GE
Global Operations, Environment, Health & Safety

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May 29, 2020

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 revised Final Status Survey Plan (FSS Plan) for review and comment by the Nuclear Regulatory Commission (NRC). This FSS Plan has been revised to incorporate review comments by NRC and the Connecticut Department of Energy and Environmental Protection (CTDEEP) Radiation Division as communicated to GE by telephone on March 25, 2020 and later transmitted via email on April 21, 2020.

In addition to the revised FSS Plan, GE has developed a Comments Resolution document which provides responses to all comments identified in the April 20 email.

Please contact me with any comments or concerns.

Sincerely,

James W Van Nortwick, Ph.D., PE

Copies:
Greg Chandler, DOE
David Delwiche, DOE
Michael Firsick, CTDEEP
James Nuss, Arcadis
Les Skoski, Arcadis
Heather Baxter, Arcadis

Enclosures:

1. Final Status Survey Plan, Revision 1 – Former United Nuclear Corporation, Naval Products Facility, New Haven, Connecticut
2. Comments Resolution

Final Status Survey Plan, Revision 1 – 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

May 29, 2020

CONTENTS

TABLES

FIGURES

ATTACHMENTS

ACRONYMS AND ABBREVIATIONS

AAA/IEM	AAA Environmental Inc./Integrated Environmental Management, Inc.
ACM	Asbestos Containing Material
AEC	Atomic Energy Commission
cm^2	centimeters squared
DCGL or DCGLw	Derived Concentration Guideline
$DCGL_{EMC}$	Derived Concentration Guideline for elevated measurement comparisons
DQO	Data Quality Objective
EMC	elevated measurements comparison
FSP	Field Sampling Plan
FSS	Final Status Survey
GE	General Electric Company
GIS	ESRI® Geographic Information System
GPS	Global Positioning System
GWS	gamma walkover scan
H_0	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
$\mu Ci/m^2$	microcuries per square meter
NaI	sodium iodide
NRC	Nuclear Regulatory Commission
ORISE	Oak Ridge Institute of Standards and Technology
pCi/g	picocuries per gram
QA	quality assurance

QAPP	Quality Assurance Project Plan
QC	Quality Control
ROC	radionuclides of concern
ROD	Record of Decision
SNM	Special Nuclear Material
SU	survey unit
WRS	Wilcoxon Rank Sum

1 INTRODUCTION

On behalf of the United Nuclear Corporation (UNC), Arcadis US, Inc. (Arcadis) has prepared this Final Status Survey Plan (FSS Plan) for the former UNC Naval Products Facility, located at 71 Shelton Avenue in New Haven, Connecticut (property, site, or facility). The basis of this FSS Plan is to collect the necessary data to demonstrate that the remaining conditions at the property, as a result of deconstruction and off-site disposal of building debris and underlying soil, have been remediated to the level acceptable to the NRC.

1.1 Background

The facility was constructed in 1914 and was used by the Winchester Corporation Olin Mathieson Chemical Corporation – Winchester Western Division (Olin) for manufacturing firearms. In the 1950s, the facility mission was changed to the manufacture of nuclear fuel components. Olin operated the facility as a contractor from April 1956 to May 1961 and obtained an Atomic Energy Commission (AEC) (later Nuclear Regulatory Commission [NRC]) special nuclear material (SNM) license (License No. SNM-368) in October 1960 for fabrication and manufacture of highly enriched reactor fuel. The facility was transferred to UNC in May 1961 and UNC operated the facility under a new license from June 1961 to April 1976. In 1974, UNC announced the closing of the facility and the transfer of assets to their Montville, Connecticut facility. The New Haven facility was decontaminated and decommissioned between 1973 and 1976. On April 22, 1976, NRC removed the nuclear component portion, called the H tract, including Building 3H and 6H from the license. The facility was released for unrestricted use in accordance with Regulatory Guide 1.86. From 1989 to 1990, the NRC initiated a Terminated Sites Review Project to certify 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 General Electric Company (GE) in 1997, concerning residual uranium on the site (ORISE 1997). GE agreed to undertake additional remediation of the site.

Additional facility building and soil characterization was completed in 1996 and 1997 (ORISE, 1997). The analysis of soil samples showed a small number of areas that contained enriched uranium exceeding the 1981 NRC soil release criteria (30 picocuries per gram [pCi/g] total uranium). In 1998, UNC prepared and submitted a Decommissioning Plan to NRC to remediate the areas identified during the sampling effort. Additional subsurface characterization was performed in 2003 and submitted to the NRC for approval in June 2005 (UNC, 2005). In 2006, a Final Status Survey (FSS) Plan was written to conduct a radiological survey to verify that the concentration of radiological constituents at the site met the release criteria in the Decommissioning Plan (AAA/IEM, 2006). The FSS was prepared in accordance with NUREG-1575, Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) [USNRC, 2000].

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. In July 2012, UNC submitted an addendum to the 2005 Decommissioning Plan (Cabrera, 2012) that used a dose-based release criterion (i.e., 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 and the DCGLw for surfaces was based upon Regulatory Guide 1.86 Table 1 “Acceptable Surface Contamination Levels”.

Most of the areas that were evaluated and remediated after 2011 met the revised DCGLw for soils or the DCGLw for surface contamination. However, these areas were limited, did not reflect the entire site and, in part, were focused on surficial contamination (e.g. the South Trench). Additionally, 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, 2016) were performed to further characterize/remediate the site. These investigations found that further work was required to remediate the contamination inside and beneath Building 3H/6H to allow release of the building.

Based on the history, characterization studies and physical condition of the building, UNC, in conjunction with the Department of Energy (DOE), proposed to deconstruct the building and remove the debris, as well as a portion of the underlying soil (as needed). From September 2019 to May 2020, much the above-grade portion of the building and underlying soils were removed and transported off-site for disposal. All above-ground building materials (i.e., walls, roof, electrical components, structural members, and windows) have been removed and shipped for off-site disposal. Most of the building floor slabs and sub-slab foundations (both perimeter and interior) have been removed. As of this writing, remediation excavation is ongoing on the Building 6H foundation/soil and the north sewer line. The South Trench and a portion of the North Trench have been deconstructed. Concrete walls and floors associated with utility chases, catch basins and equipment foundations encountered during excavation operations are being removed. Underlying soil is being assessed to determine if further removal is required.

1.2 Previous Investigations

A number of remediation operations were completed by Cabrera from 2011 to 2012. Activities performed during the remedial actions in 2011 and 2012 included the following (Cabrera, 2018):

- Decontamination of the Argyle Street sewer and soils.
- Asbestos abatement and decontamination in South Trench, Lateral Trench and North Trench.
- Characterization of soils under the South Trench weep holes, Lateral Trench and North Trench.
- Decontamination of Small Trench (floor of Building 3H).
- Decontamination of Decon Pit soils and solid surfaces.
- Decontamination of X-Ray Read Room excavation soils and solid surfaces.
- Characterization and decontamination of Laydown and Haul Road area soils.
- On-site gamma spectroscopy sample analysis.
- Packaging and transporting waste material using intermodal containers (IMCs) for safe off-site transportation and disposal.
- FSS of decontaminated areas.
- Backfilling and Restoration of Decontaminated Areas (including, but not limited to, replacing Argyle Street sewer, restoring Argyle Street asphalt and Shelton Avenue sidewalk and roadway, and replacing a garage and driveway on a neighboring property).

These activities are documented in the Remedial Action Completion Report (RACR) (Cabrera, 2018) which includes the FSSs conducted on the aforementioned areas. While the RACR has been submitted to the NRC, it has not been accepted as a Final Status Survey to allow release of the site or the Argyle Street sewer corridor.

