Verification Survey Plan

St. Anthony Mine Closeout

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TABLES

FIGURES

ACRONYMNS

Bi-214	Bismuth 214
CPM	counts per minute
DGPS	Differential Global Positioning System
DQA	data quality assessment
DQO	Data Quality Objective
emc	elevated measurement comparison
FOV	field of view
g	gram
HBL	Health-Based Level
keV	Kiloelectronvolt
L	liter
m^2	square meters
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	Minimum Detectable Concentration
NaI	Sodium Iodide
NCR	Nonconformance Report
NIST	National Institute of Standards and Technology
NUREG	U.S. Nuclear Regulatory Commission Regulation
PARCC	Precision, Accuracy, Representatives, Comparability, and Completeness
Pb-214	Lead 214
pCi	picocuries
Plan	St. Anthony Closure Plan
QA/QC	quality assurance/quality control
QAPP	quality assurance project plan
QC	quality control
Ra-226	Radium 226
Rn-222	Radon 222
RPP	Radiation Protection Plan
RSO	Radiation Safety Officer
SAL	Soil Action Level
site	St. Anthony Mine Site
SOP	standard operating procedure
UNC	United Nuclear Corporation
USEPA	U.S. Environmental Protection Agency
USNRC	U.S. Nuclear Regulatory Commission
VS	Verification Survey

1.0 INTRODUCTION

This document provides a framework for performing a Verification Survey (VS) of excavated areas following the completion of soil excavation action activities for closure of the St. Anthony Mine Site (the site) near Seboyeta, New Mexico. The soil excavation action for the site addresses excavation and removal of soil exceeding the Ra-226 Soil Action Level (SAL) as specified in Section 2.1 of the St. Anthony Mine Closeout Plan (the Plan). The SAL is 6.6 pCi/g for radium 226 (Ra-226) for excavation and removal of soils at the site, which is based on the 5.0 pCi/g Ra-226 Health-Based Level (HBL) plus the 1.6 pCi/g Ra-226 site background area concentration level as determined by the 2007 Materials Characterization (MWH, 2007). The objective of the VS is to demonstrate that the residual Ra-226 concentrations in the soil in the excavated areas meet the SAL. The 2007 Materials Characterization and the 2018 Supplemental Radiologic Characterization (AVM, 2018) identified areas totaling approximately 360 acres including mine features, such as piles and roads that exceeded the SAL. The mine impacted material will be excavated and placed in Pit 2 as discussed in the Plan. Pile 4, Pile 5 and the Topsoil/Overburden pile will be regraded and stabilized in place. The approximate remaining 225 acres of area will be excavated to meet the SAL. This approximate 225-acre area, as shown in Figure 1, will require a VS to demonstrate the removal action meets the SAL. A summary of the nature and extent of the contamination is provided in the 2018 Supplemental Radiologic Characterization report.

Upon completion of the soil excavation and placement, as discussed in Section 3.2 of the Plan, a VS will be performed to ensure the soil excavation action to the SAL has been met. Applicable aspects of the sampling and survey methods outlined in the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (USEPA 2000) will be used to demonstrate compliance with the SAL. The MARSSIM guidance was developed for use in designing, implementing, and evaluating verification surveys, known as final status radiological surveys. This Plan includes processes for evaluating residual Ra-226 activity and outlines the contents of the VS for survey areas at the site.

2.0 SITE DESCRIPTION

The site was an open pit and underground shaft uranium mine located on the Cebolleta Land Grant located in Cibola County, approximately 4.6 miles southeast of Seboyeta, New Mexico. The site is in a remote, sparsely populated area with limited access. United Nuclear Corporation (UNC) operated the site from 1975 to 1981, pursuant to a mineral lease with the Cebolleta Land Grant, the current owner of the surface and mineral rights. The original lease covered approximately 2,560 acres. This lease was obtained on February 10, 1964 and surrendered by a Release of Mineral Lease dated October 24, 1988.

The site includes underground workings consisting of one shaft, approximately eight vent shafts that are sealed at the surface, two open pits (one containing a pond), seven large piles of non-economical mine materials with some revegetation, numerous smaller piles of non-economical mine materials, and three topsoil piles. No perennial streams occur within the site, but an ephemeral stream or arroyo (Meyer Gulch) passes through the site. The layout of the site is shown in Drawing 3 of the Plan and shows the site features and the UNC mine permit boundary (permit boundary). The actively mined area encompasses approximately 430 acres and includes site roads and the other disturbed areas along with the features previously described.

3.0 DATA QUALITY OBJECTIVES

The Data Quality Objectives (DQOs) for the VS are provided below to establish a systematic procedure for SAL that will be met for the data collection design to be satisfied. The DQO process includes a description of when to collect samples, where to collect samples, the tolerable level of errors for the study, and how many samples to collect. The DQO process consists of the seven steps listed below (USEPA 2006):

1. State the problem.
2. Identify the goals of the study.
3. Identify information inputs.
4. Define the boundaries of the study.
5. Develop the analytic approach.
6. Specify performance or acceptance criteria.
7. Develop the plan for obtaining data.

The DQO process is described in the following sections as it applies to the site VS.

3.1 State the Problem

The Closure Plan includes excavation, removal and placement of site soils that exceed the SAL. The problem is to determine if the residual Ra-226 levels in survey unit soil meets the SAL after soil excavation completion.

This VS Plan will be used to determine whether residual Ra-226 concentrations in the soil at the site meet the SAL. The MARSSIM provides guidance for planning, conducting, evaluating and documenting final status surveys (herein referred to as VS) for demonstrating compliance with the SAL and is geared towards structures, such as buildings, and relatively small land areas. It is not as useful for larger impacted land area, such as this site, which consists of nearly 225 acres of impacted area. Therefore, this document includes adjustments to the approach (e.g., survey unit size) and data evaluation to facilitate an efficient VS design.

The SAL for the site refers to area average that must be met for each survey unit. Second, the SAL elevated measurement comparison (SALemc) refers to an elevated measurement comparison that addresses more localized elevated areas that may exceed the SAL based on single point measurements as opposed to the average over a survey unit. The SAL is developed so that post-soil excavation action residual activity concentrations meet the SAL criteria.

Since Ra-226 is present in the site background soils, the VS data collected in the field will be inclusive of the background level, similar to the SAL (HBL of 5.0 pCi/g plus the 1.6 pCi/g background area concentration). The data evaluation process will consider that the data from the VS survey units include the background concentration during any comparison and evaluation. Therefore, the terms SAL (indicating Ra-226 HBL of 5.0 pCi/g above background level) and SALemc (indicating health-based level emc plus the background level) will be used in this document.

3.2 Identify the Goals of the Study

The goal of this VS is to confirm that excavation and removal of soil meets the Ra-226 SAL specified in the Plan, which is 6.6 pCi/g.

Compliance with the SAL will be demonstrated by conducting gamma surface scans and systematic static surveys associated with grids consistent with the MARSSIM, and collecting systematic confirmatory soil samples (i.e., samples associated with a grid), and additional samples if deemed necessary based on professional judgment (i.e., samples targeting specific areas of concern).

The principal study question is whether Ra-226 concentrations exceed the SAL in soil following the soil excavation. The possible alternative actions are: 1) release of the survey areas, or 2) additional excavation. The decision statement is:

- If the survey unit mean Ra-226 concentration in soil is below the SAL, the areas meet the SAL.
- If the mean Ra-226 concentrations in soil is above the SAL, the areas do not meet the release criterion and require investigation and may require additional soil excavation and removal.

