on field personnel and/or field instruments decontamination procedures, as outlined in SOP # WGGM-05, will be followed.

f. All used field equipment (trowels, bowls, etc.) to be decontaminated will be placed in plastic bags. All field waste (i.e., PPE, plastic sheeting, towels, etc.) to be disposed of will be placed in another plastic bag after being frisked for contamination. If contamination is found, item/s will be placed in separate bag for proper disposal.

g. If possible, one member of the field team will enter all field activity information into the field laptop, while the other member(s) collects all of the samples. All field activities will be documented as outlined in SOP #WGGM-01.

h. Sample collection activities will proceed progressively from the suspected least contaminated area to the suspected most contaminated area.

i. Field personnel will use equipment constructed of stainless steel or carbon steel that has been properly decontaminated. The decontamination procedures outlined in SOP #WGGM-05 will be followed.

j. Quality control/quality assurance (QA/QC) samples will be collected according to SOP #WGGM-11.

k. The chain of custody procedures described in SOP #WGGM-11 will be followed.

l. The sample management procedures described in SOP #WGGM-11 will be followed.

2. Sample Collection:

Procedure for Shallow Subsurface Soil Sampling Using A Hand Auger

Hand augers are ideal for collecting shallow subsurface soils in cohesive soils such as silts and clays. In cohesive soils, a hand auger can be used to collect samples generally up to a depth of 4 ft. However, in rocky soils auger refusal is experienced almost immediately, as small stones will block and jam the cutting edge on the auger bucket. Procedures for use of the hand auger are as follows:

a. Chemical Samples

1. Prior to sample collection, record the soil sample location in the field laptop. Upload the surveyed map from the GIS/Database and mark the location on the map. Use a Global Positioning System (GPS) to locate the sample. Refer to SOP #WGGM-03 for the GPS operating procedure. If the GPS will not work on the property (e.g., too many overhead barriers), establish the location using a measuring tape. Refer to SOP #WGGM-04. Take a picture of the sample location.

2. Record the field personnel and weather conditions in the laptop.

3. Place plastic sheeting on the ground around the sampling location to prevent cross-contamination.

4. Attach a decontaminated auger to a drill rod extension. Attach the "T" handle to the drill rod.

5. Clear the area to be sampled; remove surface vegetation, debris, or large stones prior to augering.

6. There are several types of chemical samples that can be collected; TAL/TCL samples will be collected from any property that is radiologically contaminated that also had a previous or current commercial/industrial use. TCLP and RCRA characteristic samples will be collected from properties that are radiologically contaminated and will be part of the remedial design.

7. For either TAL/TCL or TCLP and RCRA characteristic samples the target sample depth will be known prior to sampling. TAL/TCL samples are collected from the interval displaying the highest pancake detector readings. The TCLP and RCRA characteristic target sample depths will be given on the design data gap drawings. Chemical samples will be collected from their target locations unless visual evidence (staining) or elevated RAD or PID readings are encountered.

8. Begin augering and continue augering until the desired depth is reached. A dedicated decontaminated auger should be used to collect the sample. After augering the six inch interval to be sampled, carefully withdraw the auger from the borehole. For TAL/TCL samples, collect the volatile organic (VOA) sample directly from the auger using the En Core® Sampler. Refer to a later section of this SOP for the procedure on using the En Core® Sampler. For TCLP samples, collect the VOA sample directly from the auger using a stainless steel scoopula. The TCLP VOA sample should be collected into 2 40-mL vials with no headspace or voids.

9. Once the VOA samples are collected, place the auger over a decontaminated stainless steel bowl, and remove the remaining soil from the auger by lightly tapping the side of the auger with a stainless steel trowel.

10. When instructed, scan the soil in the bowl with the Pancake G-M detector and photoionization detector (PID) and record the readings in the laptop.

11. Homogenize the soil (refer to a later section of this SOP) in the bowl using a stainless steel trowel or spoon. Record the soil type and color in the laptop. The samples will be collected in the following order: semi-volatiles (BNAs)/pesticides/polychlorinated biphenyls (PCBs), RCRA characteristics, and metals/cyanide (CN). The BNA/ pesticide/PCB sample will be collected into one 8-oz. glass jar, the RCRA characteristic sample will be collected into one 8-oz. glass jar, and the metals/CN sample will be collected into another 8-oz. glass jar.

