SUPPLEMENTAL RADIOLOGICAL SURVEY PLAN – BUILDINGS 3H/6H (FLOOR SURFACES), BUILDING 3H DUCTWORK, AND FORMER BUILDINGS 9H/10H/11H (SUBSURFACE SOILS)

Site Decommissioning Former UNC Manufacturing Facility

New Haven, Connecticut

Submitted to

GENERAL ELECTRIC COMPANY
319 Great Oaks Blvd.
Albany, New York 12203

UNC Naval Products
20 Research Parkway, Unit E
Old Saybrook, Connecticut 06475

Prepared by

CABRERA SERVICES
RADIOLOGICAL• ENVIRONMENTAL• REMEDIATION

50 Founder's Plaza
Suite 207
East Hartford, CT 06108

March 2016

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF APPENDICES

LIST OF FIGURES (APPENDIX A)

1.0 INTRODUCTION

Cabrera Services Inc. (Cabrera) has been contracted by United Nuclear Corporation (UNC) Naval Products to perform a supplemental radiological survey of specific areas-of-interest at their former 71 Shelton Avenue facility in New Haven, Connecticut, hereafter referred to as the "Site". The purpose of this survey is to confirm & supplement past surveys and sampling efforts in two specific areas of interest:

- Accessible floor areas within the H-Tract building, known as Building 3H/6H,
- Intact ductwork within Building 3H and;
- Subsurface soils underneath former Buildings 9H/10H/11H.

The location of the Site is displayed in Figure 1 and the locations of the various buildings noted above are shown in Figure 2 (refer to Appendix A). These tasks will be completed in accordance with Cabrera's Accident Prevention Plan (APP; Cabrera, 2014a) and Nuclear Material Control and Accountability Plan (Cabrera, 2010), and Radiation Safety Program Manual, Revision 2 and license procedures (Cabrera, 2014b).

1.1 SITE DESCRIPTION AND HISTORY

The former UNC Naval Facility was originally operated by Olin Mathieson Chemical Corporation – Winchester Western Division (Olin) from April 1956 to May 31, 1961 and by UNC from June 8, 1961 to April 22, 1976. Specifically, Olin operated as a contractor from 1956 to 1960, and obtained an Atomic Energy Commission (AEC) (later United States Nuclear Regulatory Commission [USNRC]) special nuclear material license (license number SNM-368; Docket Number 07000371) in 1960 for fabrication and manufacture of reactor fuel components for the Naval Reactors Program in New Haven, CT at Building 3H/6H. On May 31, 1961, Olin transferred these assets to United Nuclear – Fuels Division. On June 8, 1961, the USNRC re-issued SNM-368 to United Nuclear – Fuels Division, which later became known as United Nuclear Corporation Naval Products (UNC). This license authorized possession and use of enriched uranium and source materials, including natural uranium, depleted uranium, and thorium for research and nuclear fuel fabrication. The radioactive material used in these operations was primarily enriched uranium and natural uranium.

In 1974, UNC announced the closing of Building 3H/6H and transferred their inventory of radioactive materials from the New Haven, CT location to the Montville, CT location. Final surveys of the New Haven facility were completed by February 1976 and the USNRC performed confirmatory surveys from March 8 to 10, 1976. On April 22, 1976, the USNRC amended the SNM-368 license to remove the New Haven facility from the license. The site was released for unrestricted use in accordance with the existing regulations and guidance.

The SNM-368 license was terminated on June 8, 1994, following the decontamination and decommissioning of the Montville site. The USNRC's guidance and criteria for release for unrestricted use, at that time, was Regulatory Guide 1.86, dated June 1974, and "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted use or Termination of Licenses for Byproduct, Source or Special Nuclear Material," dated May 3, 1973. At about the same time the SNM license was terminated, the USNRC initiated a "Terminated Sites Review Project" to ensure that formerly licensed facilities by the AEC and/or the USNRC were terminated in accordance with current USNRC criteria for release for unrestricted use. As part of the Terminated Sites Review Project, the USNRC's contractor, Oak Ridge National Laboratory, identified the retired SNM-368 license as requiring additional review because final radiological survey records were either incomplete or inadequate. USNRC Region I staff reviewed this assessment and determined further information on this site was necessary to conclude that the facility met the current criteria for release for unrestricted use.

Therefore, the USNRC and the USNRC's contractor, Oak Ridge Institute for Science and Education (ORISE), conducted an independent measurements inspection in September 1996 using the release criteria in 1981 Branch Technical Position "Disposal or Onsite Storage of Thorium or Uranium Wastes from Past Operations", published in the Federal Register on October 23, 1981 (USNRC, 1981). The results of this inspection indicated that residual enriched uranium, in certain areas inside the building and inside a connected inactive sewer system, had exceeded the release criteria of 30 picocuries per gram (pCi/g) in soil. These contaminated areas were documented in the USNRC Inspection Report and in the ORISE "Radiological Scoping Survey of Buildings 3H and 6H at the former UNC H-Tract Facility, New Haven, Connecticut."

Based on the results of this inspection and additional information provided by UNC, the USNRC determined that more soil testing was necessary. This testing was performed by UNC on February 12, 1997. The results of the soil testing showed that a small number of local areas of soil and sediment contained enriched uranium exceeding the soil acceptance criteria established by the USNRC in 1981. These areas showed total uranium levels up to 723 pCi/g, exceeding the USNRC release criteria of 30 pCi/g. During the decontamination and decommissioning activities of 1973 to 1976 there were no published soil release criteria other than "as low as reasonably achievable" (ALARA), and meter surveys of the soil by a USNRC inspector in 1976 were found to be acceptable.

UNC developed and provided to the USNRC a characterization report that described the sampling and testing performed in 2003. A Decontamination and Decommissioning Plan was developed and submitted to the USNRC in June 2005 to remove the soil with a total uranium concentration greater than 30 pCi/g.

Limited FSS operations of impacted land areas, exterior surfaces, and structures were completed by Cabrera from 2011 to 2012. These operations provided evidence that the soils beneath utility trenches underlying Building 3H/6H required additional characterization and possibly remediation of residual radioactive contamination (refer to Figure 3, Appendix A). Cabrera investigated the extent of contamination in soil beneath the trenches in a follow-up investigation in the fall of 2014. This survey effort did not find widespread evidence of contamination exceeding the $DCGL_W$ in soils beneath the Building 3H/6H. The extent of the contamination exceeding the $DCGL_W$ is most likely limited to the areas immediately around and under drainage holes that are presented in the floor of the South Trench (Cabrera, 2015).

The site is located at 71 Shelton Avenue, New Haven, CT and consists of Building 3H/6H and a connected, but inactive, sewer system that traverses an adjacent private property line. The building is constructed of concrete floors, concrete/cinder block walls and a wooden roof. A chain link fence completely surrounds the site. The south side of the building, which borders Argyle Street, is currently owned by Olin and is overgrown with vegetation. A second chain link fence surrounds the adjacent private property. This fence separates the adjacent private property and Argyle Street. There is an inactive sewer line that lies under Argyle Street, traverses under the property line (and chain link fence) of the adjacent private residence, and ends under Shelton Avenue (refer to Figure 3, Appendix A).

1.2 RADIONUCLIDES OF CONCERN

Table 1 presents the radionuclides of concern (ROCs) for the Site. Thorium was dismissed as a radionuclide of concern through the use of process knowledge; process knowledge confirmed that the historic use of thorium on-site was far too limited to consider it a radionuclide of concern.

TABLE 1. RADIONUCLIDES OF CONCERN

Radionuclide	Half-Life	Principal Emissions
Uranium-234	2.45E+05 years	4.72, 4.77 MeV alpha; 0.053 MeV gamma
Uranium-235	7.04E+08 years	4.39, 4.36 MeV alpha; 0.18, 0.14 MeV gamma
Uranium-238	4.47E+09 years	4.19, 4.14 MeV alpha; 0.049 MeV gamma
MeV = mega-electron-volt		

1.3 PURPOSE

The purpose of this survey is to confirm & supplement past surveys and sampling efforts in three specific areas of interest:

- Radiation & Contamination measurements of accessible floor areas within Building 3H/6H for indications of elevated residual alpha, beta, and gamma radioactivity,
- Radiation & Contamination measurements of intact portions of the ductwork system used within the footprint of Building 3H (Building 3H was the location of fuel fabrication operations [USNRC, 1976]) (intact portions of the ductwork system are shown in Figure 2, Appendix A);
- Collection of subsurface soil samples using direct-push sampling methods and gamma logging technologies within the footprint of former Buildings 9H/10H/11H.

These survey results data may be used by UNC and Site stakeholders to augment and/or confirm historical measurements and support future site characterization, remediation, or release decisions.

2.0 DATA QUALITY OBJECTIVES

This supplemental survey was developed in accordance with the guidance presented in MARSSIM (MARSSIM, 2000) in order to follow the Data Quality Objective (DQO) process. The DQO process is meant to assure that the type, quantity, and quality of environmental data collected in decision making will be appropriate to substantiate stakeholder decisions. It provides systematic procedures for defining the criteria that the survey design should satisfy, including when and where to perform measurements, the level of decision errors for the survey, and how many measurements to perform. The DQOs for the site are to obtain data of sufficient quality and quantity to prove, within a specified degree of confidence, that residual radioactivity levels on the floor of Building 3H/6H and in soils found within the former Building 9H/10H/11H footprint are less than the release criteria.