3.3 Identify Input Information

The following information is needed to resolve the decision statement:

- This is a new Ra-226 data collection effort for verification by conducting gamma radiation surveys and collecting soil samples from soil excavated areas.

- The area-specific nature and extent of contamination based on gamma static and scan survey data, and surface and subsurface soil sampling data, to guide excavation during the soil excavation action.

- Gamma scan survey and any soil analytical results from the excavation control surveys.

- An emc will be calculated for the SAL. The emc for the SAL is established at the HBL plus the background level.

- The collected VS data, which includes gamma scan and static surveys of excavated areas and confirmatory soil sample analytical results, for static surveys.

- The site-specific regression equations to convert field gamma radiation survey measurements in counts per minute (CPM) to the surface soil Ra-226 pCi/g concentrations.

In addition to this quantitative information, visual observations will also be used to determine if there is an indication of contamination or buried mine waste or debris during the excavation.

The combination of the soil excavation criteria, applicable sampling methods, surveying, and guidance of the MARSSIM is the basis for this VS Plan.

VS data will be used to address VS decision-making. The excavation control survey data will also be used for VS decision-making where the excavation control data are collected in a manner consistent with VS protocols and the DQOs.

3.4 Define the Boundaries of the Study

This VS Plan will address the site areas undergoing the soil excavation activities. The removal activities include excavation and removal of soils exceeding the SAL. The site soil excavation boundary was developed based on the 2018 Supplemental Radiologic Characterization (AVM, 2018). The VS area may change depending on the actual excavation footprint following the soil excavation and removal. Definitive VS area footprints will be established prior to the initiation of the VS data collection based on the excavation control survey of the footprint of the excavated area. Areas within the site soil excavation and removal footprint will be included in the VS.

3.5 Develop the Analytic Approach

Implementing the steps for VS data analytic approach for the decision rule will be as follows:

- **Statistical parameter of interest**: The VS data statistical parameter of interest for the decision rule for the site is the mean (average) concentration of Ra-226, specified in the Plan.

- **SAL**: The Plan specifies a SAL of 6.6 pCi/g for Ra-226 for excavation and removal of soils at the site, based on the pre-determined HBL at 5.0 pCi/g, plus the 1.6 pCi/g background area mean concentration, since Ra-226 is present in background at the site.

The data evaluation and conclusions for release of survey units is described in Section 6.0 and includes demonstrating compliance with the SALemc and SAL.

3.6 Specify Performance or Acceptance Criteria

The VS data evaluation for demonstrating compliance with SAL is stated in Section 6.2. A conclusion will be drawn from the VS data evaluation. Since the SAL is a single average value over an area, the mean of the VS area data will be used to demonstrate that the site meets the soil excavation action criteria. For the SALemc requirements, gamma scan and static surveys, along with any soil sample results will be compared against a SALemc detector CPM equivalent to the SALemc Ra-226 pCi/g criteria.

To enable data testing relative to the SAL, there are two types of fundamental decision errors, a Type I decision error of 0.05 and a Type II decision error of 0.10. The fundamental decision errors will be used to calculate the minimum number of samples required for each survey unit, which will be used for data evaluation to demonstrate compliance with the SAL. A 0.05 Type I error rate will also be used for the p-value associated with the gamma radiation to Ra-226 correlations.

Data quality indicators for precision, accuracy, representativeness, comparability, and completeness (PARCC) have been established:

- Precision will be determined by a comparison of replicate values from field measurements and from duplicate sample analyses; the objective is a relative difference of 30 percent, or less of the SAL or SALemc values.

- Accuracy for field gamma measurements is the degree of agreement with the true or known (confirmatory laboratory analysis); the objective for this parameter is ±30 percent of the SAL or SALemc values.

- Representativeness and comparability will be confirmed through selecting and properly implementing systematic sampling and measurement techniques. Representativeness is a qualitative expression of the degree to which sample data accurately and precisely represent a characteristic of a population, a sampling point, or an environmental condition. Representativeness is maximized by confirming that, for a given task, the number and location of sampling points and the sample collection and analysis techniques are appropriate for the specific investigation, and that the sampling and analysis program provides information that reflects "true" site conditions.

- Completeness refers to the portion of the data that meets acceptance criteria and is therefore usable for statistical testing. The objective is a 95 percent completeness goal. The number of data points calculated for data evaluation will be increased by 20 percent to account for possible lost or unusable data, which is assumed to be sufficient to assure that the completeness goal will be met.

The generic PARCC criteria that focus on activity concentration results and analytical performance around the SAL requirements may not be meaningful if very low contamination is encountered, which is expected to be the case during VS work. Other factors, such as activity concentrations relative to the SAL, should be considered when evaluating the quality and usability of the produced data sets.

3.7 Develop the Plan for Obtaining Data

Field screening techniques, gamma surveys, soil sampling, soil sample analysis, and the Data Quality Assessment (DQA) process will be used, as appropriate, throughout the VS. As data are collected and analyzed from initial survey units, assumptions in this plan will be reviewed for accuracy.

4.0 VS DATA COLLECTION PLAN

This section describes the general VS data collection activities that will take place to satisfy the DQO described in Section 3. Section 5 provides details about field implementation of this plan.

4.1 Verification Survey Area

Areas that exceed the SAL and require soil excavation to achieve the SAL will be designated as VS areas. The 2007 Materials Characterization and the 2018 Supplemental Radiologic Characterization identified an area of approximately 360 acres exceeding the SAL. Approximately 142 acres (Pile 4, Pile 5 and Topsoil/Overburden) of this area will be stabilized in place covering approximately 191 acres and will receive a radon and erosion protection cover, as discussed in the Plan. Mine impacted material from the remaining 225 acres at the site exceeding the SAL, will be excavated, placed and stabilized in Pit 2. These 225 acres will be designated as VS areas (see Figure 1) and a VS will be performed in these areas

As shown in Figure 2 and Table 1, the VS area will be divided into three separate areas based on their locations to facilitate a manageable and efficient VS. The Mine Access Road and associated step-out excavation areas, which are outside of the mine permit boundary, cover an estimated area of approximately 22 acres and contain soil impacted by mine waste above the SAL to a depth of about one foot, designated as VS Area 1. An approximate 40 acre of excavation area in the West Shaft Area, including the West Shaft access road and associated step-out areas to the north are grouped and designated as VS Area 2. The approximate 162 acres of excavation area within the mine site area and associated step-out areas are grouped and designated as VS Area 3.

Although control measures will be implemented during the soil excavation activities, there may be a potential for contaminant migration into adjacent areas during the soil excavation, transportation, and placement activities. During the VS, the gamma scan survey will be extended into the adjacent areas, the buffer zones outside the boundaries of the VS areas. The width of some of the buffer zone areas may be physically limited due to rock outcrops, cliffs and steep arroyo banks adjacent to the VS area boundary. If the SALemc is exceeded in buffer zones, the buffer zone will be investigated, excavated if needed, and the VS will be included in these buffer zone areas.