12. Record the following information in the laptop: a) sample identification number; b) method of sample collection; c) date and time of sample collection; d) type of analyses; e) whether this is a QC sample (e.g., matrix spike, field duplicate, split sample); and f) field rinsates associated with this sample.

13. Decontaminate the exterior of all sample containers (refer to SOP #WGGM-05). Place all chemical samples in ziplock bags and place them on ice, or immediately submit the samples to the sample management officer.

14. Restore the void created by sample collection prior to leaving the sampling location. Use bentonite or the soil from the intervals not sampled. Place the soil from the intervals back into the hole in order from the deepest interval to the shallowest interval. If necessary, commercially available potting soil or topsoil can be used to fill the void. Ensure that the area has been cleaned, and all sampling material has been removed.

15. When leaving the sample location, frisk all equipment and personnel with the Pancake G-M detector. If contamination is found, refer to SOP #WGGM-05.

b. Radiological Samples

1. Prior to sample collection, record the soil sample location(s) in the field laptop. Upload the surveyed map from the GIS/Database and mark the location(s) on the map. Use a Global Positioning System (GPS) to locate the sample location. Refer to SOP #WGGM-03 for the GPS operating procedure. If the GPS will not work on the property (e.g., too many overhead barriers), establish the location using a measuring tape. Refer to SOP #WGGM-04. Take a picture of the sample location.

2. Record the field personnel and weather conditions in the laptop.

3. Place plastic sheeting on the ground around the sampling location to prevent cross-contamination.

4. Attach a decontaminated auger to a drill rod extension. Attach the “T” handle to the drill rod.

5. Clear the area to be sampled; remove surface vegetation, debris, or large stones prior to augering.

6. Begin augering. After augering down six inches, carefully withdraw the auger from the borehole, place the auger over a decontaminated stainless steel bowl, and remove the soil from the auger by lightly tapping the side of the auger with a stainless steel trowel.

7. Label the bowls (i.e., 0-6 in, 6-12 in, etc.) or keep them in sequential order on the plastic sheeting.

8. Replace the used auger with a decontaminated one and continue augering at six-inch intervals following steps 6, 7, and 8 until the depth where the gamma readings in the adjacent downhole gamma logging boring dropped significantly. If the readings do not drop significantly continue augering until a depth of four feet has been reached or auger refusal is encountered.

9. Homogenize the soil in each bowl using the procedure described on page 11 of this SOP. Scan the homogenized soil in each bowl with the Pancake G-M detector and record the reading in the laptop.

10. The sample will be collected from the interval that displays the highest screening level of gross radioactivity ≥ 2x UCL. Transfer the homogenized fraction into an 8-oz jar using the same stainless steel trowel or spoon used throughout this entire procedure. Record the soil type and color in the laptop.

11. Record the following information in the laptop: a) sample identification number; b) method of sample collection; c) date and time of sample collection; d) type of analyses; e) whether this is a QC sample (e.g., matrix spike, field duplicate, split sample); and f) field rinsates associated with this sample.

12. Decontaminate the exterior of all sample containers (refer to SOP #WGGM-05).

13. Restore the void created by sample collection prior to leaving the sampling location. Use the soil from the intervals not sampled. Place the soil from the intervals back into the hole in order from the deepest interval to the shallowest interval. If necessary, bentonite or commercially available potting soil or topsoil can be used to fill the void. Ensure that the area has been cleaned, and all sampling material has been removed.

14. When leaving the sample location, frisk all equipment and personnel with the Pancake G-M detector. If contamination is found, refer to SOP #WGGM-05.

<u>Procedure for Radiological Soil Sampling Using a Geoprobe 54LT rig, or equivalent</u>

1. Prior to sample collection, record the soil sample location(s) in the field laptop. Upload the surveyed map from the GIS/Database and mark the location(s) on the map. Refer to SOP #WGGM-04. Take a picture of the sample location.