The following sections describe inputs into the design of this supplemental survey, including:

- Detailed DQOs
- Survey planning parameters
- Instrumentation
- Measurement and sampling procedures
- Data quality assessments (DQAs)

DQOs define the purpose of this supplemental survey, identify the data needed to satisfy the purpose, and specify the performance requirements for the quality of information to be obtained from the data. The DQO process consisted of the following steps (U.S. Environmental Protection Agency [USEPA], 2006):

1. State the problem,
2. Identify the decision,
3. Identify inputs to the decision,
4. Define the study boundaries,
5. Develop the decision rule,
6. Specify tolerable limits on decision errors, and
7. Optimize the design.

2.1 STEP 1: STATE THE PROBLEM

Historic operations at the Site utilized high enriched uranium (HEU), which produces alpha, beta, and gamma radiation. Subsequent to the termination of the AEC/USNRC materials license, residual radioactivity was discovered on-site in the subsurface. The presence of residual subsurface radioactivity triggers the need to perform supplemental data collection efforts in other previously released areas of the Site; areas where residual radioactivity could be present and stakeholders have expressed specific concerns about. Residual radioactivity left on-site above applicable criteria could lead to unacceptable risk for health effects to future site occupants.

2.2 STEP 2: IDENTIFY THE DECISION

The objective of this step is to develop decision statements that required site data to address the problem statement above.

2.2.1 Principal Study Question

Does residual radioactivity remain above the release criteria for the areas of interest?

2.2.2 Decision Statements

1. Determine whether ROC concentrations on the floor of Building 3H/6H exceed the site surficial release criteria used to terminate the USNRC license in 1976 (i.e., USNRC Regulatory Guide 1.86, USNRC, 1974).
2. Determine whether ROC concentrations within intact portions of the ductwork system within Building 3H exceed the site surficial release criteria used to terminate the USNRC license in 1976 (i.e., USNRC Regulatory Guide 1.86, USNRC, 1974).
3. Determine whether soil ROC concentrations within the former Building 9H/10H/11H footprint exceed the volumetric release criteria of 435 pCi/g established using RESRAD modeling and the State of Connecticut unrestricted release criteria of 19 millirem per year (mrem/yr) (AAA/IEM, 2008).

2.3 STEP 3: IDENTIFY INPUTS TO THE DECISION

The objective of this section is to identify the informational inputs required to resolve the decision statements identified above. This section also describes the sources of those inputs, which inputs require environmental measurements, and discusses how the required inputs were obtained. The following site characteristics were determined to resolve the applicable decision statements.

2.3.1 Building 3H/6H Floor

Residual radioactivity on or embedded within the immediate surface of floors within Building 3H/6H will be determined as follows:

- “Indoor” 100% gamma walkover survey of readily accessible building areas using portable sodium-iodide detectors to identify any potential deposits of volumetric residual radioactivity otherwise attenuated from detection using alpha-beta surface scan survey instruments. Results are typically reported in units of counts per minute (cpm) or microroentgen per hour (uR/h).
- General scanning of accessible as-found floor areas (minimum 10% overall) to look for indications of residual surface radioactivity above the $DCGL_W$. Results are typically reported in units of disintegrations per minute per 100 square centimeters (dpm/100cm^2).
- Collection of unbiased static measurements and smears at floor surface locations to assess residual radioactivity summary statistics within each survey unit. Results are typically reported in units of dpm/100cm^2.
- Collection of static measurements and smears on floor surfaces at biased sentinel locations to follow-up on unexplained abnormally elevated readings identified from surface scan and/or gamma walkover surveys.
- Dose equivalent rate measurements (~one meter above floor) at each static measurement location to assess whole-body radiation levels within the building from any remaining residual or naturally-occurring radioactivity present in building materials/surfaces.

Note that dose equivalent rate measurements will be performed because:

1. The 1976 survey (USNRC, 1976) included beta/gamma data in units of millirad per hour (mrad/hr) for each 10 square foot area, and we intend to provide confirmatory data to compliment that data set in accessible areas.
2. The USNRC favors the performance of dose rate measurements with building surveys as confirmation that no large gamma radiation fields are present that may affect alpha/beta instrument backgrounds.

2.3.2 Building 3H Ductwork System

Residual radioactivity on intact ductwork system surfaces within Building 3H will be determined as follows:

- General scanning of surfaces from all accessible ductwork openings, junction boxes, blowers, and any other remaining air moving equipment associated with the ductwork system to look for indications of residual surface radioactivity above the $DCGL_W$. Results are typically reported in units of dpm/100cm^2.
- Collection of static measurements and smears from all accessible ductwork openings, junction boxes, blowers, and any other remaining air moving equipment associated with the ductwork system at biased sentinel locations to follow-up on highest readings identified from surface scan surveys.

Note that the intact ductwork system was not used to exhaust air from within Building 3H; that system was removed previously (USNRC, 1996).

2.3.3 Former 9H/10H/11H Building Locations

Residual radioactivity comingled in soils in/below the backfilled basements associated with former Building 9H/10H/11H will be determined by means of:

- Downhole gamma measurements at soil boring locations to identify depth intervals containing potential deposits of volumetric residual radioactivity surrounding the soil boring location (soil conditions permitting)
- Direct gamma scanning of soil recovered from soil bores to identify depth intervals containing potential deposits of volumetric residual radioactivity within the soil boring
- Volumetric sampling and analysis of discrete soil samples recovered from soil bores to further investigate depth intervals containing potential deposits of volumetric residual radioactivity as determined by either downhole or direct gamma measurements

2.4 STEP 4: DEFINE THE STUDY BOUNDARIES

The boundaries of the study include:

- Accessible floor surfaces within Building 3H/6H
- Intact ductwork system surfaces from all accessible ductwork openings, junction boxes, blowers, and any other remaining air moving equipment associated with the ductwork system within Building 3H
- Subsurface soils within the footprint of former Building 9H/10H/11H to a vertical extent of one foot below the assumed basement floor within underlying soils

Because no as-builts are available for former Building 9H/10H/11H, we are assuming the 15 foot depth will suffice to collect a sample beneath the basement floor slab. We will use augers to try to penetrate the concrete slab (if present). If the slab is thicker than anticipated or contains rebar, we will advance a hardened roller bit or steel casing using air rotary methods to ensure slab penetration is achieved. Once the slab is penetrated, a continuous soil sample will be collected from soils directly beneath the slab to a termination depth of 15 feet below ground surface (bgs).

2.5 STEP 5: DEVELOP THE DECISION RULES

2.5.1 Building 3H/6H Floor

To determine if unacceptable levels of residual surface radioactivity remain on the floor surfaces. Survey results will be compared to criteria established by AEC/USNRC for the original 1976 license termination (derived from USNRC Regulatory Guide 1.86) as follows:

- Smear results <1,000 dpm/100 cm^2 (removable alpha + removable beta)
- Static measurement results <5,000 dpm/100cm^2 (total alpha + total beta)

The gamma scan survey and integrated alpha/beta activity scan survey are intended to locate areas of elevated activity warranting additional biased static measurements/swipe tests, as determined by the Project Certified Health Physicist (Project CHP).

Whole-body dose equivalent rate measurements at static measurement locations are used to assess overall external radiation hazards for personnel accessing the building; no direct criteria comparisons are planned.

2.5.2 Building 3H Ductwork System

To determine if unacceptable levels of residual surface radioactivity remain on the intact ductwork surfaces. Survey results will be compared to criteria established by AEC/USNRC for the original 1976 license termination (derived from USNRC Regulatory Guide 1.86) as follows:

- Smear results <1,000 dpm/100 cm^2 (removable alpha + removable beta)
- Static measurement results <5,000 dpm/100cm^2 (total alpha + total beta)

2.5.3 Former 9H/10H/11H Building Locations

Decisions on whether soil sample data collected substantiate stakeholder decisions will be based on whether ROC concentrations within discrete soil samples are below the $DCGL_W$ of 435 pCi/g. Downhole gamma measurements at soil boring locations and direct gamma scanning of soil recovered from soil bores are intended to isolate soil samples with the highest instrument response for analysis and direct comparison to the soils $DCGL_W$.

2.6 STEP 6: DEFINE ACCEPTABLE DECISION ERRORS

The hypotheses tested as part of the DQO process are the Null Hypothesis and the Alternative Hypothesis.

2.6.1 Null Hypothesis

Concentrations of the ROCs at the Site exceed their respective $DCGL_W$.

2.6.2 Alternative Hypothesis

Concentrations of the ROCs at the Site do not exceed their respective $DCGL_W$.

Appendix D in MARSSIM (MARSSIM, 2000) provides a discussion regarding decision errors. This discussion includes the concept that acceptable error rates must be balanced between the need to make appropriate decisions and the financial costs of achieving high degrees of certainty.