Table 1: St. Anthony Mine Site VS Data

CVS Area ID	CVS Area Description	Area Approximate Size, Ft^2	Area Approximate Size, Acres	Estimated No. of Survey Units (1)	Estimated Survey Unit Average size, Acres	Estimated No. of Data (Static Survey) Points	Estimated Confirmatory Soil Samples @5% of SS Points
1	Mine Site Access Road with associated Step-out areas	940,896	21.6	9	2.4	70	4
2	West Shaft Area (Includes road out to shaft area, West Shaft Mine features, areas between features and associated Step-out areas north of the Shaft Area)	1,707,988	39.2	16	2.5	132	7
3	St. Anthony Mine Site and associated Step-out areas	7,041,910	161.7	67	2.4	524	27
TOTAL		**9,690,793**	**222.5**	**92**		**726**	**38**

Notes: (1) Typical Survey Unit Size 2.5 Acres

4.2 Background Area

A Ra-226 background value in soils for the site was established in the 2007 Material Characterization (MWH, 2007b). Background sampling consisted of 8 samples from the approximate 4-acre background area. The background area was selected from an area believed to be un-impacted by mining activities. Background sampling results showed an average Ra-226 concentration in soil of 1.6 pCi/g with a standard deviation of 1.0 pCi/g.

4.3 Sample Number Calculations

The SAL is a Ra-226-specific activity concentration average within a survey area corresponding to the release criterion. Site compliance with the SAL is demonstrated by using discrete sampling data points and sampling data evaluation. By using appropriate equations, one can determine the sample numbers required per survey area to achieve desired Type I and Type II error rates for a particular data evaluation.

The number of data points for the VS survey units for statistical data evaluation was determined. A nonparametric statistical data evaluation was selected because Ra-226 is present in background soil at the site. Sample standard deviation from the background area data set is included for calculating the minimum number of required data points. A standard deviation of 1.0 as determined from the site 2007 Material Characterization background sampling data set, which is very conservative, is used for the required number of data point calculations. The statistical parameters and the calculations used to determine the data points needed for the site are shown in Table 2.

Table 2: Parameters for Number of Data Point Calculation

Parameter	Value
Type I Error (alpha, α)	0.05
$Z_{1-\alpha}$, percentile for α = 0.05 (MARSSIM Table 5.2)	1.645
Type II Error (beta, ß)	0.10
$Z_{1-\beta}$, percentile for ß = 0.10 (MARSSIM Table 5.2)	1.282
Health-Based Cleanup Level	5.0
Standard Deviation, σ (From Background Dataset)	1.0
LBGR @ 95%, 1.96σ	1.96
Shift Δ (DCGLw - LBGR)	3.04
Relative Shift Δ/σ	3.040
Pr, probability for relative shift Δ/σ (MARSSIM Table 5.1)	**0.97891**
Number of data points from reference area/ survey unit pair, MARSSIM Equation 5.1 $N = (Z_{1-\alpha} + Z_{1-\beta})^2 / 3(Pr - 0.5)^2$	**12.45**
Adding additional 20% and rounded up to next even number	**15**
Number of data points from Background Area	**8**
Number of data points from Survey Unit	**8**

The statistical parameters shown in Table 2 were selected to achieve low error rates, as specified for the DQOs. The relative shift is based on the SAL (lower bound of the gray region and the standard deviation). As shown in Table 2, the minimum number of data points needed for the site calculates to six data points per survey unit. The number of data points determined for data evaluation was increased by 20 percent to account for possible lost or unusable data. The final rounded up number of data points resulted in eight data points being collected in each survey unit for all VS areas. The results from a minimum of six usable data points from gamma static survey locations in each survey unit will be used for the VS data statistical evaluation.

4.4 Survey Units, Sampling Grid and Transect Spacing

The verification survey units, the sampling grid (data points) and transects for gamma scan survey (discussed in Section 4.6) spacing are described in the following sections.

4.4.1 Verification Survey Units

The VS data evaluation for verification for the average SAL value is based on a 100 m^2 area (survey unit), which is approximately 0.025 acres. The number of samples (data points) in the VS areas is calculated as discussed in Section 4.3. The VS areas will be divided into appropriate size survey units. The suggested survey unit size of 0.025 acre would result in approximately 9,000 survey units with a total of approximate 45,000 data points, with the assumption of about five points in each survey unit. Thus, using a 0.025-acre survey unit size would require an unnecessarily inefficient and complex management system with onerous verification surveys and data evaluation over a large homogeneous area with uniform type of contamination/media following excavation. Therefore, the survey unit size for the VS has been modified from the suggested 0.025-acre size to a practical 2.5-acre size for verification. This will help facilitate an efficient and practical VS, as well as allow acceptable evaluation of VS data used for demonstrating compliance with the SAL for this large of a site. The 2.5-acre VS unit size conforms to risk assessment assumptions for establishing release criterion. The Ra-226 HBL for the site is based on risk from an acceptable land use exposure scenario. The RESRAD code for risk assessment uses an average concentration value for a default contamination zone of 10,000 m^2, or about 2.5 acres, which is the survey unit size proposed for the VS. Generally, an area or site may be divided into smaller survey units to facilitate considerations for different types of contamination/media of very small areas, such as drywall areas, ceiling material areas, floor material areas, outdoor paved yards and outdoor unpaved yards for an overall risk/dose assessment. At the site, there is only one media (soil) and one form of contamination (soil impacted by uranium ore). Thus, the contamination type/media would be the same in a 0.025 acre or a 2.5-acre survey unit and would not impact the overall radiologic dose/risk.

Using an average over an area (survey unit) for compliance with the SAL could allow for locations with elevated levels of residual contamination. For example, if measurements from five locations are collected within a survey unit, with four locations at about 2 pCi/g, the residual Ra-226 contamination could be as high as 25 pCi/g at the fifth location and still meet the SAL of 6.6 pCi/g. The MARSSIM approach with elevated measurement comparison (emc) incorporated into the VS would result in a more uniform soil excavation to the SAL. For example, using a calculated SALemc of 6.84, as discussed in Section 4.5, would confirm that the site meets the 6.6 pCi/g SAL. The VS for the site also includes a gamma scan survey at 30-foot transect spacing to be performed prior to measurements at the grid data points as discussed in Section 5.1. Thus, the gamma scan survey will provide additional assurance with the soil excavation action criteria.

Each VS area will generally be divided into 2.5-acres survey units and are rounded to the nearest whole number of survey units. The survey units at the perimeter of the VS areas may not be 2.5 acres due to the irregular shapes of the VS areas. The size of some survey units at the VS area perimeter may deviate up to 25% from the typical 2.5 acre area. The number of survey units may change depending on the actual excavation footprint following the soil excavation and removal. The conceptual boundaries of the VS survey units are shown in Figure 3 and Figure 4.

4.4.2 Verification Survey Data Point Grid

A triangular grid system was selected to locate data points within the survey units. The grid length calculation parameters are included in Table 3. The length of the triangular grid is determined based on the number of samples per survey unit and the typical survey unit size of 2.5 acres. The calculation results in a triangular grid length of 125 feet. Each survey unit will be sampled at a rate of eight samples per survey unit. Because the survey unit numbers are rounded to whole numbers and the size of survey units may vary slightly from the typical survey unit size, the number of sampling data points will be maintained at eight per survey unit. Also, the survey unit size at the perimeters of the VS areas may be more than the 2.5 acres typical size due to the irregular shape of the VS areas as discussed above. For the survey units with a different area than 2.5 acres, the number of data points will be adjusted to confirm that the area bounded by each point in the survey unit does not exceed the 13,530 square feet area bounded by a 125-foot triangular grid node. If a survey unit has less than six useable data points, random data points will be added to make up the difference. In no case will the number of obtained useable data points be less than six per the typical 2.5-acre survey unit, as discussed in Section 4.3.