1.3 2019 Cleanup Plan

The 2018-2019 decision to deconstruct the building has resulted in much of the previous remediation and FSS (2011-2012) having little relevance to the current work and this FSS Plan. For example, the prior FSS conducted on the concrete surface of the South Trench is no longer relevant as the Cleanup Plan (UNC, 2019) activity removed the South Trench concrete and some underlying soils. The clean backfill used in Decon Pit and X-Ray Reading Room excavations in the prior FSS effort have been comingled with other un-remediated soils. Activities performed or to be performed during the 2019-2020 remediation included the following (UNC, 2019):

- Asbestos Abatement of Category I nonfriable asbestos containing material (ACM) (i.e. built-up roofing systems, fire door insulation, glues and mastics, floor tile, paneling).
- Asbestos Abatement of Category II friable ACM (i.e., window glazing, joint caulking, pipe, ceiling, and flange gasket insulation).
- Removal of loose paint (known or assumed to contain elevated lead concentrations).

- Removal of universal wastes (i.e., hydraulic fluids, oils, light bulbs, lamps, ballast, capacitors, biological hazards, batteries, and mercury and mercury-containing equipment).
- Excavation and removal of soils under Buildings 3H and 6H, including Decon Pit, X-Ray Reading Room, Rectifier Room and Chemistry Laboratory.
- Removal of below-grade pipes, sewer/drain lines and electrical conduits.
- Removal of North Trench, South Trench and Lateral Trench concrete and piping.
- Removal of Buildings 3H and 6H concrete slab.
- Removal of soils around the edges of vertical walls and under concrete slabs.
- Packaging and transporting waste material using IMCs for off-site transportation and disposal.
- Offsite transportation and disposal of ACM, universal waste, loose paint, concrete, soil and debris.
- Characterization and FSS of site.
- Backfilling and restoration of Decontaminated Areas.

Thus, this FSS Plan will incorporate all areas of the UNC facility and combine discussions of previous remediation activities and survey results.

1.4 Purpose and Objective

The purpose and objective of the FSS Plan is to demonstrate that the deconstruction and off-site disposal operations performed at the property complies with the NRC approved DCGLw.

1.5 Health and Safety

Site- and project-specific health and safety procedures will be followed to foster FSS activities being 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 (RSP) 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.
- 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 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 see that 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 Issue

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 sufficient quality to support an evaluation of the criteria for the property. Compliance will be satisfied based on guidance found in MARSSIM (NRC, 2000). Compliance will be demonstrated using surface gamma surveys, surface alpha surveys, systematic soil samples and bias soil samples. Soil samples will include isotopic determination of U-234, U-235, and U-238.

2.2 Inputs into the Decision

Walkover gamma surveys covering 100% of the survey unit areas will be conducted to confirm there are no elevated spots within the survey units. Residual area radioactivity levels of highly enriched uranium (HEU) will be determined by quantitative means (i.e., soil samples). Quantitative surveys provide representative data from each survey unit for comparison to the DCGLw. The results from laboratory analyses of volumetric samples and gamma counts from field surveys will be used to drive decisions.

Statistical tests will be used to determine whether specific survey units meet release criteria for residual radioactivity. Uranium isotopes (i.e., U-234, U-235, U-238) are naturally occurring and are present in the environment. The background soil concentration, which was accepted by the NRC (AAA/IEM, 2005), was 3.43 pCi/g total uranium. The background concentration is a small fraction of the remedial criterion (DCGLw = 435 pCi/g total uranium) and should not adversely impact analysis results or conclusions.

MARSSIM recommends that nonparametric statistical tests, such as the Wilcoxon Rank Sum (WRS) test or the Sign test, be used to evaluate data. According to MARSSIM, the WRS test is recommended when the contaminant is present in the background, while the Sign test is used when the contaminant is not present in the background. Since the background uranium activity (3.43 pCi/g total uranium) is less than 1% of the DCGLw, the impact of the background concentration is negligible. This leads to the Sign test, rather than the WRS test, being used to demonstrate compliance with the remediation criteria. The Sign test will be used to compare each survey unit directly with the DCGLw. If all measurements are less than the DCGLw, then the survey unit meets the release criteria. If the median of the measurements is greater than the DCGLw, then the survey unit does not meet release criteria and further remediation will be required. For any measurement greater than the DCGLw, even if the overall average is less than the DCGLw, an elevated measurement comparison will be performed. (See Section 5.5 for further details.)

2.2.1 Radionuclides of concern

License No. SNM-368 authorized the use of enriched uranium (greater than 97% uranium-235), natural uranium, depleted uranium and thorium for research and nuclear fuel fabrication. Of these, thorium is dismissed as a ROC because the historical usage of thorium on-site was limited. Thus, HEU is the primary ROC for the site. HEU comprises uranium-234 (U-234), uranium-235 (U-235), and uranium-238 (U-238). HEU comprises a higher percentage of uranium-235 compared with natural uranium. When uranium is enriched to create HEU, the process separates uranium from its daughter products. Unlike natural uranium, HEU is not in secular equilibrium with its daughter products and monitoring for the daughter products is not necessary. The ROCs considered during the DCGLw determination for the FSS were total uranium (containing U-234, U-235, U-238).

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 pCi/g total uranium for the site (SECY 81-0576). This criterion was used by Cabrera to evaluate residual radioactivity in the 2011-2012 decommissioning effort. After noting that residual radioactivity exceeding this criterion was potentially under the building, a new site-specific release criterion (DCGLw) based on a suburban resident scenario was requested. The doses were calculated using RESRAD and the results for 25 mrem/yr were 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 (Cabrera, 2012), where the total uranium is the sum of the concentration of U-234, U-235 and U-238. As U-234 is an alpha emitter, when gamma spectroscopy is used to quantify the total uranium, the U-234 is estimated as 27 times the U-235 concentration (ORISE, 1997).

2.2.3 Study Boundaries

The areas under consideration for the FSS include the soils under the footprint of Buildings 3H and 6H, including the former Decon Pit, X-Ray Reading Room, Rectifier Room, Chemistry Laboratory, the soils under the North, South, and Lateral Trenches, and the surface soil of the property (including the Laydown Area, Haul Route, and the former Buildings 7H, 8H, 9H, 10H, 11H, and 14H). Any remaining concrete surfaces, footings, foundations, trenches and catch basins will be scanned. The below-grade soils and ground surface along the Argyle Street sewer will be evaluated.

2.3 Data Collection Method

The concentration of residual radioactive materials in the survey units will be determined by gamma walkover survey, volumetric sampling, and analysis of surface soils, and, if required, direct surface radioactivity measurements. Direct radiation measurements will include walkover gamma surface scans of the survey units, static gross alpha scans, direct gamma surface measurements, and sampling performed on a systematic grid and required biased samples. If the Sign test indicates contamination is still present, additional remediation, in accordance with MARSSIM, will be performed.

2.4 Minimum Detectible Concentration

All radiological measuring systems (probes and ratemeters/scalers) will be selected based upon detection sensitivity to provide technically defensible results to meet the objectives of the survey. The minimum detectable concentration (MDC) is an a-priori statement of instrument sensitivity and depends upon the background counting rate, detector efficiency and counting time.

Gamma scanning surveys will be performed using a Ludlum 44-10, 2- by 2-inch sodium iodide detector, coupled with a Ludlum 2221 ratemeter (or equivalent). Per Table 6.7 of MARSSIM (NRC, 2000), the scan MDC for a 2- by 2-inch sodium iodide detector ranges from 96 pCi/g to 132 pCi/g for enriched uranium (depending on the percent enrichment).

If required, alpha/beta surface scanning surveys will be performed using a Ludlum 43-89 Alpha/Beta detector (or equivalent) with a 126 cm^2 active window. Per Table 6.4 of MARSSIM (NRC, 2000), the scan MDC for U-238 using an alpha scintillation detector with 50 cm^2 face is 90 dpm/100 cm^2. This will be lower for a larger area (126 cm^2) detector.

For volumetric samples, the lower limit of detection was consistent with the detection level needed to evaluate environmental samples. Samples will be analyzed by a vendor laboratory for U-234, U-235 and U-238 by alpha spectroscopy method DOE A-01-R and U-235 and U-238 (thorium-234) by gamma spectroscopy method DOE GA-01-R (EML300). When gamma spectroscopy method is used, the U-234 will be estimated as 27 times the U-235. Per the vendor laboratory, the lower limit of detection for uranium-isotopic determination is approximately 0.5 pCi/g.