> *Errors can be made when making site remediation decisions. The use of statistical methods allows for controlling the probability of making decision errors. When designing a statistical test, acceptable error rates for incorrectly determining that a site meets or does not meet the applicable decommissioning criteria must be specified. In determining these error rates, consideration should be given to the number of sample data points that are necessary to achieve them. Lower error rates require more measurements, but result in statistical tests of greater power and higher levels of confidence in the decisions. In setting error rates, it is important to balance the consequences of making a decision error against the cost of achieving greater certainty.*

Acceptability decisions are often made based on acceptance criteria. If the measured concentrations of a contaminant are less than the associated acceptance criteria, for example, the results can usually be accepted. In cases where data results are not so clear, statistically based decisions are necessary. 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 Null Hypothesis is rejected when it is actually true. A Type I error is sometimes called a "false positive." The probability of a Type I error is usually denoted by alpha (α). Consequences of Type I errors include higher potential doses to future site occupants than prescribed by the dose-based criterion.

The second type of decision error, called a Type II error, occurs when the Null Hypothesis is not rejected when it is actually false. A Type II error is sometimes called a "false negative." The probability of a Type II error is usually denoted by beta (β). The power of a statistical test is defined as the probability of rejecting the null hypotheses when it is false. It is numerically equal to $1-\beta$ where β is the Type II error rate. Consequences of Type II errors include unnecessary remediation expense and project delays.

For the purposes of this survey, the acceptable error rate for both Type I and Type II errors is set to five percent ($\alpha = \beta = 0.05$).

2.7 STEP 7: OPTIMIZE THE DESIGN

Appendix D in MARSSIM (MARSSIM, 2000) notes that this step is designed to produce the most resource-effective survey design that is expected to meet the DQOs, which involves reviewing the other six steps of the DQO process. This survey plan is, in itself, an optimization of previous radiological survey designs implemented at the Site; an optimization focused on filling stakeholder identified data gaps for the floors in Building 3H/6H, for the intact ductwork within Building 3H, and in the subsurface soils beneath Building 9H/10H/11H.

Optimization of this survey design included the following:

- Adding a sodium-iodide gamma walkover survey (GWS) element to the Building 3H/6H floor survey as an initial step. Although normally reserved for outdoor MARSSIM surveys, this feature was added to address stakeholder concerns and determine if any larger previously unidentified deposits of elevated residual radioactivity are present that might not otherwise be detectable due to floor surface conditions-coverings.
- Unbiased locations for each Building 3H/6H floor survey unit will be determined using a triangular systematic grid pattern with a random starting point. If an unbiased location falls in an inaccessible area, the survey team will collect the measurements at an alternate random location from within the survey unit to ensure the minimum required measurements are obtained.

3.0 SURVEY METHODOLOGY

3.1 RADIOLOGICAL SURVEY OF BUILDING 3H/6H FLOOR

Surveying the floor of Building 3H/6H will be completed using a combination of the following:

1. Gamma scan survey
2. Integrated alpha/beta activity scan survey
3. Smear, static, and dose rate measurements at systematically-determined locations
4. Smear, static, and dose rate measurements at biased locations

Cabrera performed a site visit on March 1, 2016 to assess the condition of the floors that must be surveyed and estimate how much of the floor is accessible for survey. This assessment deemed areas inaccessible based on the presence of:

1. Cars
2. Drummed materials
3. Miscellaneous trash and debris
4. Stockpiled supplies and equipment
5. ACM (asbestos-containing material) tile floors that preclude surveying the concrete floors which are the target of this supplemental survey

Site preparation (refer to Section 4.2) is anticipated to render up to approximately 50% of the Building 3H/6H floor areas accessible for survey. The accessibility of floor areas for survey is summarized in Figure 2 (refer to Appendix A).

3.1.1 Gamma Scan Survey

Gamma scan surveys will be performed over all accessible floor surfaces throughout the footprint of Building 3H/6H using a Bicron Radiation Measurement Products model G5 FIDLER (Field Instrument for Detection of Low Energy Radiation) sodium iodide detector or equivalent paired to a Ludlum model 2221 scaler/ratemeter. The survey will be performed following MARSSIM (MARSSIM, 2000) protocol by walking straight parallel lines at a speed of 0.5 meters per second over an area with the detector kept a fixed distance from the floor (i.e., a maximum of four inches above the floor). Survey passes will be approximately 1 meter apart. Data from the scaler/ratemeter will be automatically logged. Scan coverage of all accessible floor surfaces will be a minimum of 50%. Gamma raw measurement data (in counts per minute [cpm]) will be plotted for visual review and evaluation, and to identify anomalies in the distribution of measurement data. The average and standard deviation of the entire dataset will be calculated, and the locations of the highest activity measurement will be identified.

3.1.2 Integrated Alpha/Beta Scan Survey

Floor scans will be performed with portable contamination survey instruments specifically, the Ludlum 43-37 gas flow proportional “floor monitor” detector or Ludlum Model 43-93 zinc sulfide/plastic scintillator detector. The selected detector (determined based on accessibility by the field team leader) will be coupled with an appropriate scaler-ratemeter (e.g., Ludlum Models 2221, 2224, 2360, etc.) as a pre-calibrated set.

One minute long integrated alpha/beta scan measurements will be performed on accessible floor surfaces throughout the footprint of Building 3H/6H with the exception of the floors within the section of the building identified as the Fabrication Shop shown in Appendix A, Figure 2. The floors within the Fabrication Shop are particularly wet and covered with large quantities of debris including soil-like, saturated materials. Clearing this floor adequately to allow for alpha/beta scan surveys will require considerable effort that exceeds the scope of this supplemental survey. However, static unbiased measurement locations will be sufficiently cleaned to allow for their proper survey as well as surveys of any anomaly locations identified by the Project CHP after review of GWS results data.

The scaler-ratemeter will be set to a one minute count time. At the start of each measurement, the surveyor will begin the one minute count, and move the detector at a rate of approximately one detector width every two seconds. At the completion of each one-minute count, the approximate footprint covered by the integrated scan measurement will be noted and the alpha and beta result will be recorded. A minimum of 10% of all accessible floor surface will have integrated alpha/beta scan measurements performed.

The overall completeness DQO for scan surveys is 10% coverage of accessible Building 3H/6H floor surfaces; 10-50% completeness is expected.

3.1.3 Unbiased Measurement Locations

Unbiased (random) measurement locations have been assigned throughout the Building 3H/6H floor areas based on a systematic survey design (i.e., a triangular sampling grid pattern with a random starting point) (refer to Figures 4, 5, and 6, Appendix A). All systematic measurement locations that are deemed inaccessible will have new locations assigned at random within the footprint of the survey unit. The following measurements will be collected at each systematic measurement location:

1. a one-minute static measurement will be performed on contact with the floor using a Ludlum 43-37 floor monitor or Ludlum 43-93 detector coupled to a Ludlum 2360 scaler/ratemeter or equivalent
2. a smear for removable contamination will be collected and counted for one minute using a Ludlum Model 43-10-1 zinc sulfide/plastic scintillator smear counter attached to a Ludlum 2929 alpha/beta dual-scaler counters
3. a dose rate measurement will be collected at approximately one meter above the floor.

3.1.4 Biased Measurement Locations

The following measurements will be collected at each biased measurement location:

1. a one-minute static measurement will be performed on contact with the floor
2. a smear for removable contamination will be collected and counted for one minute
3. a dose rate measurement will be collected at approximately one meter above the floor

Biased measurement locations will be assigned based on:

1. Z scores equal to or greater than 3.0 obtained from the gamma scan survey (refer to Section 3.1.1)
2. Integrated scan results that exceeding the surface $DCGL_W$ (5,000 dpm/100cm^2) (Section 3.1.2)

Additional biased measurements may be performed at the direction of the field team leader or the Project CHP based on observed conditions.

3.1.4.1 Gamma Scan Survey Biased Measurements

Z scores will then be calculated for each gamma scan survey data point; a z score describes how many standard deviations above the mean (positive) or below the mean (negative) a number falls. All areas with z scores exceeding three standard deviations above the average (i.e., the z score is equal to or greater than 3.0) will be identified and one biased measurement location will be assigned for each contiguous area with a z score is equal to or greater than 3.0. Summary statistics (mean, median, and standard deviation) will be calculated separately for each survey unit.

3.1.4.2 Integrated Alpha/Beta Scan Survey Biased Measurements

Biased measurement locations will be established based on integrated scan results that exceed the 5,000 dpm/100 cm^2 surface activity $DCGL_W$. A biased measurement will be assigned for each integrated scan result where the total net activity exceeds 5,000 dpm/100 cm^2. For each integrated scan assigned for bias measurement, the field team will locate the relative maxima from the area to ensure the most conservative measurement is obtained. Conversion of measured results in counts to dpm/100 cm^2 is described below in Section 3.1.5. If no integrated scan result exceeds 5,000 dpm/100 cm^2, biased measurement locations will be selected based solely on gamma scan survey z score results or Project CHP direction.