2. Record the field personnel and weather conditions in the laptop.

3. Place plastic sheeting on the ground around the sampling location to prevent cross-contamination.

4. Clear the area to be sampled; remove surface vegetation, debris, or large stones prior to sampling.

Using all proper procedures the driller will complete steps 5 through 13

5. Place a 4’ x 4’ sheet of plywood adjacent to proposed sampling location. Maneuver Geoprobe 54LT rig or equivalent on top of plywood sheeting.

6. Attach Large Bore Soil Sampler (Drive head, Piston Rod/Stop-Pin, decontaminated Sampler Tube with enclosed acetate sample liner, decontaminated Cutting shoe, and decontaminated Piston Tip) to the Geoprobe 54LT rig to form the Geoprobe drive assembly.

7. Place the Geoprobe drive assembly into a vertical position over the sample location.

8. For the initial sample section (i.e., 0-4 feet), remove the Piston Stop Pin and drive the Cutting Shoe to a depth of 4 feet below ground surface (bgs). Retract the Geoprobe drive assembly to the surface.

9. Remove the filled standard acetate sample liner from the Large Bore Soil Sampler and place the liner on dedicated polyethylene sheeting.

10. Re-assemble Large Bore Soil Sampler and position Geoprobe drive assembly into a vertical position above the sampling location. Drive the Large Bore Soil Sampler to a depth 4 feet bgs. Remove the Piston Stop Pin. Drive the Cutting Shoe 4 feet, from a depth of 4 to 8 feet bgs. Retract the Geoprobe drive assembly to the surface

11. Remove the filled standard acetate sample liner from the Large Bore Soil Sampler and place the liner on dedicated polyethylene sheeting

12. To collect additional samples repeat steps 10 and 11 for sequential depth sections.

13. After the required depth has been reached or refusal in encountered, remove Geoprobe drive assembly and insert temporary PVC casing into borehole.

14. Perform downhole gamma logging of borehole according to procedures presented in SOP #WGGM-08. Upon the completion of the downhole gamma logging, scan the acetate sleeve with the Pancake G-M detector, scanning each stratigraphic unit as determined by the Hydrogeologist, and record the results adjacent to the stratigraphic unit on the field boring log. After review of downhole gamma logging results, the proposed sampling location will be identified. The four-foot section that bridges the highest subsurface downhole gamma activity level, that also exceeds action criteria, will be selected for sampling.

15. For the four-foot section identified, divide the contents into foot long sub-sections. For example, if the highest downhole gamma logging reading in a borehole is at 1.5 feet bgs, the intervals from 0-1, 1-2, 2-3, and 3-4 feet will be separated into subsections and placed into bowls. Typically the interval above the highest reading, the interval at the highest reading and the two intervals below the highest reading are placed into bowls. Place the bowls in sequential order on the plastic sheeting.

16. For some boreholes, the elevated downhole gamma logging readings will obviously be associated with a thin layer of soil in the sleeve that is visually distinct from the rest of the soil (e.g., fine ash layer). If the soils in the acetate sleeve exhibit stratification, the soil will be scanned while still in the sleeve to determine if the elevated readings are associated with a particular stratigraphic layer. If so, the specific layer will be separated from the rest of the soil and placed in a jar (and not homogenized since there is often limited volume and the sample will be diluted that way) for analysis.

17. Homogenize the soil in each bowl using the procedure described in a later section of this SOP. Scan the homogenized soil in each bowl with the Pancake G-M detector and record the reading in the laptop. As stated in #15 above, soil may be separated and scanned within the acetate sleeve. The field crew will be instructed as to which method to use.

18. The sample will be collected from the interval that displays the highest screening level of gross radioactivity. If all intervals have background readings, the sample will be collected from the interval that spans the highest downhole gamma logging measurement. Transfer the homogenized fraction into the appropriate sample container(s) using the same stainless steel trowel or spoon used throughout this entire procedure. The amount of soil required will be determined by the contract laboratory; however, one 8-oz. jar is usually sufficient. Log the soil core using Unified Soil Classification System Procedures. Take a photograph of the sample collection activities.