Table 3: Grid Length Calculation Parameters

Parameter	Survey Unit Values
Survey Unit Area, square Feet, A	108,900
Survey Unit Area, square meters, A	10117
Number of data points required per survey unit, n	8
Calculated Length (L) of Triangular grid, L= √(A/0.866n), Feet	125.4
Length (L) of Triangular grid, Rounded Down	**125**

The 21.6-acre VS Area 1 consists of approximately 11,070 linear feet of Access Road totaling an area of about 16.5 acres, plus about 5.1 acres of associated step-out areas. VS Area 1 is divided into nine survey units with an average size of about 2.4 acres each. A 125-foot triangular grid within the Access Road survey units with an average width of about 50 feet is not realistic due to its narrow shape. In two of the VS Area 1 survey units with a width of more than 125 feet, eight data points were located using the 125-foot triangular grid system. In the other seven VS Area 1 survey units with a width less than 125 feet, eight data points were located at near equal spacing along the length of the survey unit. This data point placement will result in a conservative area of less than the 13,530 square feet per triangular grid node.

A one-minute gamma static survey will be conducted at each node of the triangular grid in each survey unit. A total of approximately 726 grid nodes are estimated for the VS survey units, as shown in Table 1. The conceptual grid nodes for the VS gamma static survey are based on the excavation footprint determined by the 2018 Supplemental Radiological Characterization, as shown in Drawing 5 and Drawing 6 of the Closeout Plan. The actual number of grid nodes may change depending on the actual excavation footprint.

4.4.3 Verification Gamma Scan Survey Transects

A systematic gamma scan survey will be performed in each survey unit at 20 percent scan coverage, similar to the 2018 Supplemental Radiological Characterization scan coverage, prior to the one-minute gamma static survey. Transect spacing for the VS systematic gamma scan surveys is calculated using the detector field of view (FOV) for gamma radiations from Ra-226 sources (transect spacing = FOV/% scan coverage). For example, using a conservative FOV of at least 6.0 feet for 2x2 Sodium Iodide (NaI) detectors for Ra-226 gamma radiation, a 20 percent scan coverage requires a transect spacing of 30 feet. The detector baseline (background) counts will be obtained with the detector held 12 inches above the ground surface and without exposing the detector to the source. The detection range limit will be verified by obtaining gamma counts for the source under the detector and moving the source at an increment of one foot away from the detector on the ground and obtaining counts until the counts are not significantly (95 percent confidence level) above the baseline counts.

4.5 Small Areas of Elevated Activity

Elevated areas of concern are assumed to be primarily associated with the soil excavation areas. Small isolated and elevated areas may be encountered. This VS Plan addresses these areas through the definition of the SALemc requirement. Locations with elevated Ra-226 concentrations are expected to be excavated before VS work begins. It is expected that these types of areas will be initially identified by the scan results as being above the SAL and that this finding will be confirmed based on soil sample results.

When a measurement at a discrete location and scan exceeds the SALemc, the first action will be to confirm the SALemc exceedance and to confirm the instrumentation is functioning properly. A SALemc exceedance is not conclusive of exceeding the SAL but may require further investigation. This may involve making further measurements to determine that the level of the elevated residual contamination in the area is such that the resulting residual contamination assessment meets the release criterion, which may require re-survey. If the investigation indicates that the elevated residual contamination in the area will result in the dose exceeding the HBL, the location or area may require further excavation.

The systematic sampling densities in VS areas should be verified to be sufficient to also address SALemc concerns, given the expected scan Minimum Detectable Concentration (MDC) values. The SALemc was calculated consistent with MARSSIM guidance. The area factor needed for SALemc calculation was determined using RESRAD 7.2. A total dose with all exposure pathways and assuming a unity concentration of 1 pCi/g of Ra-226 with the 10,000 m^2 default area of contamination zone in RESRAD 7.2 calculated at 17.4 mrem/year. The total dose with replacing the default 10,000 m^2 contamination zone area by the 1257 m^2 (13,530 ft^2) bounded by the 125-foot triangular grid node, and keeping all other RESRAD default values, was calculated at 16.61 mrem/year. The area factor was computed by taking the ratio of the 17.4 mrem/yr dose per unit concentration generated by RESRAD for the default 10,000 m^2 to the 16.61 mrem/yr generated for the 1,257 m^2 bounded by the triangular grid nodes. If the HBL for residual radioactivity distributed over 10,000 m^2 is multiplied by this value, the resulting concentration distributed over the specified smaller area results in the same calculated dose. As shown in Table 4, a Ra-226 SALemc of 6.84 pCi/g was calculated for the 125-foot triangular grids, using Ra-226 HBL of 5.0 pCi/g plus 1.6 pCi/g mean background concentration. Gamma survey techniques (i.e., surficial surveys) with a 2x2 NaI scintillation detector and soil sample analysis using USEPA Method 901.1 modified (gamma spectroscopy) will be adequate to detect any SALemc exceedances.

Table 4: SALemc Calculation Parameters

Parameter	Survey Units 125-foot TRG
Area Bounded by grid nodes (TRG grid node for CVS), m^2, Contamination zone area	1257
Dose, mrem/yr, RESRAD 7.2 (Ra-226 concentration @ unity (1 pCi/g) and all default pathways and parameters, including default contamination zone area @ 10,000 m^2)	17.4
Annual dose, mrem/yr, RESRAD 7.2 (Ra-226 concentration @ unity (1 pCi/g) and all default pathways and parameters, except contamination zone area)	16.61
Area Factor	1.05
Site Ra-226 Cleanup Level, pCi/g	5.00
Ra-226 Health-Based Levelemc, pCi/g	**5.24**
Site SALemc (Cleanup Level+Background) pCi/g	**6.84**

4.6 Gamma Radiation Surveys

Direct gamma radiation surveys will be used to detect Ra-226 in soils for the VS. Ra-226 is primarily an alpha emitting radionuclide with a gamma radiation emission of 186 KeV at about 4 percent intensity. Field measurement of alpha radiation from soils using radiation detection is an inadequate technique. Due to the low energy of its gamma radiation emission, field determination of Ra-226 is not practical. However, Ra-226 in soil can be determined by measuring gamma radiation levels of its decay products (Pb-214 and Bi-214), which emit high energy gamma radiation at higher intensities and are easily detected and quantified by a sodium iodide (NaI) scintillation detector. This is a surrogate method consistent with MARSSIM guidance (Section 4.3.2).

The HBL is presented in terms of mass activity concentration. When applied to soil, the HBL is expressed in units of activity per unit mass of soil, pCi/g. The direct gamma radiation measurements, using a NaI scintillation detector, provide radiation levels in counts per unit time. The counts per unit time for a given radioactivity depend on the efficiency of the detector. Pb-214 and Bi-214 are decay products of Ra-226 through radon-222 (Rn-222), a gaseous form, some of which emanates from soil. This process results in activity disequilibrium between Ra-226 and Bi-214 in the soil. The Rn-222 gas emanation fraction from the soil varies with different geometric characteristics of a particular soil type. Therefore, a site-specific calibration is necessary. Typically, about 20 percent of the Rn-222 gas decayed from Ra-226 in soil emanates out of the surface soil, indicating that a significant percentage (about 80 percent) of this will decay into Pb-214 and Bi-214 in the soil matrix. If the soil geometry and other parameters such as moisture, radon emanation fraction, contamination distribution profile, gamma ray shine from nearby sources, and land topography are assumed to be consistent, the ratio of Pb-214/Bi-214 to Ra-226 is consistent. This results in a direct correlation between Pb-214/Bi-214 gross gamma radiation levels and Ra-226 concentrations in the soil. Therefore, a site-specific correlation between direct gamma radiation levels and Ra-226 soil concentrations in pCi/g included in Attachment 1 to the Excavation Control Plan will be used to convert the CPM measurement to equivalent Ra-226 in soil.