3.1.5 Reference Areas and Background Correction

To the extent practicable, similar surface materials will be selected from the floor of the adjacent, non-impacted property, 91 Shelton Avenue. Integrated scan and static measurements will be collected from floors within that building to establish counts to subtract for each measurement to allow calculation of net dpm/100 cm^2 using an appropriate material-specific background, total instrument efficiency, and geometric factors associated with the instrumentation. Cabrera will assess what types of reference material measurements are required for comparison to concrete floor surfaces surveyed within 71 Shelton Avenue.

3.2 RADIOLOGICAL SURVEY OF BUILDING 3H DUCTWORK SYSTEM

3.2.1 Integrated Alpha/Beta Scan Survey

Ductwork scans will be performed with portable contamination survey instruments specifically, the Ludlum Model 43-93 zinc sulfide/plastic scintillator detector or equivalent. The selected detector (determined based on accessibility by the field team leader) will be coupled with an appropriate scaler-ratemeter (e.g., Ludlum Models 2221, 2224, 2360, etc.) as a pre-calibrated set.

One minute long integrated alpha/beta scan measurements will be performed on all accessible ductwork openings, junction boxes, blowers, and any other remaining air moving equipment associated with the ductwork throughout the intact sections of ductwork system (shown in Figure 2, Appendix A). The scaler-ratemeter will be set to a one minute count time. At the start of each measurement, the surveyor will begin the one minute count, and move the detector at a rate of approximately one detector width every two seconds. At the completion of each one-minute count, the approximate footprint covered by the integrated scan measurement will be noted and the alpha and beta result will be recorded.

3.2.2 Biased Measurement Locations

The following measurements will be collected at each biased measurement location:

1. a one-minute static measurement will be performed on contact with the surface
2. a smear for removable contamination will be collected and counted for one minute

Biased sentinel measurement locations will be assigned in conjunction with the highest readings identified from surface scan surveys.

3.3 SUBSURFACE RADIOLOGICAL INVESTIGATION OF FORMER BUILDING 9H/10H/11H LOCATIONS

Sentinel measurements (i.e., soil borings) will be performed within the footprints of formerly controlled areas of the basement of Building 9H/10H/11H. Based on review of gridded area results within the basement as described in Section 3.1.4.2 and identification of areas where elevated results were historically recorded, six borings will be performed within the former Metallurgy Laboratory footprint and seven borings will be performed within the former Hot Waste Processing area footprint (refer to Figure 7, Appendix A).

At each boring location, the boring will proceed until a maximum depth of 15 feet bgs is reached or to a depth of one foot below the assumed basement floor within underlying soils is encountered. Sample cores from boreholes will be scanned for beta-gamma activity to identify thin layers of elevated activity. A Bicron model G5 FIDLER sodium iodide detector or equivalent paired to a Ludlum model 2221 scaler/ratemeter will be moved over the surface of the soils slowly, with the average count rate for each approximately one foot interval recorded.

Downhole gamma logging will be performed at each borehole to provide data regarding the variation in gamma fluence with depth. A one-minute integrated measurement will be performed using a Bicron Radiation Measurement Products model G1 environmentally encapsulated one-inch by one-inch sodium iodide detector or equivalent. Measurements will be collected at approximately one foot intervals, starting at the bottom of the borehole and working toward ground surface. Each borehole will be sleeved with schedule-40, threaded Polyvinyl Chloride (PVC) pipe casing prior to insertion of the probe to prevent cave-in of sidewall soils and capture of the detector at depth. Integrated count rates in units of cpm at each borehole location will be recorded.

Direct soil core scanning and downhole gamma logging results will be compared to collectively identify the interval containing the highest observed count rate from each boring. Generally, a single soil sample will be collected from each borehole to submit to an off-site laboratory for radioanalysis. Cabrera reserves the right to keep this approach flexible should multiple intervals of interest be located within a single boring or none within a given soil boring; 15 total samples from the these 13 borings are anticipated. Soil samples will be submitted for alpha spectroscopy isotopic analysis for uranium-234, uranium-235, and uranium-238.

3.4 CLASSIFICATION AND SURVEY LEVEL OF EFFORT

3.4.1 Building 3H/6H Floor

Building 3H/6H floor survey units for this supplemental survey are designated impacted MARSSIM Class 2 to match stakeholder expectations for the level of additional survey requested. As such, the floor of Building 3H/6H measuring approximately 5,200 square meters will be broken up into approximately 1,000 square meter areas or up to six survey units.

A minimum of 10% of all accessible floor surface will have integrated alpha/beta scan measurements performed. A minimum of 50% of all accessible floor surface will receive a gamma scan survey; the gamma scan survey will provide a higher minimum percent coverage because of its higher production rate and because floor areas do not need to be cleared to allow for the gamma scan survey to proceed. Each survey unit will have 22 systematic locations assigned for consistency with the existing FSSP (AAA/IEM, 2006). Survey unit maps are provided as Figures 4, 5, and 6 (refer to Appendix A).

3.4.2 Building 3H Ductwork System

The intact portions of the ductwork system within Building 3H is considered a MARSSIM Class 3 level of effort, with sentinel measurement locations of potential interest assigned at the direction of the field team leader or the Project CHP based on process knowledge of where contaminant deposition was most likely.

3.4.3 Former 9H/10H/11H Building Locations

The footprint of former Buildings 9H/10H/11H is considered a MARSSIM Class 3 level of effort, with boring locations assigned as sentinel measurements of potential interest from past termination surveys in the now demolished buildings.

3.5 MEASUREMENT MINIMUM DETECTABLE CONCENTRATIONS

Nominal instrument minimum detectable concentrations for instrumentation are as follows:

TABLE 2. MINIMUM DETECTABLE CONCENTRATIONS

Instrument Model	Radiation Type	Background Count Time (minutes)	Sample Count Time (minutes)	Area (cm^2)	Total Eff.	Background (cpm)	Static MDC (dpm/ 100 cm^2)	Scan MDC (dpm/ 100 cm^2)
2360/43-37	alpha	1	1	582	0.06	5	38.4	54.1
2360/43-37	beta	1	1	582	0.08	500	229.9	405.9
2360/43-93	alpha	1	1	100	0.06	3	184.3	244.0
2360/43-93	beta	1	1	100	0.08	150	749.8	1,293.8
2929/43-10-1	alpha	1	1	100	0.35	0.2	14.5	N/A
2929/43-10-1	beta	1	1	100	0.2	40	162.1	N/A
N/A = not applicable								

Detailed example derivations of these values are provided as Appendix B.

4.0 FIELD IMPLEMENTATION

The following presents a listing of the work evolutions for this supplemental survey. A planned schedule of field implementation based on assumed start date of June 13, 2016 is provided as Appendix C.

4.1 MOBILIZATION

It is anticipated that the mobilization and site preparation activities will require approximately two days and will include:

- Personnel travel to the Site
- Review project plans with site personnel
- Conduct required site-specific training
- Set-up project offices and support facilities
- Performing initial quality control checks of field radiological instrumentation

4.2 SITE PREPARATION

Areas are only considered accessible for survey if all potentially hazardous conditions in the work area are adequately evaluated and addressed, permitting safe personnel access. Areas where overhead hazards are of particular concern are illustrated in Figure 8 (refer to Appendix A). Inaccessible areas of Building 3H/6H will be made accessible to the maximum extent possible by clearing debris from the floor. Efforts to expand access to floor/ductwork surfaces will be limited to debris that can be easily and safely swept or moved; any debris that is moved will be added to existing debris piles. Areas occupied by items that require greater effort to move and render the floor/ductwork accessible, such as cars and drummed chemicals, will be deemed inaccessible areas.