19. From each boring, typically one archive sample will be collected from each acetate sleeve collected, although this is not a requirement. More or less can be collected based on DHG, pancake G-M readings, soil appearance or contents (fill), and at the discretion of the FTL or Hydrogeologist. Archive samples will only be sent for analysis at the direction of the DPM or SQO.

20. In an indelible marker, record the Property Address, Property Number, Point Name, Borehole Number (SB-X), depth of archive sample, date and time of collection on the archive sample bottle. Log the soil core using Unified Soil Classification System Procedures. On the field boring log note the depth of the archive sample and note which stratigraphic unit the sample came from. Archive samples should always be collected from discrete strata. Never collect archive samples across two separate stratigraphic units.

21. Record the following information in the laptop: a) sample identification number; b) method of sample collection; c) date and time of sample collection; d) type of analyses; e) whether this is a QC sample (e.g., matrix spike, field duplicate, split sample); and f) field rinsates associated with this sample. If an archive sample is collected, the following should be recorded in the comments section: "Archive sample collected from X feet."

22. Decontaminate the exterior of all sample containers (refer to SOP #WGGM-05).

23. The driller will restore the void created by sample collection prior to leaving the sampling location. Bentonite pellets or fine sand will be used to fill the boring from bottom of bore hole to a depth of 2 feet bgs. The top 2 feet of the boring will be filled with commercially available potting soil or topsoil. If boring was done through concrete or asphalt, top 2 feet of bore hole will be filled with same material. Ensure that the area has been cleaned, and all sampling material has been removed.

24. When leaving the sample location, frisk all equipment and personnel with the Pancake G-M detector. If contamination is found, refer to SOP #WGGM-05.

<u>Procedure for Chemical Soil Sampling Using a Geoprobe 54LT rig, or equivalent</u>

Follow steps 1 through 18 outlined in <u>Procedure for Radiological Soil Sampling Using a Geoprobe 54L rig, or equivalent,</u> as described above. The chemical soil sample will either be collected from the same interval as the radiological sample or the chemical sample will be collected from the interval designated on the design data gap drawing. To collect the chemical sample, the driller will advance the geoprobe to the correct interval and collect sufficient volume to collect the required parameters. Each new boring will be installed adjacent to the previous boring. Once the sleeve(s) is obtained from the correct interval, the

samples will be collected as described in steps 6 through 11 outlined in Procedure for Shallow Subsurface Soil Sampling Using a Hand Auger – Chemical Samples.

VOA Sample Collection Using the En Core® Sampler

1. Remove a 5-gram sampler and cap from package and position plunger rod so that the plunger can be moved freely from the top to the bottom of the coring/storage chamber. This is accomplished by pushing the plunger rod down until the small O-ring rests against the tabs. Note: The En Core® sampler is a single-use device.

2. Attach the T-handle to the sampler body by depressing the locking lever on the T-handle, placing the coring body (plunger end first) into the open end of the T-handle, aligning the slots on the coring body with the locking pins in the T-handle, and twisting the coring body clockwise to lock pins in slots. The plunger should be positioned so that the bottom of the plunger is flush with the bottom of the coring body/storage chamber.

3. Using the T-handle, push the En Core® sampler into the soil in the stainless steel Auger until the coring body/storage chamber is completely full.

4. Verify that the coring/storage chamber is full by looking into the 5 gram viewing hole in the T-handle. The coring body/storage chamber is completely full if the small O-ring on the plunger rod is centered in the T-handle viewing hole.

5. Scrape a decontaminated spatula across the bottom of the coring body/storage chamber so the surface of the soil in the sampler is flush with the opening of the coring body/storage chamber.

6. Quickly wipe the external surface of the coring body/storage chamber with a clean paper towel.

7. After ensuring that the sealing surfaces are clean, cap the coring body/storage chamber while it is still on the T-handle. This is done by gently sliding the cap onto the coring body/storage chamber with a twisting motion.
8. Remove the T-handle from the sampler and lock the plunger into position by rotating the plunger rod.