3 SURVEY CRITERIA

3.1 Release Criteria

The objective of FSS activities is to obtain data of sufficient quality and quantity to support an evaluation that the radiological conditions of properties following remediation meet the release criteria. In order to release a property, it must be adequately demonstrated that overall radiological residual concentrations in the soils and on surfaces do not exceed the dose based DCGLw criteria. The approved DCGLw for soil is 435 pCi/g total uranium.

Currently, it is expected that all concrete structures (e.g., equipment foundations, catch basins, trench floors and walls) will be deconstructed and disposed of in a regulatorily compliant manner. Should any structure or portion thereof remain on site, it will be designated as a Class 1 area and an FSS will be conducted using the surface contamination guidance from the Fuel Cycle Policy and Guidance Directive (FC 83-23) “Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material” (NRC, 1993).

3.2 Elevated Measurement Comparison Criteria

Samples with activity concentrations of total uranium above the DCGLw (435 pCi/g total U), though unexpected, are possible. Soil samples from Class 1 survey units (SUs) that exceed the DCGLw must also be evaluated for compliance with the $DCGL_{EMC}$. MARSSIM includes the use of elevated measurement to address the concern for small areas of elevated activity by using a simple comparison to an investigation level ($DCGL_{EMC}$). The elevated measurement comparison is a statistical test for demonstrating compliance such that some small areas in a survey unit may have samples that exceed the DCGLw, yet the survey unit still meets the cleanup criteria. Therefore, both the statistically based (systematic) and biased samples exceeding the DCGLw must be compared with a $DCGL_{EMC}$ that corresponds with the size of a given area of elevated activity, defined in Equation 1 (MARSSIM Equation 8-1):

Equation 1 $$DCGL_{EMC} = DCGLw \times A_F$$

Where A_F is the area factor for the area of the systematic grid area impacted by the contamination. If a measurement exceeding the DCGLw is confirmed, the size of the area of elevated activity and the median concentration within that area of elevated activity will be determined by sampling the area of elevated contamination. NUREG-1505 Table 8.1 list various outdoor area factors for U-235 and U-238 based upon the size of the area of elevated activity (NRC, 1998)

Table 1 - Area Factors from NUREG-1505

Nuclide	10 m^2	30 m^2	100 m^2	300 m^2	1000 m^2
U-235	15.9	10.3	3.84	2.18	1.19
U-238	11.1	5.73	2.27	1.43	1.04

After the EMC calculation is completed, the elevated sample results will be evaluated using Equation 2 (MARSSIM Equation 8-2).

Equation 2
$$\frac{\delta}{DCGLw} + \frac{(average\ concentration\ in\ elevated\ area - \delta)}{(area\ factor\ for\ elevated\ area) \times DCGLw} < 1$$

Where δ is the average uranium concentration within the SU. If there is more than one elevated area, a separate term should be included for each. The survey unit will fail if the calculation result is greater than one.

3.3 Investigation Criteria

Data collected during surface gamma scans will be evaluated for further investigation. The average count rate and standard deviation will be calculated for each SU to allow evaluation of the data via z-score. Z-scores represent the number of standard deviations the data point lies from the mean, based on the following Equation 3:

Equation 3
$$Z - score = \frac{Count\ Rate - Mean\ Count\ Rate}{Count\ Rate\ Standard\ Deviation}$$

All areas exceeding three standard deviations above the mean (i.e., z-score greater than or equal to 3.0) will be flagged for further investigation. A biased sample will be collected at the location with the maximum z-score in each SU.

4 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. All impacted soil areas can be subdivided into separate SUs based upon contamination potential and size. MARSSIM defines different classes for areas with different potential for contamination that require different degrees of survey effort. Section 2.2 of MARSSIM provides the following designations.

- 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 to 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.

MARSSIM recommends limiting survey unit sizes for soils as follows:

- Class 1 up to 2,000 m^2 for open areas and 100 m^2 for structure.
- Class 2 2,000 to 10,000 m^2 for open areas and 100 to 1000 m^2 for structures.
- Class 3 no limit for open areas or structures.

Survey units were originally assigned based upon the 2006 Final Status Survey Plan Table 1 (AAA/IEM, 2006). In the 2006 FSS Plan, the areas of the site subject to decommissioning were placed into three categories: subfloor soils; indoor residues; and sewer residues. The subsurface soils under the Decon Pit, Rectifier Room, X-Ray Reading Room, Chemistry Laboratory, Buildings 3H and 6H, and Argyle Street Sewer were classified as Class 1 areas. The soil outside of the Argyle Street sewer was classified as a Class 2 area. Fill soil from previous excavations were classified as Class 3 area.

Additional areas were classified based upon the Supplemental Characterization Survey (Cabrera, 2015). The site trench soils, onsite sewer and catch basins were classified as impacted areas and were all designated as Class 1 because of the similar potential for residual contamination.

Soils under the Decon Pit, Rectifier Room, X-Ray Reading Room, Chemistry Laboratory and the Argyle Street sewer were remediated, with an FSS conducted on each and documented in the 2018 Supplemental Characterization Survey (Cabrera, 2018). An FSS on the concrete in the South Trench was also conducted as a Structural FSS. However, as total removal of the building is nearly complete, these areas, including the South Trench but excluding the Argyle Street sewer, are now incorporated as Class 1 survey units, discussed as follows and as listed in Table 2.

Table 2 - Survey Units

Survey Unit	Classification	Approximate Size ($meter^2$)[1]	Description
Argyle Street Sewer	Class 1	1,108	Subsurface soils adjacent to former Argyle Street sewer
Former Site of Building 3H Column 33 to 48	Class 1	1,585	Subsurface soils under Building 3H includes Decon Pit, Rectifier Room, X-Ray Reading Room areas
Former Site of Building 6H Center Column 14 to 33	Class 1	1,716	Subsurface soils under Building 6H includes Lateral and North Trench areas
Former Site of Building 6H West Column 1 to 14	Class 1	1,327	Subsurface soils under Building 6H includes Chemistry Laboratory and North Trench areas
Former Site of Buildings 7H, 8H, and 14H	Class 1	1,948	Surface soils under former Buildings 7H, 8H and 14H
Former Site of Buildings 9H, 10H, 11H	Class 1	1,317	Surface soils under former Building 9H offices, 10H Hot Waste Processing and 11H Metallurgy Laboratory
Laydown Area and Haul Road	Class 1	2,259	Surface soils north and east of Building 3H
Former Site of South Trench	Class 1	864	Soils underneath the former South Trench and includes weep holes from Building 3H, Building 6H, and Chemistry Laboratory and property between the South Trench and southern property line
Storm Sewer	Class 1	2,000	Soils outside of storm sewer and associated catch basins along northside of Buildings 3H and 6H. The surface soils are included in the respective surface survey unit.

Note 1 – Estimated

4.1 Class 1 Survey Units

Based on previous remediation efforts and historical records, the following seven survey units are established: Building 3H Column 33 to 48; Building 6H Center Column 14 to 33; Building 6H West Column 1 to 14; Former Site of Buildings 7H, 8H and 14H; Former Site of Buildings 9H, 10H and 11H; Laydown Area and Haul Road; and the South Trench. The size and shape of the survey units presented in Figure 4 and Table 2 are estimates. After remediation activities are completed, formal surveys, identifying the exact coordinates of each location, will be performed. The coordinates will be uploaded into an ESRI® Geographic Information System (GIS) map to obtain exact survey unit size and boundaries.

As defined in the Cleanup Plan, the impacted soils in each survey unit were excavated and packaged for disposal. The FSS for the subsurface areas will include soil scanning and sampling. Direct measurements, as described in Section 5 of this Plan, will be completed, as will analyses of discrete samples to verify the remaining areas satisfy the release criteria. Any measurement that exceeds the DCGLw or has a z-score of greater than 3, will be flagged for further investigation. The results of the investigation and any additional remediation that was performed will be included as part of this FSS.