4.3 QUALITY ASSURANCE/QUALITY CONTROL

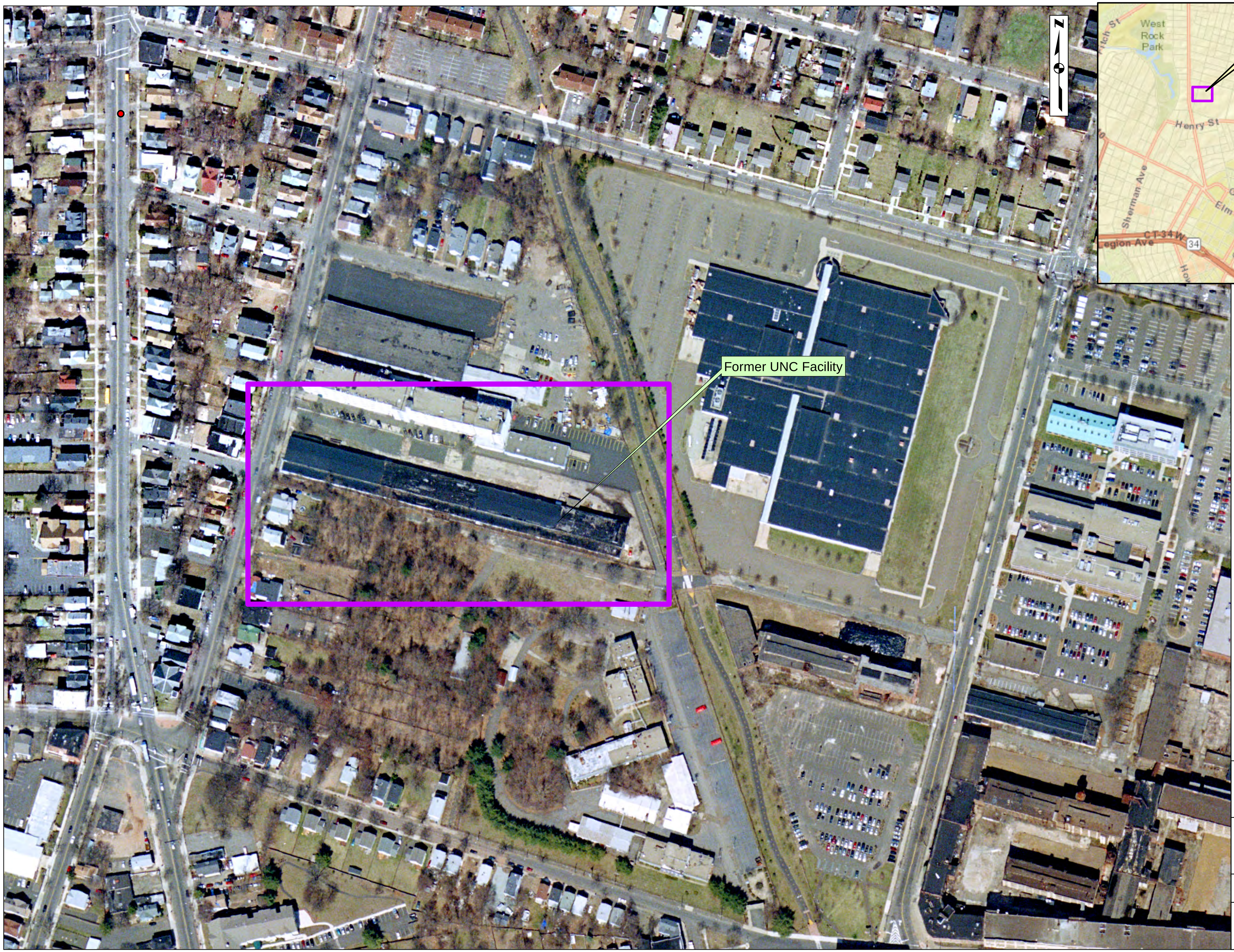
Quality control criteria established for instrumentation and daily performance checks will be conducted prior to using instrumentation on a daily basis. QC criteria will include establishing a mean source count rate using a radioactive source in a reproducible geometry, standard deviation and multiples of the standard deviation (two and three times the standard deviation of the mean) to define control limits. QC performance checks will include analysis of the check source in the same counting geometry and comparison of the result with the QC criteria. Typically, the daily performance QC checks fall within the mean plus two standard deviations which demonstrate acceptable performance. Whenever a daily performance check falls outside the mean plus two standard deviations but within the mean plus three standard deviations the result will be flagged as “questionable.” Measurements following a questionable QC measurement will be reviewed to ensure a trend adverse to performance is not occurring. Daily performance checks that fall outside the mean plus three standard deviations will result in an instrument being removed from service.

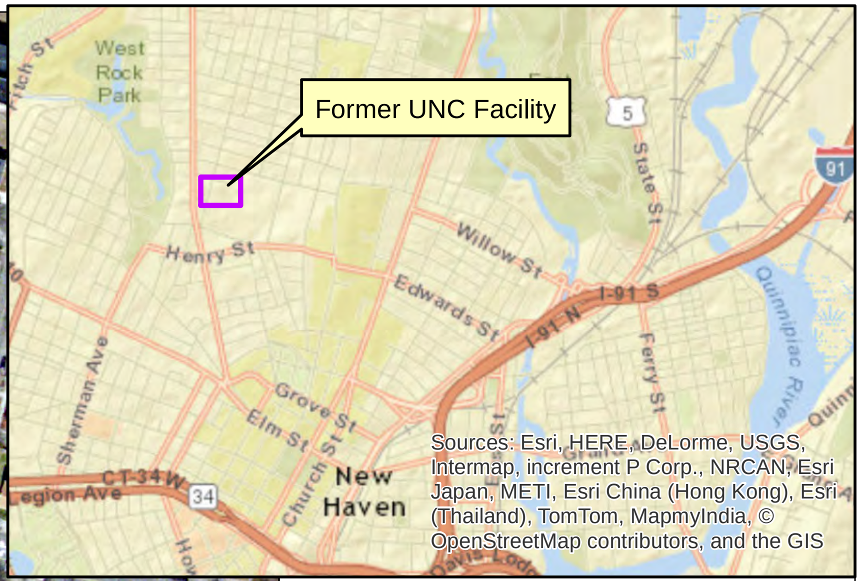
5.0 REFERENCES

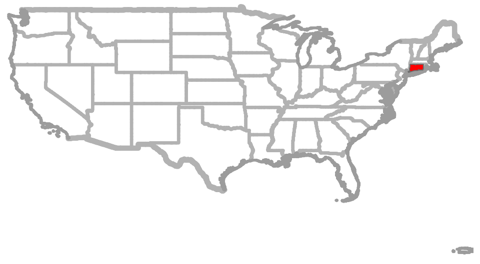
AAA/IEM, 2006	Integrated Environmental Management, Inc. Final Status Survey Plan for Decommissioning the former UNC Manufacturing Facility, New Haven, Connecticut. AAA Environmental, Inc./Integrated Environmental Management, Inc. September 6, 2006.
AAA/IEM, 2008	Integrated Environmental Management, Inc. Derived Concentration Guideline Levels for Decommissioning the former UNC Manufacturing Facility, New Haven, Connecticut. AAA Environmental, Inc./Integrated Environmental Management, Inc. June 16, 2008.
Cabrera, 2010	Nuclear Material Control and Accountability Plan. Site Decommissioning Former UNC Manufacturing Facility, New Haven, Connecticut. Cabrera Services Inc. March, 2010.
Cabrera, 2014a	Accident Prevention Plan. Site Decommissioning Former UNC Manufacturing Facility, New Haven, Connecticut. Cabrera Services Inc. 2014.
Cabrera, 2014b	Radiation Safety Program Manual, Revision 2. Cabrera Services Inc. April, 2014.
Cabrera, 2015	Characterization Survey Report. Site Decommissioning Former UNC Manufacturing Facility, New Haven, Connecticut. Cabrera Services Inc. April, 2015.
MARSSIM, 2000	Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), NUREG-1575, EPA 402-R-97-016, DOE/EH-0624, Revision 1. U.S. Department of Defense, U.S. Department of Energy, U.S. Environmental Protection Agency & U.S. Nuclear Regulatory Commission. August, 2000.
USEPA, 2006	Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA/240/B-06/001. U.S. Environmental Protection Agency. February, 2006.
USNRC, 1973	Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted use or Termination of Licenses for Byproduct, Source or Special Nuclear Material." U.S. Nuclear Regulatory Commission. May 3, 1973.
USNRC, 1974	Regulatory Guide 1.86, Termination of Operating Licenses for Nuclear Reactors. U.S. Nuclear Regulatory Commission. June, 1974.
USNRC, 1976	Final Status Survey Report After Decontamination. United Nuclear Corporation, Naval Products Division, H-Tract Facility. U.S. Nuclear Regulatory Commission. February 26, 1976.
USNRC, 1981	Branch Technical Position, Disposal or Onsite Storage of Thorium or Uranium Wastes from Past Operations. U.S. Nuclear Regulatory Commission. October, 1981.

USNRC, 1996 USNRC, Inspection Report. Former United Nuclear Corporation (UNC), Buildings 3H and 6H, 71 Shelton Avenue, New Haven, Connecticut. U.S. Nuclear Regulatory Commission. July 26, 1996.