9. Fill out sample label and attach to the cap of the En Core® sampler.

10. Place sampler in the protective moisture-proof zip-lock bag it came in.

11. Fill out sample information on bag and store bag on ice.

12. Repeat the above procedure using one more sampler. A total of two En Core® samplers will be collected per six-inch sampling interval.

Homogenization Procedure for the Collection of Non-VOA Soil Samples

1. Thoroughly mix the sample using the same stainless steel trowel or scoop, used during the sample collection. The soil in the bowl should be scraped from the sides, corner and bottom, rolled to the middle of the bowl and initially mixed.

2. The sample should be quartered and separated.

3. Each quarter should be mixed individually and then rolled to the center of the bowl.

4. Mix the entire sample again.

3. Sample Preservation:

Methods of sample preservation are relatively limited and are generally intended to retard biological action, and hydrolysis, and to reduce sorption effects. Preservation methods for soil samples are generally limited to no headspace in sample container (VOA samples only), refrigeration, and/or protection from light. Sample preservation procedures as outlined in the SOP for Sample Preservation, #WGGM-12 will be followed.

4 REFERENCES

ASTM D1452. Standard Practice Method for Soil Investigation and Sampling by Auger Borings. American Society for Testing and Materials, Philadelphia, Pennsylvania. June 12, 1980.

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ASTM D6418. Standard Practice for Using the Disposable En Core® Sampler for Sampling and Storing Soil for Volatile Organic Analysis. American Society for Testing and Materials, West Conshohocken, Pennsylvania. June 10, 1999.

ASTM D4547. Standard Guide for Sampling Waste and Soils for Volatile Organic Compounds. American Society for Testing and Materials, West Conshohocken, Pennsylvania. September 10, 1998.

EPA, 1984 Characterization of Hazardous Waste Sites -- A Methods Manual, Volume 11, Available Sampling Methods, Second edition, Section 2.2, Soils, pp. 2-2 to 2-3. Section 2.2.1, Method II-1: Soil Sampling with a Spade and Scoop, p. 2-4. Section 2.2.2, Method 11-2: Subsurface Solid Sampling with Auger and Thin-walled Tube Sampler, pp. 2-5 to 2-7.

Section 2.4.1, Method II-7: Sampling of Bulk Material with a Scoop or Trier, pp. 2-19 to 2-21. Environmental Monitoring Systems Laboratory, Office of Research and Development. U.S. Environmental Protection Agency, Las Vegas, Nevada. EPA-600/4-84-076. December 1984.

EPA, 1987. A Compendium of Superfund Field Operations Methods. Section 8.1.6.1.1: Hand augers, pp. 8.1-4 to 8.1-6. Section 8.1.6.2.1: Split-spoon Samplers, p. 8.1-20. Section 8.1.6.2.2: Thin-walled Tube Samplers, p. 8.1-21. Office of Emergency and Remedial Response, Office of Waste Programs Enforcement. U.S. Environmental Protection Agency, Washington, D.C. EPA/540/P-87/001. December 1987.

USACE, 1994. Requirements for the Preparation of Sampling and Analysis Plans. Appendix C: Environmental Sampling Instructions, pp. C-43 to C-49. September 1994.

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Example of Visual Sample Plan Report