4.2 Additional Survey Unit

Recent investigation revealed the existence of a sewer line along the north side of Buildings 3H and 6H from Shelton Avenue to the Laydown area (Storm Sewer). A section of this sewer line was identified in the 2006 Final Status Survey Plan Figure 3 (AAA/IEM, 2006). Pursuant to the 2006 Final Status Survey Plan "*the soil surrounding the sewer tile soil outside of building 3H and 6H is potentially impacted if the sewer tile was breached and leaked into the surrounding soil. The sewer tile will include soil sampling, following the remediation of the impacted residues*." Discrete samples will be collected adjacent to the sewer line and catch basins during remediation activities. Surface scans will be performed over accessible areas of open land surfaces. If areas of elevated activity are identified greater than the DCGLw, the areas will be excavated, and additional remediation will be performed.

4.3 Class 2 Survey Unit

There are no Class 2 survey units on this site.

4.4 Class 3 Survey Unit

In the 2006 Final Status Survey Plan, the clean backfill used to fill previous remediated areas, such as the area under the Decon Pit, was considered a Class 3 Survey Unit. Due to ongoing remediation and excavation activities, these soils can no longer be considered as clean fill material. Therefore, there are no class 3 survey units.

4.5 Argyle Street Sewer

Inspection activities conducted in 1997 revealed 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 Street sewer and adjacent soils were removed in 2011 - 2012 and replaced. The FSS conducted included a 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 for disposal and the sewer trench was backfilled. Cabrera used the Sign test to evaluate the sample results from the excavation spoils and subsequently disposed as clean material as reported in the 2018 Remedial Action Completion Report (Cabrera, 2018). The results from the RACR will be evaluated against the DQOs of this FSS to determine if additional sampling is required to meet the release criteria.

4.6 Background Radioactivity

Uranium isotopes (i.e., U-234, U-235 and U-238) are naturally occurring and are present in the environment. The background soil concentration was previously determined as 3.43 ±1.2 pCi/g and accepted by the NRC in 1999 (AAA/IEM, 2005).

5 SAMPLING

Once decommissioning is complete, gamma walkover surveys, volumetric sampling and analysis of surface soils and if required direct surface radioactivity measurements, will be employed to assess the quantity of residual radioactivity present at the site. The FSS data for the ROC will be compared with the release criteria presented in Section 3.1. Specifically, the DCGLw limit for uranium in the soil is 435 pCi/gram and total uranium on surfaces is less than 5,000 dpm α/100 cm^2, 1,000 dpm α/100 cm^2 for removable contamination, and a maximum of 15,000 dpm α/100 cm^2.

5.1 Define Acceptable Limits on Decision Errors

The decisions necessary to determine compliance with the soil cleanup criteria are based on statistical hypotheses. These hypotheses will be tested using data from each 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. The following discussion is based on MARSSIM (NRC, 2000).

5.1.1 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 $DCGL_W$ and meets the release criterion.

These hypotheses were chosen because the burden of proof is on the H_0. The measured median concentration in the survey unit must be less than the DCGLw in order to pass. Even if the median concentration is less than the DCGLw, an elevated measurement comparison test will be performed for any result greater than the investigation level or DCGLw to ensure the hypothesis remains satisfied.

Statistically based decisions will be utilized for evaluating whether the survey unit meets the release criteria. Statistical acceptability decisions, however, are always subject to error. Two possible error types are associated with such decisions.

The first type of decision error, called a Type I error, occurs when the H_0 is rejected even though 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 α= 0.05.

The second type of decision error, called a Type II error, occurs when the H_0 is not rejected even though 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-β. Type II errors do not cause a higher dose to future occupants, but rather cause unnecessary remediation expenses, disposal costs and project delays. For UNC site, the Type II error rate has been set as β=0.05.

5.1.2 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 (NRC, 2000).

5.2 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 (NRC, 2000).

MARSSIM provides methods to determine 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 minimum number were calculated using the equation below (equation 5-2 in MARSSIM), 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 while also allowing for possible lost or unusable data.

Equation 4, 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.

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

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 pCi/g.
- The shift (Δ) is equal to the width of the gray region (DCGL – LBGR). 435 – 217.5 = 217.5 pCi/g
- 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 provides 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 (Z_{1-a} and $Z_{1-\beta}$)

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

Results in a total of 10.82 sample points. An additional 20% (+2.16) will be added to account for sampling uncertainties, for a total of 13.96, rounded up to 14 samples.

According to MARSSIM, the MDC of the scanning unit must be below the $DCGL_{EMC}$ so that potential elevated areas are detected. The MDC for the Ludlum 44-10 sodium iodine probe is 136 pCi/gram, which is less than the required site DGCLw and $DCGL_{EMC}$ for a survey unit. Therefore, 14 sample locations are sufficiently sensitive to detect an area of elevated concentration and no additional systematic sample locations are required. Thus, the minimum number of systematic samples is 14 for each Class 1 survey unit.

5.3 Sample Collection

As noted in MARSSIM Appendix D, a triangular grid is generally 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 (PNL, 2020). The minimum number of locations for each Class 1 SU will be 14. The number of systematic samples in an SU may be increased due to grid edge effects. The locations of the sampling points may shift based on site interferences. It is also expected that all concrete slabs, floors, trench and catch basin covers, and equipment foundations will be removed for disposal. If it is decided to leave a concrete feature (e.g. equipment foundation) because discrete soil samples cannot be performed on concrete surfaces, any systematic sample point location on concrete will be obtained from soil located as close as possible to the sample point. The remaining concrete surfaces will be alpha/beta scanned and tested for removable and fixed contamination.

Prior to taking a soil sample, a one-minute gamma count of the location of the sample will be taken with a sodium iodine probe coupled to a ratemeter (e.g. Ludlum 44-10 2 x 2 sodium iodine probe coupled to a Ludlum 2221 ratemeter scaler, or equivalent). These results will be compared to the GWS (see below section 5.4).

Volumetric discrete soil samples will be taken in accordance with approved sampling procedure (see attached SOP#: WGGM-09). Generally, a single soil sample will be obtained from the surface at each sample location to a depth of two to three inches. The sample will consist of the collection of 400 to 500 grams of soil, which will be homogenized and shipped to an off-site laboratory.

Fixed and removable contamination on residual surface concrete will be taken in accordance with approved sampling procedures. In general, the surface will be brushed to remove any loose debris and dirt. The face of an alpha/beta probe will be placed over the sample location and the total counts (alpha and beta) recorded for 1 minute. Subsequently, swipe samples, using dry glass fiber filters (47 mm Whatman filters, or equivalent), will be taken over the designated surface area. The swipes will be shipped to an off-site laboratory for analysis.

Volumetric samples will be analyzed for U-234, U-235 and U-238 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, as was previously done by ORISE to estimate the U-234 activity concentration.

Swipe samples will be analyzed for total alpha and total beta using a gas proportional counter. Each observed count will be adjusted to account for the sample area, background, concrete self-absorption and detector's efficiency.

5.4 Gamma Survey

MARSSIM suggests that gamma scan surveys for Class 1 SUs be performed to cover 100 percent of the accessible areas in each SU. Class 2 and Class 3 SU 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.

GWSs will be performed to cover 100 percent of all accessible areas in each Class 1 SU.

The GWS will be conducted using a gamma survey system with sensitivity to distinguish the presence of contamination less than the DCGLw and consistent with survey equipment used by regulators (e.g. Ludlum 44-10 2 x 2 sodium iodine probe coupled to a Ludlum 2221 ratemeter scaler, or equivalent). The sample 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. Transects will be spaced six feet apart and each the length of the SU. As the field of view of the probe is about six feet, this facilitates adequate coverage of all areas. The gamma probe and rate meter/scaler are coupled to a GPS and a screen pen-based computer. All will be linked electronically to support the creation of an electronic file that records the coordinates every second, along with the surface soil gamma count rate as the transects are traversed. At the conclusion of the survey, the file is uploaded to a computer where GIS software will be used to create a spatial representation of the data (count rate).

Gamma exposure count rates will be 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 three times background, etc.) and mapped. The resulting color-coded figure will illustrate the spatial distribution of gamma counts relative to background.

In addition to the color-coded maps, z-scores will also be calculated. Areas with a z-score greater than 3 (Section 3.3) will be further investigated, and a bias soil sample will be collected for laboratory analysis.