APPENDIX A
FIGURES







Location of Connecticut

Location of Former UNC Facility

0 100 200 400

Feet

SITE LOCATION

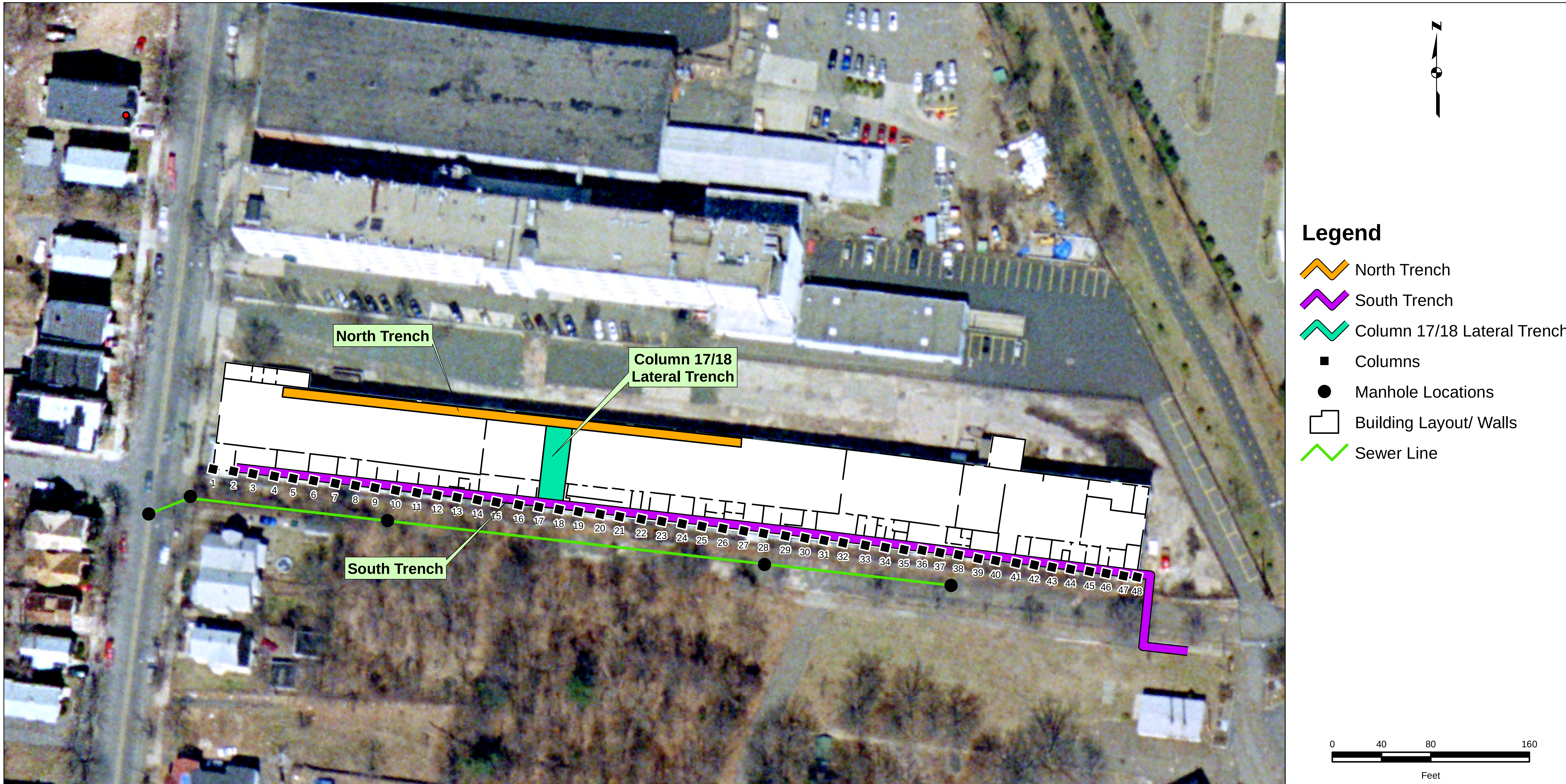
FORMER UNC FACILITY
NEW HAVEN, CONNECTICUT

2/2016	SMO	PROJECT NO. 10-1007.00	FIGURE 1
	Cabrera Services Baltimore, MD		

SITE BUILDINGS
BUILDING 3H/6H
ACCESSIBLE AREA

FORMER UNC FACILITY
NEW HAVEN, CONNECTICUT

2/2016	SMO	PROJECT NO. 10-1007.00	FIGURE 2
	Cabrera Services Baltimore, MD		



BUILDING 3H/6H UTILITY TRENCHES

FORMER UNC FACILITY NEW HAVEN, CONNECTICUT

2/2016	SMO	PROJECT NO. 10-1007.00	FIGURE 3

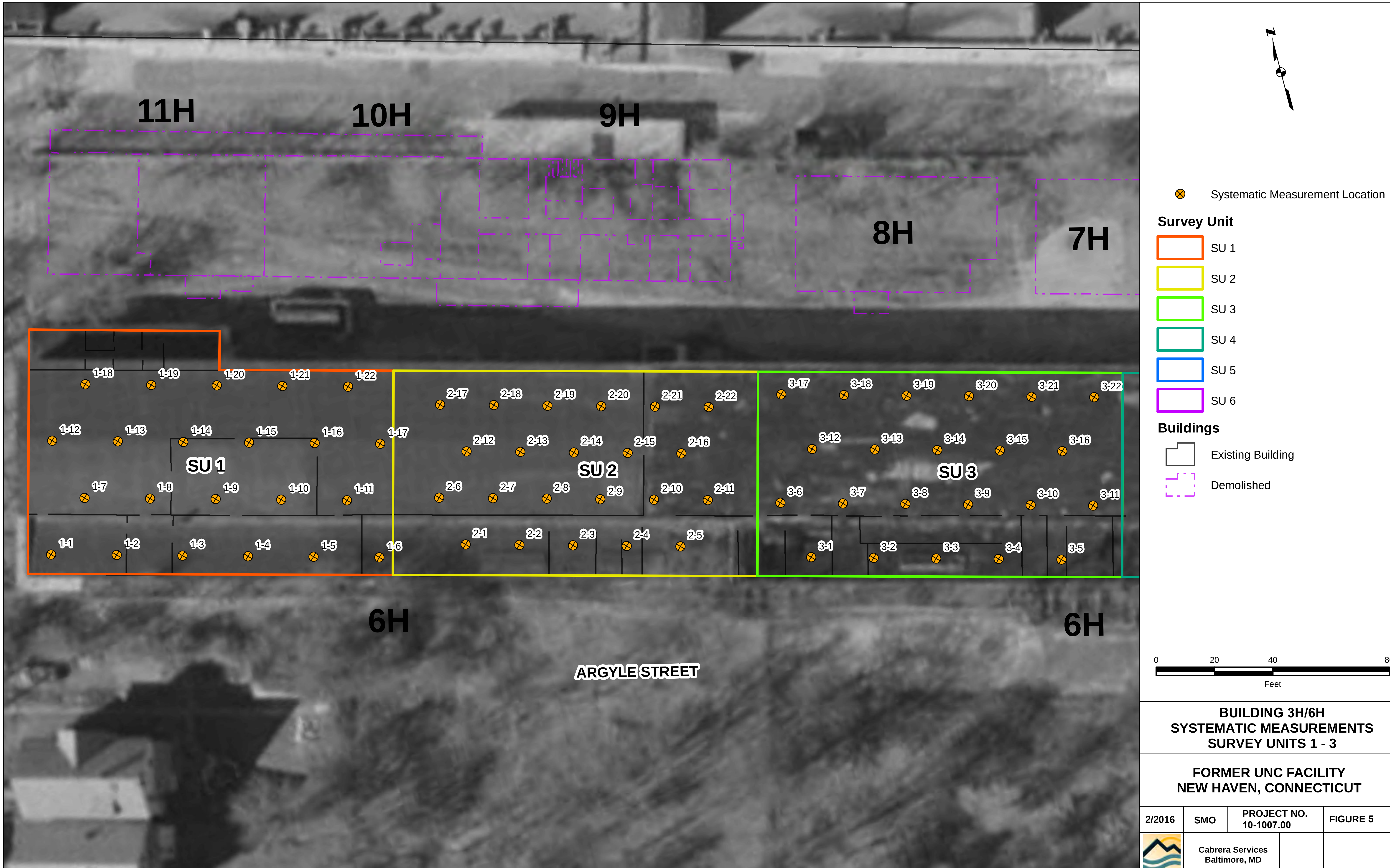
Cabrera Services
Baltimore, MD

BUILDING 3H/6H
SURVEY UNIT BOUNDARIES

FORMER UNC FACILITY
NEW HAVEN, CONNECTICUT

2/2016	SMO	PROJECT NO. 10-1007.00	FIGURE 4

Cabrera Services
Baltimore, MD

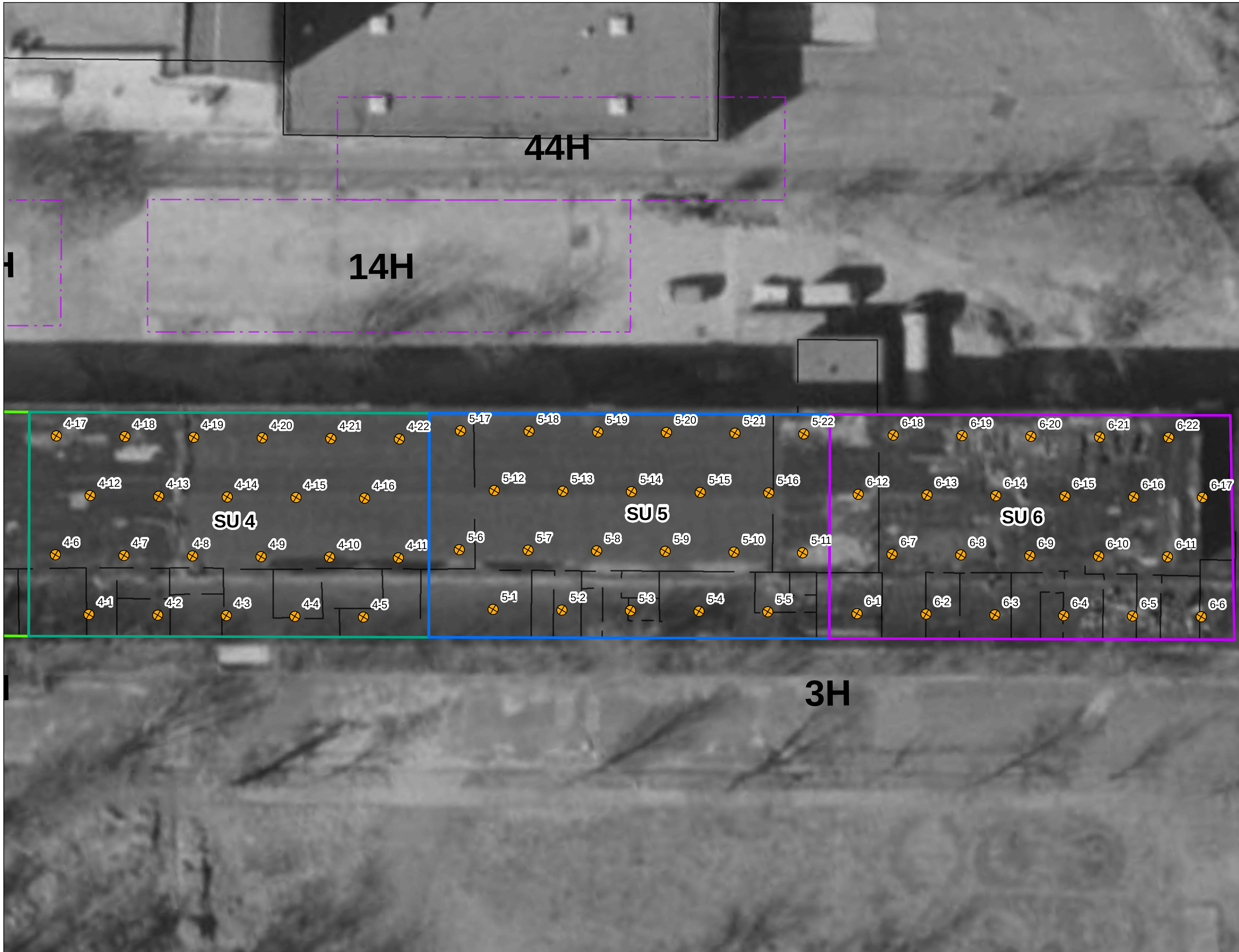


**BUILDING 3H/6H
SYSTEMATIC MEASUREMENTS
SURVEY UNITS 1 - 3**

**FORMER UNC FACILITY
NEW HAVEN, CONNECTICUT**

2/2016	SMO	PROJECT NO. 10-1007.00	FIGURE 5

Cabrera Services
Baltimore, MD



Systematic Measurement Location

Survey Unit

- SU 1
- SU 2
- SU 3
- SU 4
- SU 5
- SU 6

Buildings

- Existing Building
- Demolished

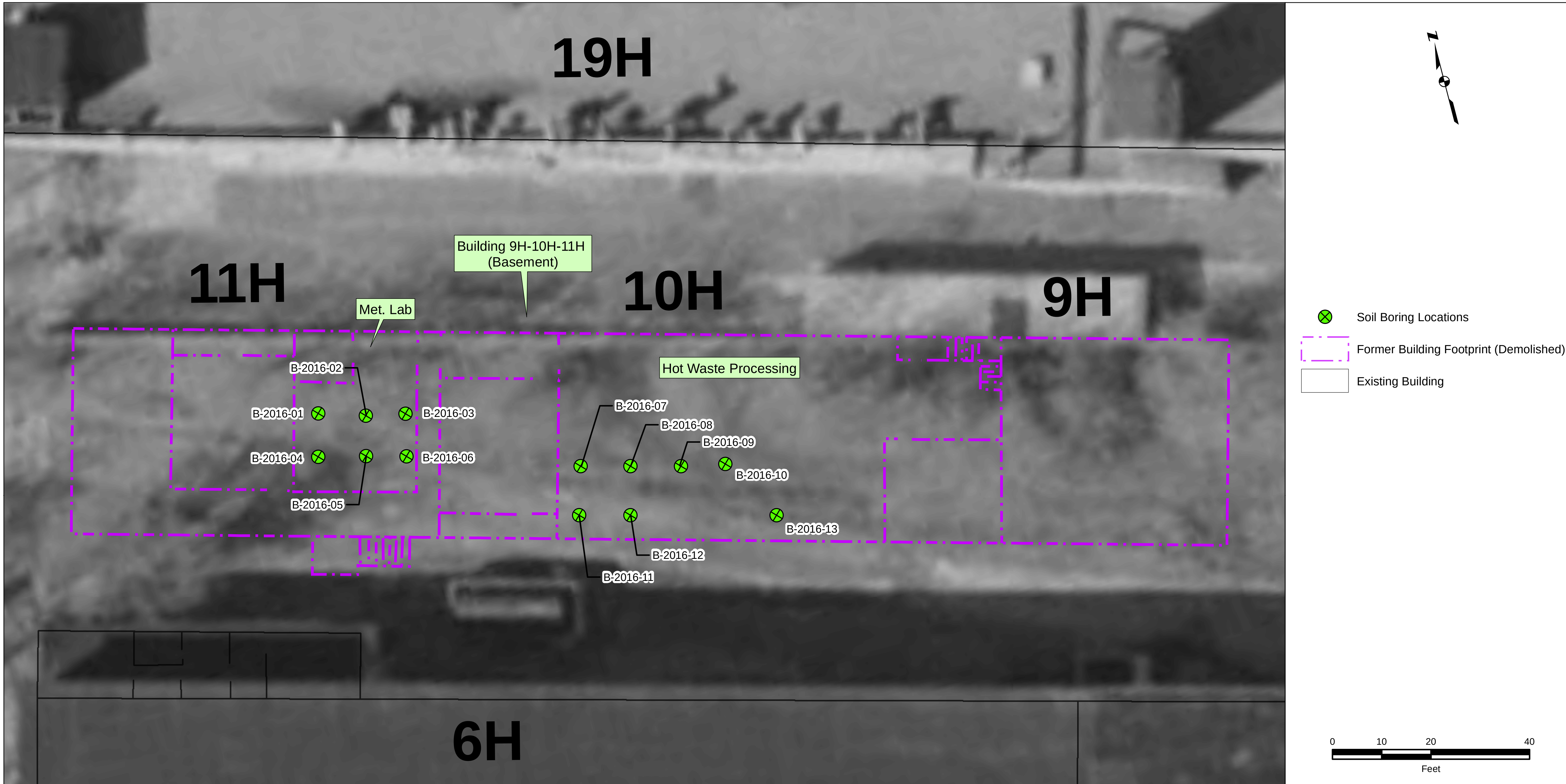
0 20 40 80
Feet

BUILDING 3H/6H
SYSTEMATIC MEASUREMENTS
SURVEY UNITS 4 - 6

FORMER UNC FACILITY
NEW HAVEN, CONNECTICUT

2/2016	SMO	PROJECT NO. 10-1007.00	FIGURE 6

Cabrera Services
Baltimore, MD



FORMER BUILDING 9H/10H/11H
SOIL BORING LOCATIONS

FORMER UNC FACILITY
NEW HAVEN, CONNECTICUT

2/2016	SMO	PROJECT NO. 10-1007.00	FIGURE 7
	Cabrera Services Baltimore, MD		

Buildings

Existing Building

Demolished

Overhead Hazard Areas