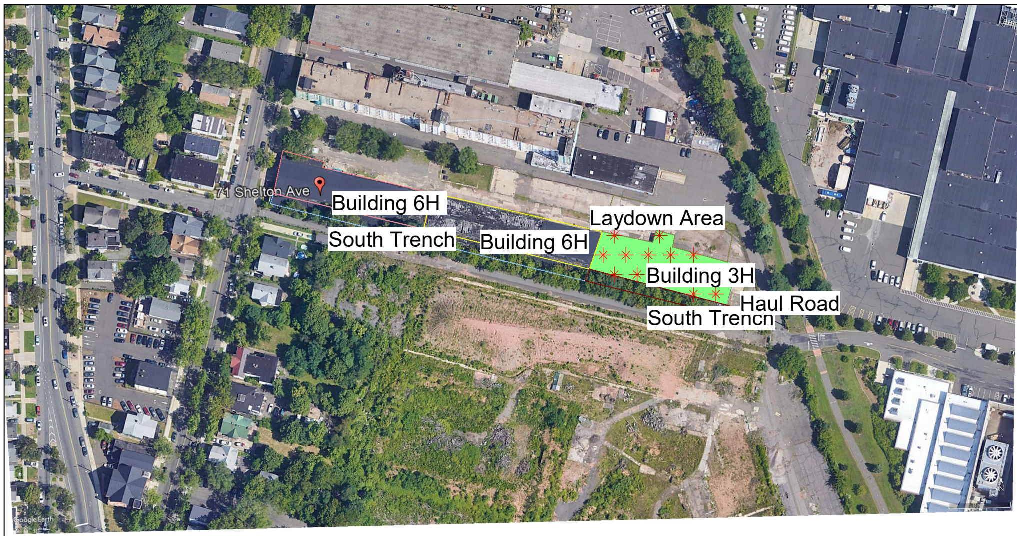
Systematic sampling locations for comparing a median with a fixed threshold (nonparametric - MARSSIM - Surface Soil Unity Rule)

Summary
This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed. A figure that shows sampling locations in the field and a table that lists sampling location coordinates are also provided below.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean or median to a fixed threshold
Type of Sampling Design	Nonparametric
Sample Placement (Location) in the Field	Systematic with a random start location
Working (Null) Hypothesis	The median(mean) value at the site exceeds the threshold
Formula for calculating number of sampling locations	Sign Test - MARSSIM version for Soil Surface
Calculated number of samples	11
Number of samples adjusted for EMC	11
Number of samples with MARSSIM Overage	14
Number of samples on map [a]	15
Number of selected sample areas [b]	1
Specified sampling area [c]	1480.35 m^2
Size of grid / Area of grid cell [d]	36.2525 feet / 1138.17 ft^2
Grid pattern	Triangular

[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.
[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.
[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.
[d] Size of grid / Area of grid gives the linear and square dimensions of the grid used to systematically place samples. If there was more than one sample area, this represents the largest dimensions used.



Area: Building 3H							
X Coord	Y Coord	Label	Value	Type	Historical	Ref/Surv	Sample Area
673124.2226	4576784.2475			Systematic		Undefined	
673135.2724	4576784.2475			Systematic		Undefined	
673085.5485	4576793.8168			Systematic		Undefined	
673096.5982	4576793.8168			Systematic		Undefined	
673107.6480	4576793.8168			Systematic		Undefined	
673118.6978	4576793.8168			Systematic		Undefined	
673129.7475	4576793.8168			Systematic		Undefined	
673140.7973	4576793.8168			Systematic		Undefined	
673080.0236	4576803.3862			Systematic		Undefined	
673091.0734	4576803.3862			Systematic		Undefined	
673102.1231	4576803.3862			Systematic		Undefined	
673113.1729	4576803.3862			Systematic		Undefined	
673124.2226	4576803.3862			Systematic		Undefined	
673085.5485	4576812.9556			Systematic		Undefined	
673107.6480	4576812.9556			Systematic		Undefined	

Primary Sampling Objective
The primary purpose of sampling at this site is to compare a site median or mean value with a fixed threshold. The working hypothesis (or 'null' hypothesis) is that the median(mean) value at the site is equal to or exceeds the threshold. The alternative hypothesis is that the median(mean) value is less than the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative one, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach
A nonparametric systematic sampling approach with a random start was used to determine the number of samples and to specify sampling locations. A nonparametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that typical parametric assumptions may not be true.

Both parametric and non-parametric equations rely on assumptions about the population. Typically, however,

non-parametric equations require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than if a non-parametric equation was used.

VSP offers many options to determine the locations at which measurements are made or samples are collected and subsequently measured. For this design, systematic grid point sampling was chosen. Locating the sample points systematically provides data that are all equidistant apart. This approach does not provide as much information about the spatial structure of the potential contamination as simple random sampling does. Knowledge of the spatial structure is useful for geostatistical analysis. However, it ensures that all portions of the site are equally represented. Statistical analyses of systematically collected data are valid if a random start to the grid is used.

Nuclides
The following table summarizes the analyzed nuclides.