4.6.1 Gamma Survey Instrumentation

Similar to the instrumentation used for the site Characterization, the instrumentation configuration for direct gamma radiation level measurement during this survey consists of a 2x2 NaI scintillation detector (such as Eberline SPA-3 and Ludlum 44-10) for detection of gamma radiation, connected to a scaler/rate meter (such as Ludlum 2221 or Ludlum 2241) for processing and counting the detected gamma radiation. This instrument configuration has been used widely for this type of application and is recommended by the MARSSIM. The SPA-3 and L44-10 scintillation detectors are rugged with the highest sensitivity gamma radiation detection for field application and this type of field survey. For radiation surveys where significant shine interference is present from nearby areas, such as areas with deep excavation and areas within close proximity of waste piles, the 2x2 NaI scintillation detector will be installed in a 0.5-inch-thick lead collimator to reduce lateral gamma shine interference. During the surveys, the detector will be held approximately 12 inches above ground level, which should focus on, and be most sensitive to, an approximately 6-foot diameter area under the bare detector and 3-foot diameter area under the collimated detector. The Scaler/Rate meter will be interfaced with a sub-meter accurate differential global positioning system (DGPS) and a data logger controller for electronically recording the gamma radiation levels to corresponding location coordinates for systematic gamma scan surveys. The instrumentation will be calibrated consistent with Standard Operating Procedure (SOP)-1, provided in Appendix C.3.

Direct gamma radiation measurements using a NaI scintillation detector provide radiation levels in counts per unit time. The gamma survey results in counts per unit time have no intrinsic meaning to Ra-226 SAL in pCi/g. The counts per unit time for a given radioactivity depend on the efficiency of the detector. The direct gamma radiation level in detector CPM for the collimated and bare detectors, below which there is an acceptable level of assurance that the established SAL is attained, will be based on the site-specific correlations between gamma radiation count rates and surface soil Ra-226 activity. Final gamma radiation level to surface soil Ra-226 correlations for 2x2 NaI bare and 0.5-inch lead collimated detectors were developed, as described in Attachment 1 to the Excavation Control Plan (Appendix C.1) from data collected for previous correlations during the 2018 Supplemental Radiological Characterization.

The 2018 correlations were developed for surface soils at the site, with no recent rain or temperatures below freezing, and no snow cover or frozen ground surface. Gamma radiation surveys will not be conducted if the ground surface is covered with snow or is frozen. Also, the survey will not be conducted for at least two hours following a rainstorm and the ground surface will be inspected to verify that there is no excessive moisture.

MDCs for both the static and gamma scan radiation surveys will be calculated as discussed in SOP-1. Based on data collected with this instrumentation during the 2018 Supplemental Radiological Characterization surveys, the instrument MDC is expected to be well below 3.3 pCi/g (50 percent of the 6.6 SAL for static surveys). The instrument scan MDC is expected to be below 3.4 pCi/g, which will be less than 50 percent of the 6.84 pCi/g limit (the SALemc).

4.6.2 Gamma Scan Surveys

Gamma scan survey data will be collected from excavated soil surfaces as part of the VS data collection process. The gamma scan surveys serve three primary roles:

1. Establish that an area is ready for VS gamma static surveys and soil sampling (i.e., no significant evidence of elevated gross activity that may indicate SAL exceedances).
2. Identify Ra-226 activity anomalies that might indicate SALemc exceedances within VS areas.
3. Identify spatial trends in Ra-226 activity within or across VS areas that will assist in interpreting systematic static gamma survey results at data point locations if there are SAL exceedances in systematic sampling results.

The MARSSIM provides procedures for calculating scan MDCs for particular survey instruments. More detail on signal detection theory and instrument response is provided in NUREG-1507, Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions (USNRC, 1998). A typical/example scan MDC calculation for Land Areas, based on site-specific survey and proposed instrumentation parameters is described in SOP-1. The actual scan MDC will be calculated using actual VS instrumentation and survey parameters to demonstrate that it does not exceed the SAL. It will generally be below 50 percent of the 6.84 pCi/g SALemc for the survey units. Based on operational and function check data, and survey parameters for this instrumentation during previous surveys at the site, the scan MDC is estimated at less than 1.0 pCi/g for the bare and collimated 2x2 NaI detectors.

Prior to static gamma surveys and confirmatory soil sampling, gamma scan surveys will be conducted for 20 percent coverage in each VS area. The VS gamma scans will be digitally recorded, including date, time, location and count rate.

4.6.3 Gamma Static Surveys

Following the VS gamma scan surveys, a one-minute gamma static survey will be conducted at each triangular grid node in survey units as a part of the VS systematic sampling as discussed above. The estimated 726 gamma static survey data points within the 92 survey units listed in Table 1 are shown on Figure 3 and Figure 4. The VS systematic static surveys will be used to evaluate compliance with SAL requirements and to confirm that the emc exceedances are not an issue for the survey units each systematic sample represents.

An example of a typical static measurement MDC calculation based on site-specific survey and instrumentation parameters is described in SOP-1, which was calculated in accordance with MARSSIM Section 6.7.1. Based on operational and function check data, and survey parameters for this instrumentation during previous surveys at the site, the static gamma measurement MDC for a 2x2 NaI detector is estimated at less than 1.0 pCi/g for the bare and collimated detector, far below 50 percent of the 6.6 pCi/g SAL for the site.

4.6.4 Investigation Levels

Investigation levels are established for use during the VS. The VS area measurements are subject to the emc. Since Ra-226 is present in the background at the site, the SALemc will be the investigation level for the VS. Any static measurement at a discrete location or scan measurements in a discrete area above the SALemc will be flagged for further investigation. Supplemental investigation may be necessary in some areas if the SALemc is exceeded and would involve taking further measurements to determine that the area and level of the elevated residual radioactivity are such that the residual activity meets the SAL. The investigation may also require additional excavation and/or a resurvey depending on investigation results.

4.7 Soil Samples

Systematic confirmatory and judgment-based surface soil samples will be collected from the excavated areas as a part of the VS. The surface soil sample results will be used for confirmation of gamma static survey for SAL and SALemc requirements and will also be used for updating the gamma radiation level to surface soil Ra-226 concentration correlations, as discussed in SOP-2 provided in Appendix C.3.

4.7.1 Judgment Based Soil Samples

Surface soil samples will be collected based on professional judgment to target specific locations where there are concerns about potential SALemc exceedances from the scan and gamma static surveys within VS areas. Judgment based sampling locations will be selected based on a variety of factors, such as an elevated gamma scan survey result (either collected as part of excavation control surveys or VS), visual evidence of contamination, or the presence of physical infrastructure that still exists within the VS area footprint. Soil samples for the VS will be analyzed by field ex-situ soil screening as discussed in Section 5.3. If the ex-situ soil screening results show that the SALemc is not exceeded, it will be confirmed by vendor laboratory analysis. Soil samples collected during excavation control surveys will be collected consistent with the VS requirements so that the soil sampling data obtained can be used for the VS where appropriate.

4.7.2 Systematic Soil Samples

Systematic surface samples will be collected for vendor laboratory analysis as confirmation samples for the VS systematic gamma static surveys to evaluate compliance with SAL requirements. Confirmatory surface soil samples will be collected at a rate of five percent of the gamma static survey locations from each buffer zone VS area. A surface soil sample will be collected every 20th gamma static survey location.

5.0 FIELD ACTIVITIES

The VS field activities follow the same general approach in each VS area and include:

1. Initially collecting gamma scan survey data.

2. Performing judgment-based sampling as necessary with evaluation of the samples by on-site ex-situ soil gamma screening to determine if elevated area concerns (i.e., SALemc) exist that require additional excavation and removal.