Note: Overhead hazards must be addressed in these areas of Building 3H/6H to allow safe entry and for work to proceed.

0 40 80 160
Feet

BUILDING 3H/6H
OVERHEAD HAZARD AREAS

FORMER UNC FACILITY
NEW HAVEN, CONNECTICUT

2/2016	SMO	PROJECT NO. 10-1007.00	FIGURE 8
	Cabrera Services Baltimore, MD		

APPENDIX B
MINIMUM DETECTABLE CONCENTRATIONS

The following are example derivations of minimum detectable concentrations (MDCs) for instruments used for this supplemental survey to substantiate that these MDCs are sufficiently low to detect alpha and beta surface radioactivity at surficial release concentration criteria used to terminate the USNRC license in 1976 (i.e., USNRC Regulatory Guide 1.86, USNRC, 1974).

Smear measurements of surface alpha/beta radioactivity will be performed to compare contaminant concentrations at discrete sampling locations on the concrete surfaces to the DCGLw of 1,000 dpm/100 cm^2. A Ludlum Model 43-10-1 zinc sulfide and plastic scintillation alpha/beta detectors will be used to perform these measurements. The static alpha MDC is calculated based on the following typical parameters for this instrument using NUREG-1507 (1995), equation 3-10:

$$\text{Static MDC} = \frac{3 + 3.29\sqrt{(R_b)(t_g)\left(1+\frac{t_g}{t_b}\right)}}{(t_g)(\varepsilon_i)\left(\frac{\text{Probe Area}}{100}\right)}$$

Background count rate (R_b) or (b)	0.2	(cpm)
Background count time (t_b)	1	(minutes)
Sample count time (t_g)	1	(minutes)
Instrument efficiency (e_i)	0.35	(cpm/dpm)
Probe area (PA)	100	(cm^2)
Alpha Static Minimum Detectable Concentration (MDC)	14.5	(dpm/100cm^2)

Based on these parameters and an alpha background count rate of 0.2 cpm, the static MDC is approximately 15 dpm/100 cm^2.