Nuclides Analyzed by Study		
Nuclide	**$DCGL_W$** *pCi/g*	**$DCGL_{EMC}$**
EU(98.4%),TotU	435	

Number of Total Samples: Calculation Equation and Inputs
The equation used to calculate the number of samples is based on a Sign test (see PNNL 13450 for discussion). For this site, the null hypothesis is rejected in favor of the alternative one if the median(mean) is sufficiently smaller than the threshold. The number of samples to collect is calculated so that if the inputs to the equation are true, the calculated number of samples will cause the null hypothesis to be rejected.

The formula used to calculate the number of samples is:

$$n = \frac{\left(Z_{1-\alpha} + Z_{1-\beta}\right)^2}{4(SignP - 0.5)^2}$$

where

$$SignP = \Phi\left(\frac{\Delta}{S_{\text{sof}}}\right)$$

$\Phi(z)$ is the cumulative standard normal distribution on $(-\infty,z)$ (see PNNL-13450 for details),
n is the number of samples,
S_{sof} is the estimated standard deviation for the sum-of-fractions as defined in the **Unity Rule** section below
Δ is the width of the gray region,
α is the acceptable probability of incorrectly concluding the site median(mean) is less than the threshold,
β is the acceptable probability of incorrectly concluding the site median(mean) exceeds the threshold,
$Z_{1-\alpha}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is $1-\alpha$,
$Z_{1-\beta}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is $1-\beta$.

Note: MARSSIM suggests that the number of samples should be increased by at least 20% to account for missing or unusable data and uncertainty in the calculated value of n. VSP allows a user-supplied percent overage as discussed in MARSSIM (EPA 2000, p. 5-33).

The values of these inputs that result in the calculated number of sampling locations are:

n^a	n^b	n^c	Parameter					
			S_{sof}	Δ	α	β	$Z_{1-\alpha}$ [b]	$Z_{1-\beta}$ [c]
11	11	14	0.05	0.5	0.05	0.05	1.64485	1.64485

[a] The number of samples calculated by the formula.

[b] The number of samples increased by EMC calculations.
[c] The final number of samples increased by the MARSSIM Overage of 20%.
[d] This value is automatically calculated by VSP based upon the user defined value of α.
[e] This value is automatically calculated by VSP based upon the user defined value of β.

Unity Rule
VSP calculated the Mean and Standard Deviation Sum-of-Fractions using the following formulas:

$$Mean_{sof} = \frac{Mean_1}{DCGL_1} + \frac{Mean_2}{DCGL_2} + etc.,$$

$$S_{sof} = \sqrt{(\frac{S_1}{DCGL_1})^2 + (\frac{S_2}{DCGL_2})^2 + etc.},$$

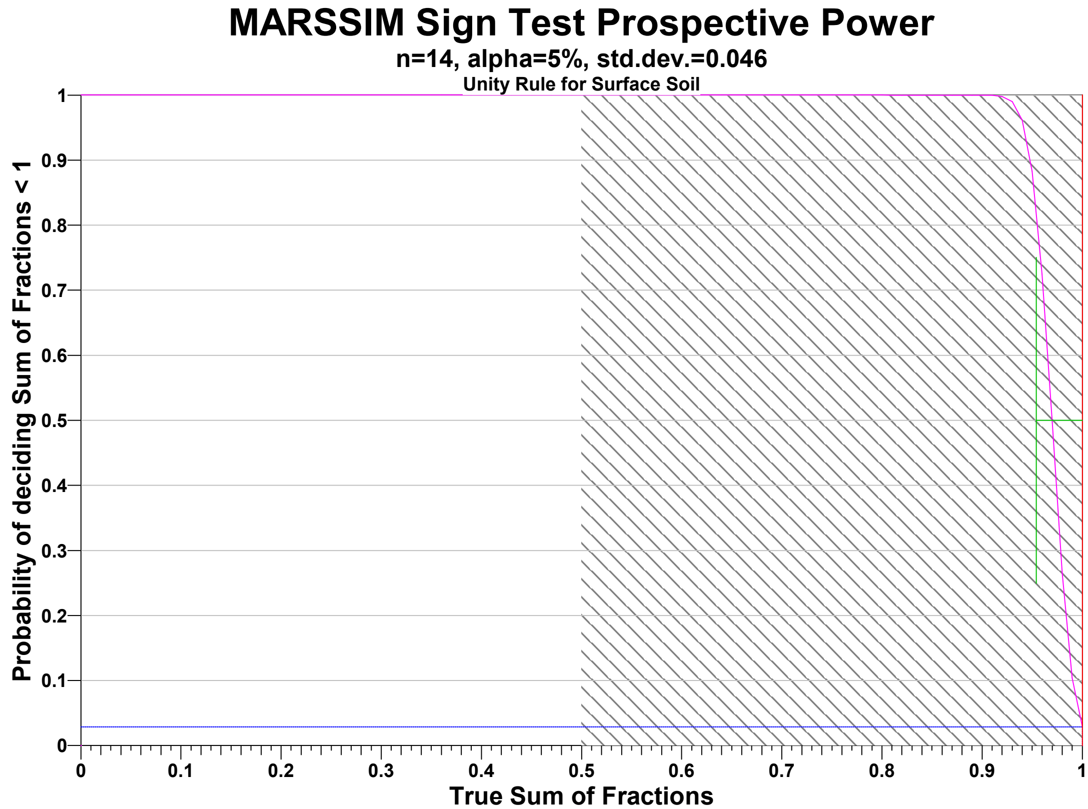
These formulas were applied to the nuclides of concern in the soil study (see the **Nuclides Analyzed by Study** table) and are summarized in following table.

Nuclide	DCGLw	Units	Mean	StdDev	$\frac{Mean}{DCGL}$	$\left(\frac{S}{DCGL}\right)^2$
EU(98.4%),TotU	435	pCi/g	0	20	0.000	0.002
Sums:						0.00
SOF:						0.05

If required, VSP adjusts the calculated number of examples upward to account for areas of elevated activity using the procedure for Elevated Measurement Comparison (EMC) discussed in MARSSIM (EPA 2000, Section 5.5.2.4).

Performance
The following figure is a performance goal diagram, described in EPA's QA/G-4 guidance (EPA, 2000). It shows the probability of concluding the sample area is dirty on the vertical axis versus a range of possible true median(mean) values for the site on the horizontal axis. This graph contains all of the inputs to the number of samples equation and pictorially represents the calculation.

The red vertical line is shown at the threshold (action limit) on the horizontal axis. The width of the gray shaded area is equal to Δ; the upper horizontal dashed blue line is positioned at 1-α on the vertical axis; the lower horizontal dashed blue line is positioned at β on the vertical axis. The vertical green line is positioned at one standard deviation below the threshold. The shape of the red curve corresponds to the estimates of variability. The calculated number of samples results in the curve that passes through the lower bound of Δ at β and the upper bound of Δ at 1-α. If any of the inputs change, the number of samples that result in the correct curve changes.



Statistical Assumptions

The assumptions associated with the formulas for computing the number of samples are:

1. the computed sign test statistic is normally distributed,
2. the variance estimate, S^2, is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected probabilistically.

The first three assumptions will be assessed in a post data collection analysis. The last assumption is valid because the gridded sample locations were selected based on a random start.

Recommended Data Analysis Activities

Post data collection activities generally follow those outlined in EPA's Guidance for Data Quality Assessment (EPA, 2000). The data analysts will become familiar with the context of the problem and goals for data collection and assessment. The data will be verified and validated before being subjected to statistical or other analyses. Graphical and analytical tools will be used to verify to the extent possible the assumptions of any statistical analyses that are performed as well as to achieve a general understanding of the data. The data will be assessed to determine whether they are adequate in both quality and quantity to support the primary objective of sampling.

Because the primary objective for sampling for this site is to compare the site median(mean) value with a threshold value, the data will be assessed in this context. Assuming the data are adequate, at least one statistical test will be done to perform a comparison between the data and the threshold of interest. Results of the exploratory and quantitative assessments of the data will be reported, along with conclusions that may be supported by them.

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