5.5 Survey Unit Evaluation – Sign Test

Because the background natural concentration of uranium is less than 1% of the site's DCGLw, all survey units 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 survey unit will be greater than the DCGLw. This is assumed to be true unless the statistical test indicates that it should be rejected. If the null hypothesis is rejected, the survey unit "passes" the FSS and can be released for unrestricted use. 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 14. 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=1,14
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. The value of S+ is compared to the critical value. For 14 samples, the critical value is 10 (MARSSIM Appendix I Table I.3, α =0.05). If S+ is greater than the critical value (10 for this case), the null hypothesis is rejected.
6. If samples are greater than the DCGLw, then elevated measurement comparison $DCGL_{EMC}$, as discussed in section 3.2, will be used.

If the Sign test's null hypothesis is rejected and the $DCGL_{EMC}$ is less than 1, then it has been adequately demonstrated that overall radiological residual concentrations in the soil do not exceed the dose based DCGLw criteria.

6 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

6.1 QA/QC

Activities associated with this FSS will be performed in accordance with written procedures and approved protocols in order to achieve consistent, repeatable results. The site RSO will review the survey results to confirm any areas that may exhibit elevated radiation levels. This review will verify that the data are recorded in a consistent manner and are suitable for inclusion in the FSS Report.

6.2 Preparation for Surveys

GWS transects and systematic sample points will be identified prior to sampling to facilitate reproducibility of sample results. The computer code, Visual Sample Plan (VSP), will be used to select systematic sample locations within each SU. The sample locations will be marked in the field or flagged to assist sampling and confirmatory surveys (PNL, 2020).

The survey activities for each SU will begin with a GWS, conducted over 100 percent of each Class 1 SU. The surface scans will be reviewed to determine if any measurements appear to exceed the investigation criteria. Next, the VSP-identified systematic soil samples and surface direct gamma measurements will be taken. Additional biased soil samples will be obtained on any locations exceeding the investigation criteria (Section 3.3).

6.3 Field Instruments

Instruments and equipment used will meet the required minimum detectible concentration. Instruments will be operated in accordance with either written procedures or manufacturer's manuals. Current calibration will be kept onsite for review and inspection 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 foster 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. This is essentially a "drift test" to assure the instrument response is not "drifting" due to factors such as low battery voltage, light leaks, declining photomultiplier tube, or the like. QC source checks will consist of one-minute integrated counts with the designated source positioned in a reproducible geometry, performed at the designated location. Background checks will be performed in an identical fashion, but 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 ten 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 change, 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.

6.4 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.

6.5 Laboratory

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

7 REFERENCE

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SECY-81-0576, 1981, Disposal or Onsite Storage of Residual Thorium or Uranium (Either as Natural Ores or Without Daughters Present) from Past Operation. October

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UNC, 2019 Cleanup Plan Former United Nuclear Corporation Naval Products Facility, New Haven Connecticut. May 2019