3. Systematic one-minute gamma static surveys at the triangular grid nodes (125-foot grid length for survey units) to support SAL evaluations.

4. Confirmatory soil sampling with off-site laboratory analyses for systematic gamma static surveys.

A description of field activities is provided in the subsections below.

5.1 Gamma Scan Surveys

When excavation in an area is complete based on the excavation control survey, systematic gamma scan surveys of the excavated areas will be conducted. Gamma scan surveys will be performed in a manner that provides 20 percent coverage of excavated soil surfaces by walking along transects with the bare detector held 12 inches above the ground surface (see SOP-3, in Appendix C.3). Initially, a 30-foot transect spacing is determined based on a conservative detector FOV of 6.0 feet. If a different FOV is used, it will be verified by an FOV test. An average scan rate of three feet per second will be maintained depending on terrain, but will not exceed six feet per second.

The gamma scan survey measurements will be electronically logged with a suitable sub-meter DGPS which provides a real-time corrected location coordinates. If elevated activities above the applicable investigation level are encountered, one-minute static readings will be collected over the location of interest. In addition, for each location where a soil sample is collected, a one-minute gamma static measurement will be collected above each soil sampling location.

Gamma scan results will be compared to the SAL and SALemc discussed above and locations where the data indicate an anomaly will be flagged (defined as a contamination level that exceeds the SALemc). Judgment based soil samples will be collected at these locations for ex-situ analysis and compared to the SALemc, and/or the soil in that location will be excavated and removed.

Gamma scan survey data that satisfy quality control (QC) requirements will be archived electronically in a readily retrievable format along with appropriate metadata (e.g., date collected, detector identification, technician identification, purpose of survey, and any necessary explanatory notes).

5.2 Gamma Static Surveys

Following completion of the VS gamma scan surveys in an area, a one-minute gamma static measurement will be conducted at each node of the 125-foot triangular grid, as shown in Figure 3 and Figure 4 as a part of the VS systematic sampling. The numbers of the estimated static survey locations for each VS area are shown in Table 1. The gamma static surveys will be conducted using the same instrumentation used for the excavation control survey and the VS gamma scan surveys. The VS gamma static surveys will be conducted with the detector fitted with 0.5-inch lead collimator. The gamma static surveys will be conducted for a one-minute counting time with the detector at 12 inches above the ground surface (see SOP-3, provided in Appendix B.3). The gamma static surveys will be electronically logged with a suitable sub-meter accuracy DGPS which provides real time corrected location coordinate data.

The gamma static survey results in CPM will be converted to equivalent Ra-226 concentration in surface soil by using the linear regression analysis equation from the site-specific correlation for Ra-226 concentration in soil. Gamma static survey data that satisfy quality control requirements will be archived electronically in a readily retrievable format along with appropriate metadata (e.g., date collected, detector identification, technician identification, purpose of survey, and any necessary explanatory notes).

5.3 Field Gamma Radiation Ex-Situ Soil Screening

VS soil samples may be screened on-site (ex-situ soil screening) to verify the absence of significant contamination issues. Ex-situ soil screening by single channel analysis for Ra-226 content will be performed (see SOP-4 in Appendix C.3) specifically on the soil samples collected based on professional judgment. This screening allows corrective actions (e.g., additional excavation and re-sampling) to be taken immediately before committing resources to off-site laboratory analyses. Data from ex-situ soil screening will not be used to demonstrate SAL compliance.

For an expedited estimate of Ra-226 in soil, a reference soil with a known Ra-226 concentration (similar to 6.6 pCi/g SAL) will be used. This method, which is more reliable than the scan or the gamma static surveys, was successfully implemented during the 2018 Supplemental Radiological Characterization for expedited estimates of Ra-226 in soil. A single channel analyzer, Ludlum L2221 integrated with Ludlum 44-20 3x3 NaI scintillation detector will be used to measure 609 KeV radiation of the Ra-226 decay product Bi-214. The sample will be placed in a plastic liner around the detector in a heavily lead shielded counting chamber. The heavily shielded counting chamber lowers the system background noise, thus improving the MDC. The 609 KeV gamma radiation counts are obtained and compared to the reference soil and sample soil for field screening. Based on operational and function check data during the previous soil screening during the 2018 Supplemental Radiologic Characterization, the Ra-226 MDC for this screening system is estimated at less than 1.0 pCi/g.

5.4 Judgment Based Soil Samples

If elevated activities are encountered during the VS gamma scan surveys, one-minute gamma static survey readings will be collected over the location of interest to confirm the elevated reading. If the one-minute reading is above the SALemc value, a soil sample based on professional judgment will be collected from that location. A one-minute static reading from a height of 12 inches will be collected above each soil sampling location. Field samples will be collected using a stainless-steel scoop, or spoon, and will be homogenized in a stainless-steel bowl and placed in a sample bag (see SOP-5 in Appendix C.3). The soil sample will initially be field screened for expedited Ra-226 content by ex-situ soil screening, as discussed above. If the field screening of the soil sample shows Ra-226 content below the SALemc, the sample will be sent to a vendor laboratory for confirmation Ra-226 analysis.

5.5 Systematic Soil Samples

Systematic surface soil samples will be collected as confirmation samples for the VS systematic gamma static survey measurements, which will be used to evaluate compliance with SAL requirements. Confirmation surface soil samples will be collected at five percent of the gamma static survey locations in all VS areas, as shown on Figure 3 Figure 4. The estimated numbers of systematic confirmatory soil samples for each VS area are listed in Table 1. Field samples will be collected by using a stainless-steel scoop or spoon and will be homogenized in a stainless-steel bowl and placed in a sample bag (see SOP-5). The systematic soil samples will be sent to an off-site vendor laboratory for Ra-226 analysis.

5.6 Laboratory Analysis

Confirmatory surface soil samples will be shipped to an off-site contract laboratory for Ra-226 (reporting limit of 0.5 pCi/g) analysis using USEPA Method 901.1 modified for soil media. Any laboratory used for environmental sample analysis will have appropriate Environmental Laboratory Approval Program certification or equivalent. Laboratory instrumentation will be calibrated by using National Institute of Standards and Technology (NIST) traceable standards.

5.7 Instrument Calibration and Function Checks

Instruments and equipment used during the VS will be operated, calibrated, and maintained according to the manufacturer's guidelines and recommendations. Instruments will be calibrated annually. Daily operational and functional checks will be performed for radiological instruments before first use. Equipment that fails calibration or becomes otherwise inoperable during the VS will be removed from service and segregated to prevent inadvertent use. Such equipment will be tagged to indicate that it should not be used until the problem can be corrected. Equipment requiring repair or recalibration must be approved for use by the Radiation Safety Officer (RSO) or designee before being placed back into service. Equipment that cannot be repaired or recalibrated will be replaced. Potentially affected data acquired on such equipment will be identified and evaluated for usability and potential impact on data quality

5.8 Corrective Actions

Corrective actions will be initiated if problems related to survey/equipment errors or noncompliance with approved procedures are identified. Corrective actions include repair and/or recalibration or replacement of the equipment and resurvey of the area, as necessary. Corrective actions will be documented through a formal corrective action program at the time the problem is identified.

Nonconformance with the established procedures presented in this VS Plan will be identified and corrected. A nonconformance report (NCR) will be prepared for each nonconforming condition. In addition, corrective actions will be implemented and documented in the appropriate field logbook.