Direct activity measurements will include integrated scans and integrated measurements (i.e., static measurements) of surface alpha/beta radioactivity. Static measurements will be performed to compare contaminant concentrations at discrete sampling locations on the concrete surfaces to the DCGLw of 5,000 dpm/100 cm^2. Ludlum Model 43-37 gas flow proportional (active area 582 cm^2) alpha/beta detectors will be used to perform integrated scans and static activity measurements. The static alpha MDC is calculated based on the following typical parameters for this instrument using NUREG-1507 (1995), equation 3-10:

$$\text{Static MDC} = \frac{3 + 3.29\sqrt{(R_b)(t_g)\left(1+\frac{t_g}{t_b}\right)}}{(t_g)(\varepsilon_i)\left(\frac{\text{Probe Area}}{100}\right)}$$

Background count rate (R_b) or (b)	5	(cpm)
Background count time (t_b)	1	(minutes)
Sample count time (t_g)	1	(minutes)
Instrument efficiency (e_i)	0.06	(cpm/dpm)
Probe area (PA)	582	(cm^2)
Alpha Static Minimum Detectable Concentration (MDC)	38.4	($dpm/100cm^2$)

Based on these parameters and an alpha background count rate of 5 cpm, the static MDC is approximately 38 dpm/100 cm^2. With the static MDC established, the scan MDC is calculated using the methodology discussed in MARSAME (Multi-Agency Radiation Survey and Assessment of Materials and Equipment manual), Section 8.3.5.8:

$$i = \frac{w}{s}$$

$$\mathrm{MDCR} = d' \sqrt{b * \left(\frac{i}{60}\right)} * \left(\frac{60}{i}\right)$$

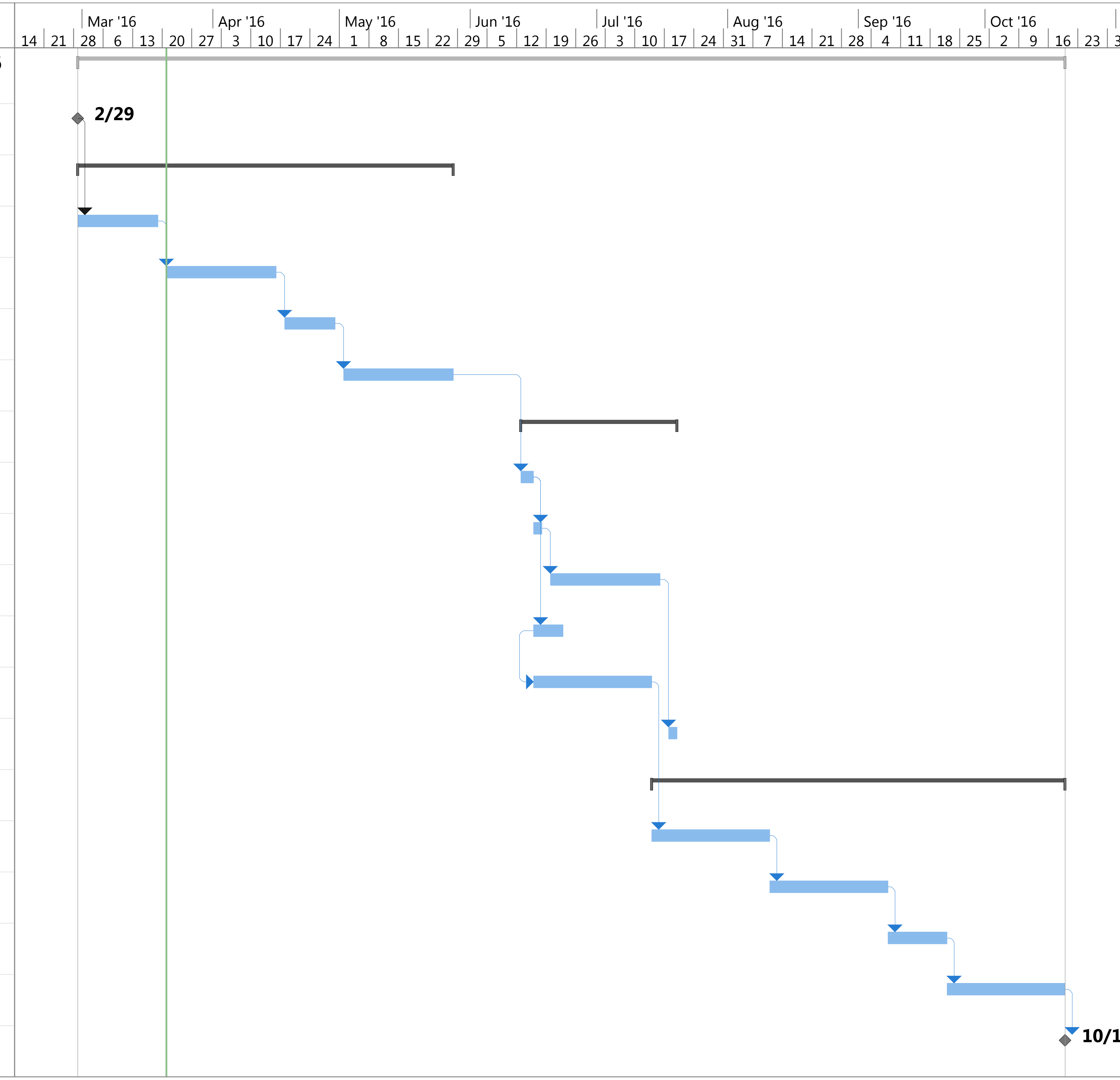
$$\text{Scan MDC} = \frac{\mathrm{MDCR}}{\left(\sqrt{p}\right)\left(\varepsilon_i\right)\left(\frac{\text{Probe Area}}{100}\right)}$$

Alpha Static Minimum Detectable Concentration (MDC)	38.4	($dpm/100cm^2$)
i	3.2	(unitless)
Minimum Detectable Count Rate (MDCR)	13.4	(cpm)
Width of the probe face (w) or (d)	16	(cm)
Scan speed (s) or (v)	5	(cm/sec)
Index of detectability (d')	1.4	(unitless)
Surveyor efficiency (p)	0.5	(unitless)
Alpha Scan Minimum Detectable Concentration (MDC)	54.1	($dpm/100cm^2$)

Based on these parameters, the scan MDC is approximately 54 dpm/100 cm^2.

APPENDIX C
SCHEDULE

ID	WBS	Task Name	Duration	Start	Finish
0		**20160323_UNCNH_SuplSurvey_2016_Rev0**	**168 days**	**Mon 2/29/16**	**Wed 10/19/16**
1	0	**Notice to Proceed**	0 days	Mon 2/29/16	Mon 2/29/16
2	**1**	**Supplemental Survey Plan**	**65 days**	**Mon 2/29/16**	**Fri 5/27/16**
3	1.1	Prep and Submittal	15 days	Mon 2/29/16	Fri 3/18/16
4	1.2	NRC Review	20 days	Mon 3/21/16	Fri 4/15/16
5	1.3	Incorporate Comments and Submit Revised Plan	10 days	Mon 4/18/16	Fri 4/29/16
6	1.4	NRC Review and Acceptance	20 days	Mon 5/2/16	Fri 5/27/16
7	**2**	**Survey Field Work**	**27 days**	**Mon 6/13/16**	**Tue 7/19/16**
8	2.1	Mobilization and Set-up	3 days	Mon 6/13/16	Wed 6/15/16
9	2.2	Building 3H Ductwork Survey	2 days	Thu 6/16/16	Fri 6/17/16
10	2.3	3H/6H Floor Survey	20 days	Mon 6/20/16	Fri 7/15/16
11	2.4	Former 9H, 10H, 11H Soil boring/sampling	5 days	Thu 6/16/16	Wed 6/22/16
12	2.5	Off-site Lab analysis	20 days	Thu 6/16/16	Wed 7/13/16
13	2.6	Demobilization	2 days	Mon 7/18/16	Tue 7/19/16
14	**3**	**Survey Report**	**70 days**	**Thu 7/14/16**	**Wed 10/19/16**
15	3.1	Prep and Submittal	20 days	Thu 7/14/16	Wed 8/10/16
16	3.2	NRC Review	20 days	Thu 8/11/16	Wed 9/7/16
17	3.3	Incorporate Comments and Submit Revised Report	10 days	Thu 9/8/16	Wed 9/21/16
18	3.4	NRC Review and Acceptance	20 days	Thu 9/22/16	Wed 10/19/16
19		**Survey and Reporting Complete**	0 days	Wed 10/19/16	Wed 10/19/16



Project: 20160323_UNCNH_SuplSurvey_2016_Rev0
Date: Wed 3/23/16

Task	Project Summary	Manual Task	Start-only	Deadline
Split	Inactive Task	Duration-only	Finish-only	Progress
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks	Manual Progress
Summary	Inactive Summary	Manual Summary	External Milestone	