FIGURES

Figure 1 - UNC New Haven Site - 71 Shelton Avenue, New Haven, Connecticut

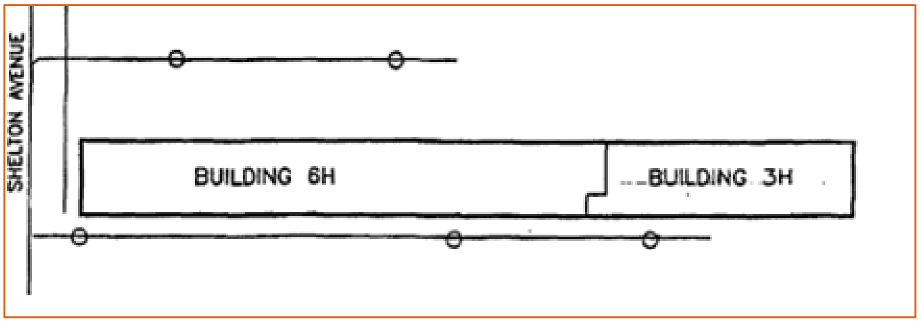

Figure 2 – UNC Buildings Sketch

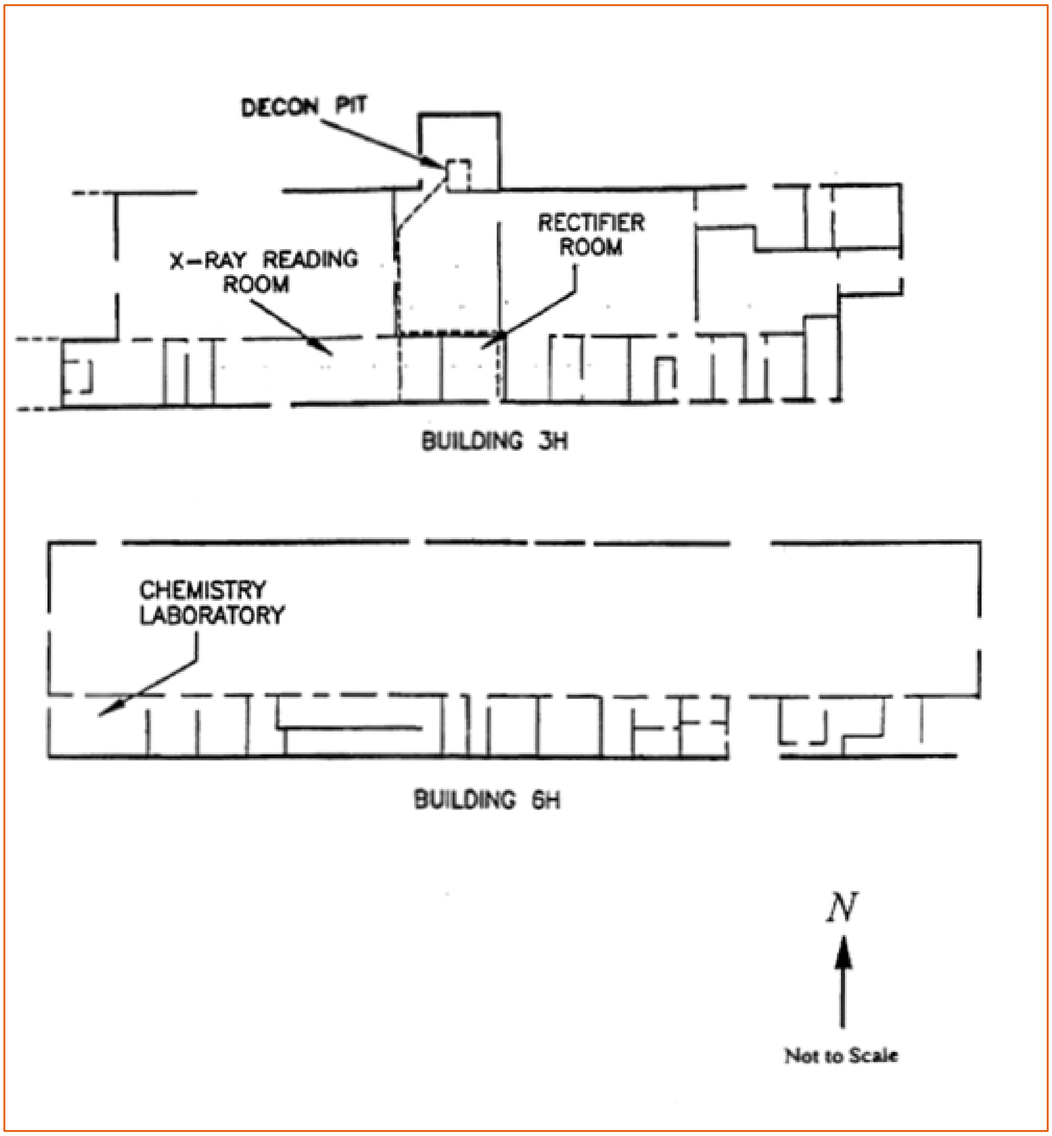

Figure 3 - Building 3H and 6H

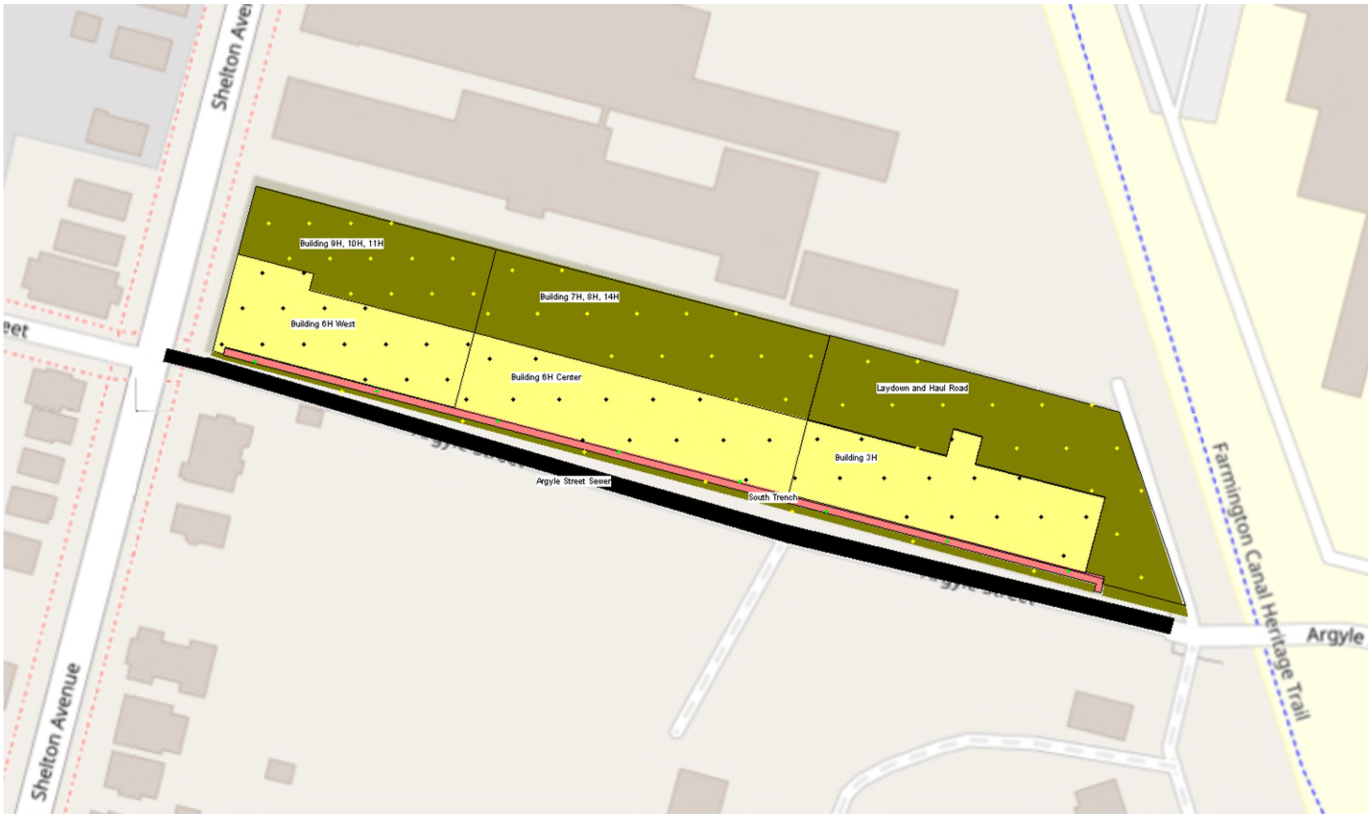

Figure 4 - Survey Units with Sample Points

The survey units are colored for visual ease where the yellow areas are the site associated with Buildings 3H and 6H, the red is the South Trench, the green is the vacant land, and the black is the Arygle Street Sewer. Systematic sample points are identified by “dots”.

ATTACHMENT

SOP #: WGGM -09

PROCEDURE FOR SHALLOW AND DEEP SUBSURFACE SOIL SAMPLING

ARCADIS Design & Consultancy for natural and built assets

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

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Reviewed by: Michael Barone — Date: 5/5/2016
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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. <u>Radiological Samples</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. 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 $\geq$ 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.

ASTM D1586. Standard Method for Penetration Test and Split-barrel Sampling of Soils. American Society for Testing and Materials, Philadelphia, Pennsylvania. September 11, 1984.

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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ATTACHMENT

Example of Visual Sample Plan Report

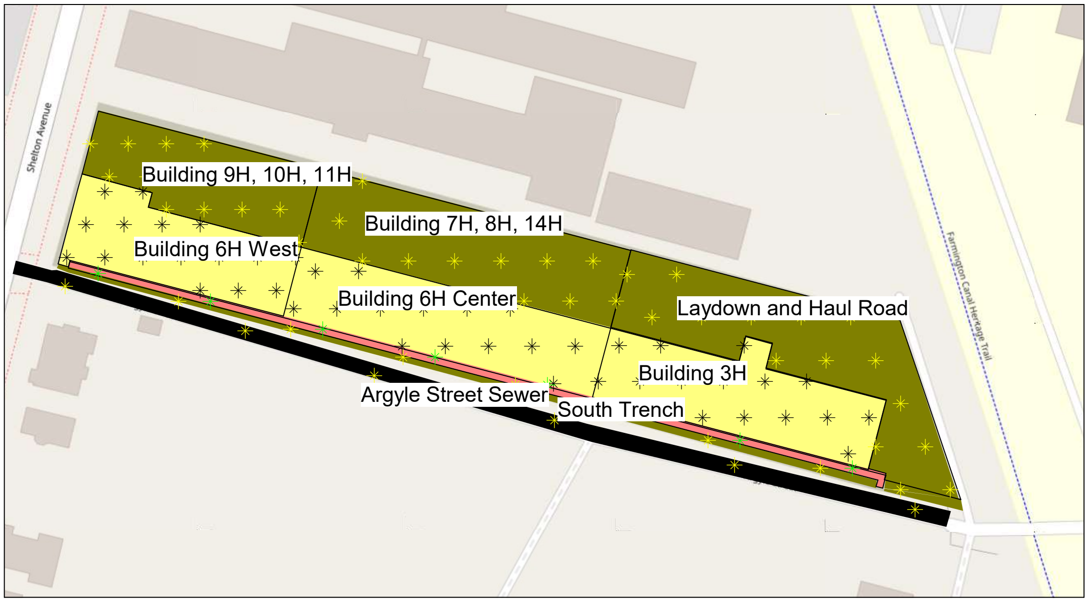
Systematic sampling locations for comparing a median with a fixed threshold (nonparametric - MARSSIM)

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 is 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
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]	111
Number of selected sample areas [b]	10
Specified sampling area [c]	131336.11 ft^2
Size of grid / Area of grid cell [d]	46.4062 feet / 1865.02 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.



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.

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

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

$\Phi(z)$ is the cumulative standard normal distribution on $(-\infty,z)$ (see PNNL-13450 for details),
n is the number of samples,
S_{total} is the estimated standard deviation of the measured values including analytical error,
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).

For each nuclide in the table, the values of these inputs that result in the calculated number of sampling locations are:

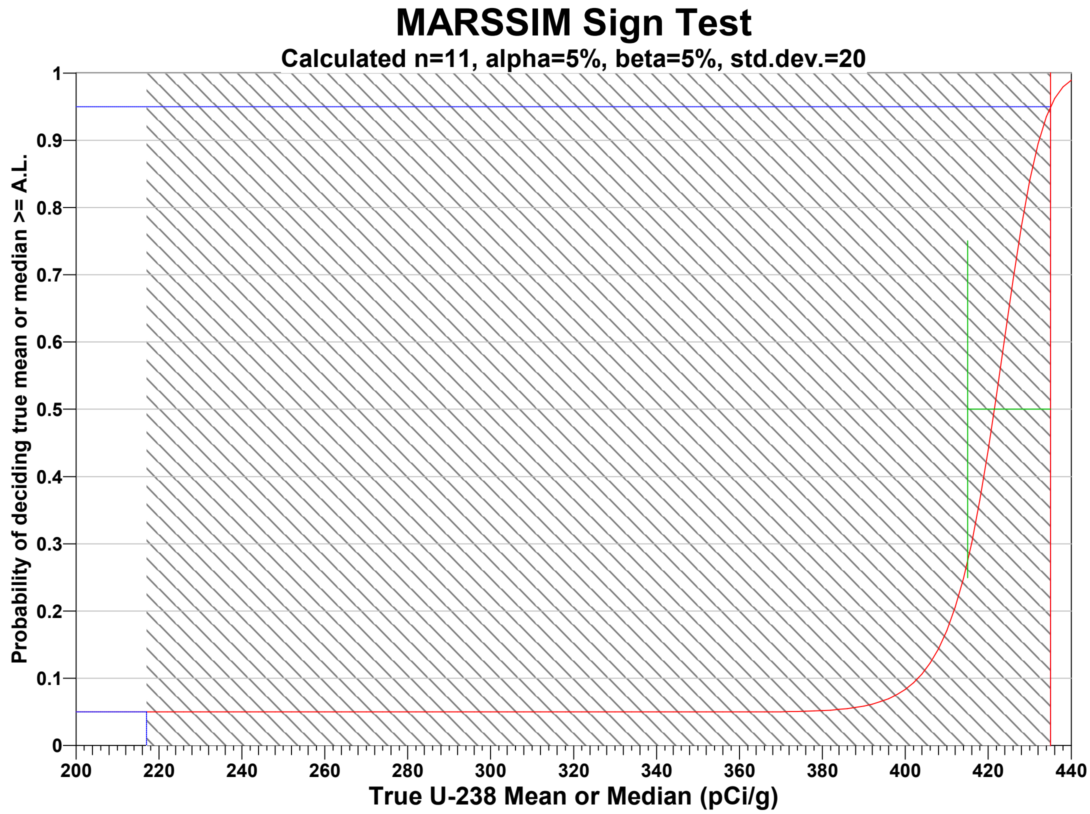
Nuclide	n[a]	n[b]	n[c]	Parameter					
				S_{total}	Δ	α	β	$Z_{1-\alpha}$ [d]	$Z_{1-\beta}$ [e]
U-238	11	11	14	20	218	0.05	0.05	1.64485	1.64485

[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.

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 $1-\alpha$ 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 $1-\alpha$. 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.

Sensitivity Analysis
The sensitivity of the calculation of number of samples was explored by varying the standard deviation, lower bound of gray region (% of action level), beta (%), probability of mistakenly concluding that μ > action level and alpha (%), probability of mistakenly concluding that μ < action level. The following table shows the results of this analysis.

Number of Samples							
AL=435		α=5		α=10		α=15	
		s=40	s=20	s=40	s=20	s=40	s=20
LBGR=90	β=5	26	15	21	12	17	10
	β=10	21	12	16	9	14	8
	β=15	17	10	14	8	11	6
LBGR=80	β=5	15	14	12	11	10	10
	β=10	12	11	9	9	8	8
	β=15	10	10	8	8	6	6
LBGR=70	β=5	14	14	11	11	10	10
	β=10	11	11	9	9	8	8
	β=15	10	10	8	8	6	6

s = Standard Deviation
LBGR = Lower Bound of Gray Region (% of Action Level)
β = Beta (%), Probability of mistakenly concluding that μ > action level
α = Alpha (%), Probability of mistakenly concluding that μ < action level
AL = Action Level (Threshold)

Note: Values in table are not adjusted for EMC.

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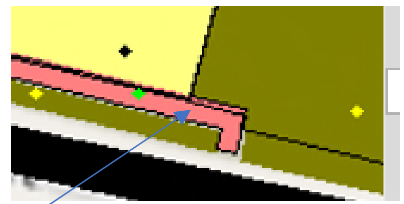
Comments Resolution

Comments	Resolution
1. It is true that the Atomic Energy Commission (AEC) (now NRC) had ‘released’ the site on April 22, 1976, utilizing Regulatory Guide 1.86 criteria, and the NRC had initiated a program in the 1990s to ensure that facilities formerly licensed through the AEC and/or early NRC had been terminated in accordance with the NRC’s current (1990s) release criteria for unrestricted use. However, because the cleanup at this site has been extraordinarily lengthy, several additional areas of the site had been identified as suspect and reinvestigated, and, as of March 2019, the cleanup plan has significantly changed and includes the deconstruction of the 3H/6H building, slab removal, and the evaluation, excavation, and removal of any contaminated soil, the NRC considers the entire site to be suspect. The NRC will re-release the site after the we determine that the entire site meets the release criteria for unrestricted use. In Section 1.1, the first sentence of paragraph 4, of the final status survey plan (FSSP) states that, “The majority of the areas that were remediated and evaluated met the criteria for unrestricted radiological release.” This statement refers to the ‘release’ of the site in 1976 by the AEC, prior to the re-investigation in the 1990’s, please consider modifying this sentence to reflect the precise interpretation.	Section 1.1 Paragraph 4 (page 2): The text has been revised to more accurately reflect the status of the site prior to the current work. The phrase "criteria for unrestricted radiological release" has been changed to “*Most of the areas that were evaluated and remediated after 2011 met the revised DCGLw for soils or the DCGLw for surface contamination. However, these areas were limited, did not reflect the entire site and, in part, were focused on surficial contamination (e.g. the South Trench).* “

Comments	Resolution
a. Section 3.4 of the final status survey plan (FSSP) identifies areas of the site that are categorized as non-impacted and were reported as “clean” in the 2018 Remedial Action Completion Report (RACR). The NRC understands that several areas of the site have previously received significant investigation and the resulting data from some of these investigations are intended to support final status survey decisions. However, it is unclear if these data satisfy current project data quality objectives (DQOs) and if there are potential data gaps that should be addressed in the FSSP. Please provide detailed DQOs and describe how the data satisfies any potential data gaps that should be addressed in the FSSP. Also, to a non-technical individual, the word “clean” connotes not radiologically impacted. Please rephrase the statement to support the technical context of this cleanup project.	Section 3.4 originally discussed non-impacted areas. This section has been deleted and replaced with a revised strategy and is documented in Section 4. Buildings 9H, 10H, 11H, the Argyle Street Sewer, and the remaining 71 Shelton Area properties (Buildings 6H and 3H, the laydown area, the “decon area”, etc.) have been incorporated into a set of eight Class 1 survey units. These are presented in section 4.0 of the revised FSS and listed in Table 2 (page 11).
b. Section 3.4 As part of the radiation site survey and investigation (RSSI) process, the entirety of the subject site starts as an impacted Class 1 area, as recommended by MARSSIM. Throughout the phases of the RSSI process, the site is portioned into survey units (SUs) and classification is reduced based on supporting evidence. Area classifications can be fluid until the FSS, and should not downgraded during the FSS. Your FSSP does not provide justification, or reference appropriate supporting documents, of the non-impacted designation of the areas identified in Section 3.4. Please provide justification, or reference appropriate supporting documents, of the non-impacted designation of the areas**.**	As discussed in the response to comment 1a the site has been classified as a set of eight Class 1 areas. Each area will undergo an FSS. As noted in the above response this will assure all site areas are addressed.

Comments	Resolution
c. Section 3.4.1 of the FSSP states that core bores in the footprint area of the former building 9H (offices), 10H (hot waste processing), 11H (metallurgy laboratory) had been sampled and analyzed. The previous service provider reported the highest activity to be 3.25 picoCuries per gram (pCi/g) total uranium, which is less than the DCGLw of 435 pCi/g. In this section, you stated that the area was disposed as “clean” in the 2018 RACR. As discussed above, please rephrase the word “clean” and clearly state if soil samples might be collected and analyzed as a result of the gamma walk-over survey.	Section 3.4 originally discussed non-impacted areas. This section has been deleted and replaced with a revised strategy and is documented in Section 4. Buildings 9H, 10H, 11H, the Argyle Street Sewer, and the remaining 71 Shelton Area properties (Buildings 6H and 3H, the laydown area, the “decon area”, etc.) have been incorporated into a set of eight Class 1 survey units. These are presented in section 4.0 of the revised FSS and listed in Table 2 (page 11).
d. Section 3.4.2 of the FSSP states that the Argyle Street Sewer is a non-impacted area. However, the Argyle Street Sewer was considered as impacted. For your consideration, I have included two documents that indicate that Argyle Street Sewer was considered impacted. (Oak Ridge Institute for Science and Education (ORISE), Final Report-Radiological Scoping Survey of Buildings 3H and 6H at the Former UNC H-Tract Facility, New Haven, Connecticut (CT), letter dated February 13, 1997 (ADAMS Accession No.: ML110120443) and UNC Characterization Plan and Decommissioning Plan, dated August 14, 1998 (ML12069A047).)	As discussed in the response to comment 1a the site has been classified as a set of eight Class 1 areas.