5.9 Sample Chain of Custody and Documentation

Documentation of pertinent field activities, such as instrument calibrations/function check data, field measurements, and field sample data will be recorded in the field forms or field logbooks as necessary. Sample chain of custody will be completed.

5.10 Correction to Documentation

Original information and data in field forms and logbooks, on sample labels, on chain-of-custody forms, and any other project-related documentation will be recorded in waterproof ink in a legible manner. Errors made on any accountable document will be corrected by crossing out the error and entering the correct information or data. Any error discovered on a document will be corrected by the individual responsible for the entry. Erroneous information or data will be corrected in a manner that will not obliterate the original entry, and corrections will be initialed and dated by the individual responsible for the entry.

5.11 Sample Packaging and Shipping

Sample containers will be packaged in thermally insulated rigid-body coolers. Sample packaging and shipping will be conducted in accordance with applicable U.S. Department of Transportation specifications. A checklist will be used by the individual responsible for packaging environmental samples to verify completeness of sample shipment preparations. In addition, the laboratory will document the condition of the environmental samples upon receipt. All samples collected during the project will be shipped within the six-month sample holding time specified by the analytical method. Samples will be stored in a secure area between sample collection and shipment to the laboratory.

5.12 Field Decontamination

Field sampling equipment used during soil sampling will be decontaminated between samples. Equipment to be decontaminated includes stainless steel scoops, bowls, spoons and hand auger barrels.

5.13 Radiation Protection

Radiation protection for workers and the public during the VS is addressed and included in the site-specific Radiation Protection Plan (RPP).

6.0 DATA EVALUATION AND CONCLUSIONS

The data collected for the VS will include systematic gamma scans, static gamma measurements at systematic data points, static gamma measurement at discrete locations and soil samples. The VS radiologic data collected by gamma surveys are in CPM, which have no intrinsic meaning relative to the SAL activity concentration in pCi/g. The gamma survey CPM will be converted to Ra-226 in surface soil using site-specific correlation. Basic statistical parameters (mean and standard deviation) of the VS data set will be calculated for data evaluation. Through the course of the VS design, implementation, and data collection process, there are a number of generic key decision points that include:

- Demonstrating there are no SALemc exceedances for areas through a combination of gamma scan surveys, soil sampling (as necessary) based on professional judgment, and systematic gamma static surveys and soil sampling.

- Demonstrating compliance with SAL requirements using systematic gamma static surveys and confirmatory soil samples from VS areas and data evaluation.

The data evaluation is only applied to measurements made at systematic data points.

6.1 Demonstrating SALemc Compliance

Compliance with the SALemc is demonstrated through a combination of gamma scan surveys and sampling. Since the VS gamma scan survey is sensitive enough to detect if SALemc exceedances exist, SALemc compliance may be demonstrated with gamma scan surveys alone. In the course of SAL compliance, sufficient systematic static surveys and samples will be collected to demonstrate SALemc compliance (or vice versa).

The generic process for demonstrating SALemc compliance is for VS areas. Logged, spatially complete gamma survey data will be collected for each VS area. These data will be compared to the SAL. If a result is above the SAL, the individual systematic survey result will be compared to the SALemc. If the result exceeds the SALemc, additional data may be collected to better define the excavated area, and additional excavation may be necessary before the VS process continues. Locations flagged as potential anomalies by the gamma scan data or for any other reason (e.g., visual evidence of contamination, historical information, etc.) will be sampled based on professional judgment.

6.2 Demonstrating Compliance with SAL

Each survey unit will have systematic gamma static surveys and confirmatory soil samples collected to allow for a SAL compliance evaluation. The data evaluation will be applied to VS systematic gamma static survey results collected at the nodes of 125-foot triangular grid in each survey unit. Examples of circumstances leading to specific conclusions based on a simple examination and evaluation of the data for this VS are summarized below:

- If all Ra-226 measurements in a survey unit are less than the 6.6 pCi/g SAL, the survey unit meets the criteria.
- If the mean of the Ra-226 measurements in a survey unit is less than the 6.6 pCi/g SAL, with any measurement greater than the 6.6 pCi/g SAL but less than the 6.84 pCi/g SALemc, the survey unit meets the criteria.
- If the mean of the Ra-226 measurements in a survey unit is greater than the 6.6 pCi/g SAL, the survey unit does not meet the criteria.
- If the mean of the Ra-226 measurements in a survey unit is less than the 6.6 pCi/g SAL, with some measurements greater that the 6.84 pCi/g SALemc, the survey unit may not meet the criteria, and require further investigation and evaluation.

If the VS data evaluation indicates that a survey area does not meet the criteria, the reason will be investigated and appropriate action will be taken. If additional excavation and removal is required within a survey unit, the VS data collection process will be repeated in those specific areas.

7.0 QUALITY ASSURANCE AND QUALITY CONTROL MEASURES

Quality Assurance and Quality Control (QA/QC) measures will be employed throughout the VS process to verify that decisions are made using data of acceptable quality. A QA/QC program will be conducted during surveys that, in accordance with established procedures, will specify and measure the performance of measurement methods through the collection of an appropriate number or frequency of field duplicate QC samples. Field instruments will be calibrated on NIST traceable standards at a frequency prescribed in the SOPs. A daily function check will be performed for all field instruments before use. Corrective actions will be conducted if performance falls outside expected ranges.

All surveys and sample collection for this VS will be performed in accordance with established QC requirements. Replicate surveys, sample recounts, instrument performance checks, chain of custody, control of field survey data and databases, and QC investigations will provide a sufficient level of confidence in the data collected to support the survey outcome. The radiologic survey instrument QA/QC frequencies, such as calibration and function checks, are described in SOP-3, SOP-4 and SOP-5. The field QA/QC replicate survey and sampling include the following:

- Duplicate measurement at 5 percent of gamma static survey locations.
- Confirmatory soil sample for gamma static survey at 5 percent of gamma static measurement locations.
- Field QA/QC duplicate soil samples for offsite vendor laboratory analysis at a frequency of 5 percent of the soil samples collected.
- Replicate recounting of on-site ex-situ gamma soil screening at a frequency of 5 percent of the total number of samples screened with a minimum of one per day.

In addition, QA/QC measures will confirm that trained personnel conduct surveys with approved procedures and properly calibrated instruments. Procedures will cover sample documentation, chain of custody, field and laboratory QC measurements, and data management.

8.0 REPORT OF VS FINDINGS

Survey procedures and sampling results will be documented in a VS report. This VS report will become an integral part of the Closure Report. This VS report will contain, at a minimum, the following information:

1. A site map that shows scan data, locations of elevated direct radiation levels, and sampling locations from each survey area

2. Tables of Ra-226 concentrations in each sample from each survey unit, including, but not limited to, the results in pCi/g, measurement errors, detection limits, and sample depths

3. Summary statistics for analytical data, surface scan data, and gamma logging data from each survey area

4. Results of the VS data evaluation

The last step of the DQA process will be documenting the results and drawing conclusions.