Comments	Resolution
2. The South Utility Trench extends to the East of Building 6H, as indicated in Figure 4-1 of the RACR and provided below. However, the FSSP does not address this section of the trench. Please include this portion of the trench within the study boundaries.	As shown in Figure 4 of the revise FSS Plan - the South Trench was extended beyond the end of Building 3H to the property line. A portion of the figure is shown below.  South Trench
3. Section 4.3 indicates that a z-score will be determined for each data point collected during the gamma walkover survey. However, this section is titled Sample Collection. Section 4.1 states that the post-processed gamma survey data will be binned and graphically presented based on a multiple of background. Additionally, the investigation level presented in each section are different (gamma response greater than 4 times background in Section 4.1, and areas with a z-score greater than 3 in section 4.3). Please clarify the application of the z-score in Section 4.3, and address the discrepancy between investigation levels presented in Section 4.1 and 4.3. Also, clarify how the scan data assessment methods are intended to identify areas of elevated activity.	See section 3.3 "Investigation Criteria"- the discrepancy was removed. Gamma counts as multiples of background will be used to produce maps to illustrate spatial distribution of the gamma counts. Separately, the z score for each gamma count will also be calculated. Biased soil sampling will depend on the z scores. As noted in section 3.3 biased soil samples will be collected at those points with z scores greater than three (3).

Comments	Resolution
4. MARSSIM guidance states that the actual scan minimum detectable concentration (MDC) ($MDC_{Scan, Actual}$) must be less than the required scan MDC ($MDC_{Scan, Required}$) for Class 1 SUs. The $MDC_{Scan, Required}$ is typically based on the DCGL for an elevated area of contamination (i.e. the $DCGL_{EMC}$). The FSSP does not present area factors, therefore, the $MDC_{Scan, Required}$ is the $DCGL_{W}$ for total uranium. The FSSP should demonstrate that the selected instrumentation is capable of detecting contaminant concentrations at or below the $DCGL_{W}$. NUREG-1507 presents an industry and regulatory accepted methodology for determining scan sensitivities of typical field instruments. Additionally, the NUREG-1507 scan MDC paradigm is based on the surveyor monitoring the audio output of the instrument and making real-time decisions related to the presence of contamination. This paradigm is not applicable when investigation decisions are based solely on post-processed GIS scan data. The scan data assessment methods discussed in the previous comment do not demonstrate that the selected instrumentation and scan procedure will be sufficient to identify discrete locations of contamination at concentrations equal to the $DCGL_{W}$. Please provide information related to scan sensitivity of the instrumentation selected for gamma walkover surveys.	Section 2.4 Minimum Detectable Concentration (MDC) (page 7) was added to the text which discusses the detector's ability to detect elevated areas of total uranium. As noted, the scan MDC for a 2- by 2-inch sodium iodide detector ranges from 96 to 132 pCi/g for enriched uranium (depending on the percent enrichment). This limit is about three times lower than the DCGLw of 435 pCi/g total uranium. Lower Limit of detection for laboratory analysis of uranium is 0.5 pCi/gram for gamma spectroscopy and alpha spectroscopy. Also to Section 5.2 (last paragraph, page 16) the following was added "*According to MARSSIM, the MDC of the scanning unit must be below the $DCGL_{EMC}$ so that potential elevated areas are detected. The MDC for the Ludlum 44-10 sodium iodine probe is 136 pCi/gram, which is less than the required site DGCLw and $DCGL_{EMC}$ for a survey unit. Therefore, 14 sample locations are sufficiently sensitive to detect an area of elevated concentration and no additional systematic sample locations are required. Thus, the minimum number of systematic samples is 14 for each Class 1 survey unit.*" Lastly, our surveyors are trained to respond to changes in the audio from the gamma survey meter so that elevated areas are detected in real-time.

Comments	Resolution
5. The FSSP does not address actions for areas above the $DCGL_W$. Section 4.4 discusses the application of the Sign test and states “Note that if all the samples are less than the $DCGL_W$ no further evaluation is required as the survey unit will always pass the Sign test.” Without an elevated measurement comparison, the previous statement must always be true for the SU to pass. In other words, without a $DCGL_{EMC}$ the $DCGL_w$ is treated as a not-to-exceed value, such that all measurements must be less than the $DCGL_W$. The reviewer assumes that if a single measurement exceeds the $DCLG_W$, the SU will fail and additional actions will be taken. Please revise the plan to address the potential for individual measurements to exceed the $DCGL_W$ and the alternative actions.	Section 3.2 was added to the text which discusses elevated measurement comparisons, area factors and the equations used to determine if an area with an elevated sample (activity greater than the DCGLw) is in compliance. Section 5.5 Step 6 was added to refer to section 3.2 for Class 1 area with samples greater than the DCGLw and the requirement that the $DCGL_{EMC}$ must be less than 1. (page 19)

Comments	Resolution
6. The column labeled “Direct Measurement” in Table 3 is unclear. The term “direct measurement” is a surface activity measurement (in units of dpm/100 cm^2), that would be collected with a hand-held alpha and/or beta detector. The acronym table lists the unit dpm/100 cm^2, but no reference to these measurements are presented in the body of the plan. If surface activity measurements are to be performed as part of the FSS, then the collection, assessment, and acceptability of these data should be specified in the plan (i.e. there are no DQOs supporting surface activity measurements). Please provide supporting information in the body of the plan.	Table 1, Table 2 and Table 3 have been removed and replaced by a new Table 2 (page 11). The new Table 2 identifies the survey units with their estimated sizes. All survey units are Class 1 and all will be gamma scanned and soil samples analyzed for total uranium. Currently, it is expected that all concrete structures (e.g., equipment foundations, catch basins, trench floors and walls) will be deconstructed and disposed of in a regulatorily compliant manner. Should any structure or portion thereof remain on site, it will be designated as a Class 1 area and an FSS will be conducted using the surface contamination guidance from the Fuel Cycle Policy and Guidance Directive (FC 83-23) “Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material”. (see Section 3.1 page 8)
7. Section 2.2.2. states, “Due to analysis methodology limitation, when gamma spectroscopy was used to quantify the total U, the U-234 was estimated as 27 times the U-235 concentration.” Please include the reference for this statement.	Section 2.2.2 discusses the Derived Concentration Guideline Level. The referenced sentence was changed to “As U-234 is an alpha emitter, when gamma spectroscopy is used to quantify the total uranium, the U-234 is estimated as 27 times the U-235 concentration (ORISE 1997). “ The reference added is ORISE, 1997, 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

Comments	Resolution
8. In Section 2.2.3, the FSSP discusses a 20 foot buffer surrounding Building 3H/6H footprint and Section 3.2.1 discusses a 10 foot buffer surrounding Building 3H/6H footprint. Additionally, the buffer area is identified as a Class 1 in Table 1 and a Class 1 or 2 in Table 2. The text in Section 3.2 states the buffer area will be a Class 2. Please resolve the inconsistencies in the plan.	As discussed in the response to comment 1a the site has been classified as a set of eight Class 1 areas. These buffer areas are now included in specific Class 1 survey units. Section 2.2.3 was modified to better describe the study boundaries. The new Table 2 identifies the survey units with their estimated sizes. The size of the survey units identified in Table 2 may be adjusted due to field conditions and actual GPS coordinates. While the Laydown Area and Haul Road are estimated to be greater than 2,000 m^2, there are sixteen systematic sample points identified for this area. The density of the sample point for the Laydown Area/Haul Road is 141 m^2 (2259 m^2 /16 points) which is similar to the recommended density of sample points for the Class 1 survey unit (143 m^2) 2000 m^2/14 points]