9.0 REFERENCES

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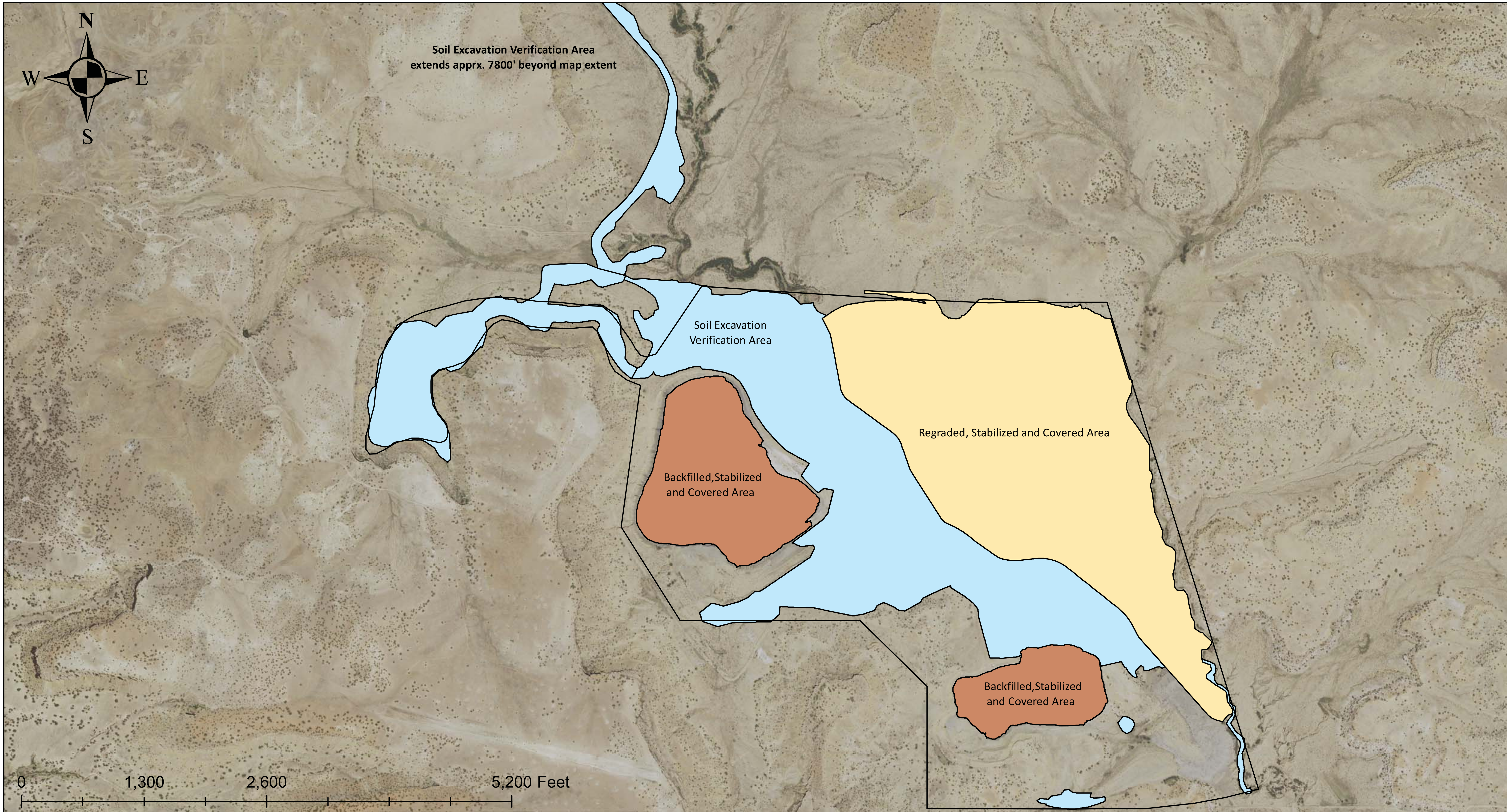
USEPA, 2006. Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA QA/G-4, EPA/240/B-06/001, Office of Environmental Information, Washington, D.C., February

U.S. Nuclear Regulatory Commission (USNRC), 1998, Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions, NUREG- 1507, June.

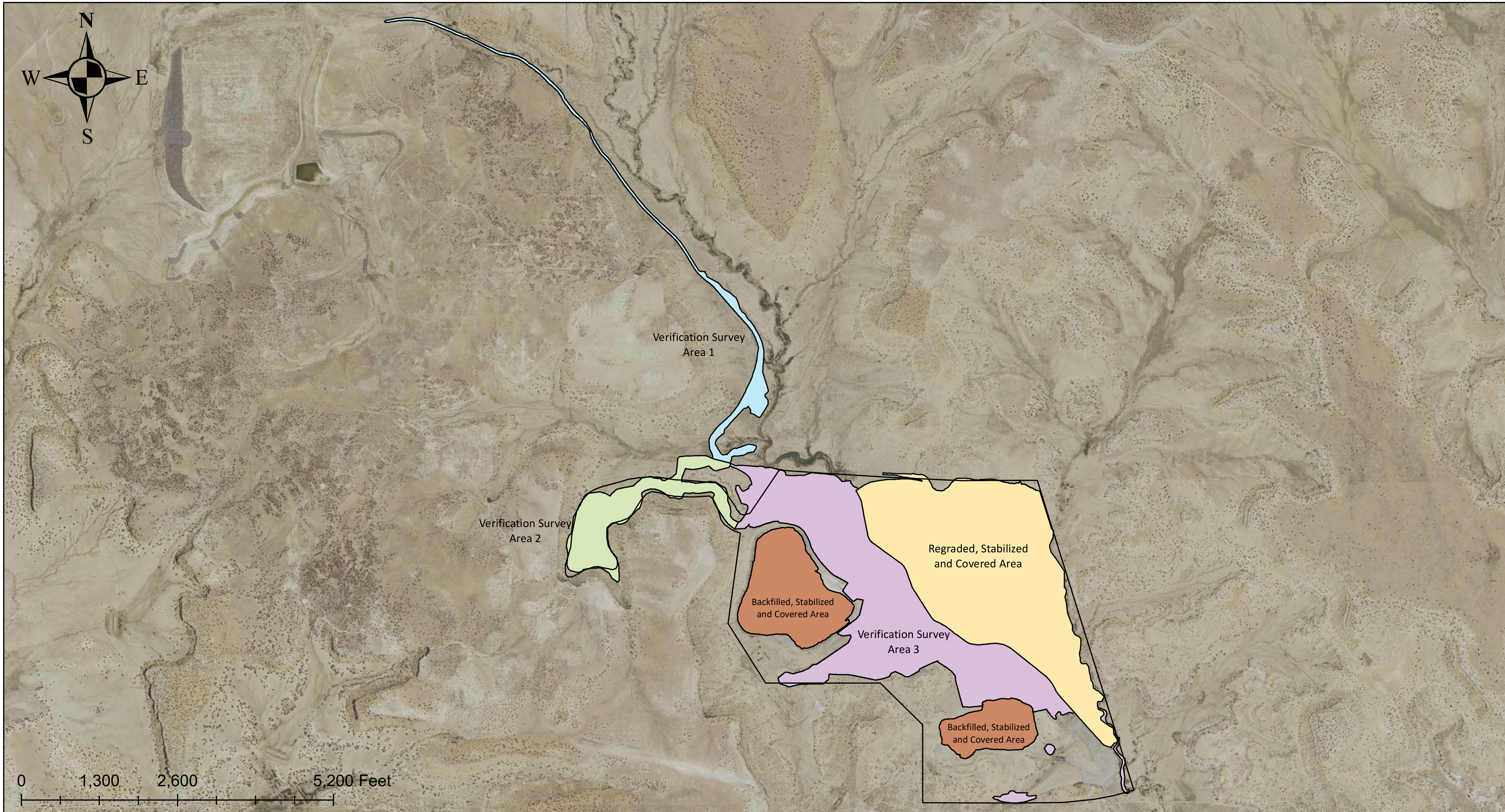
Figures



AVM Environmental Services, Inc.

Figure 1
Soil Excavation Verification Area
St. Anthony Mine Site Verification Survey Plan

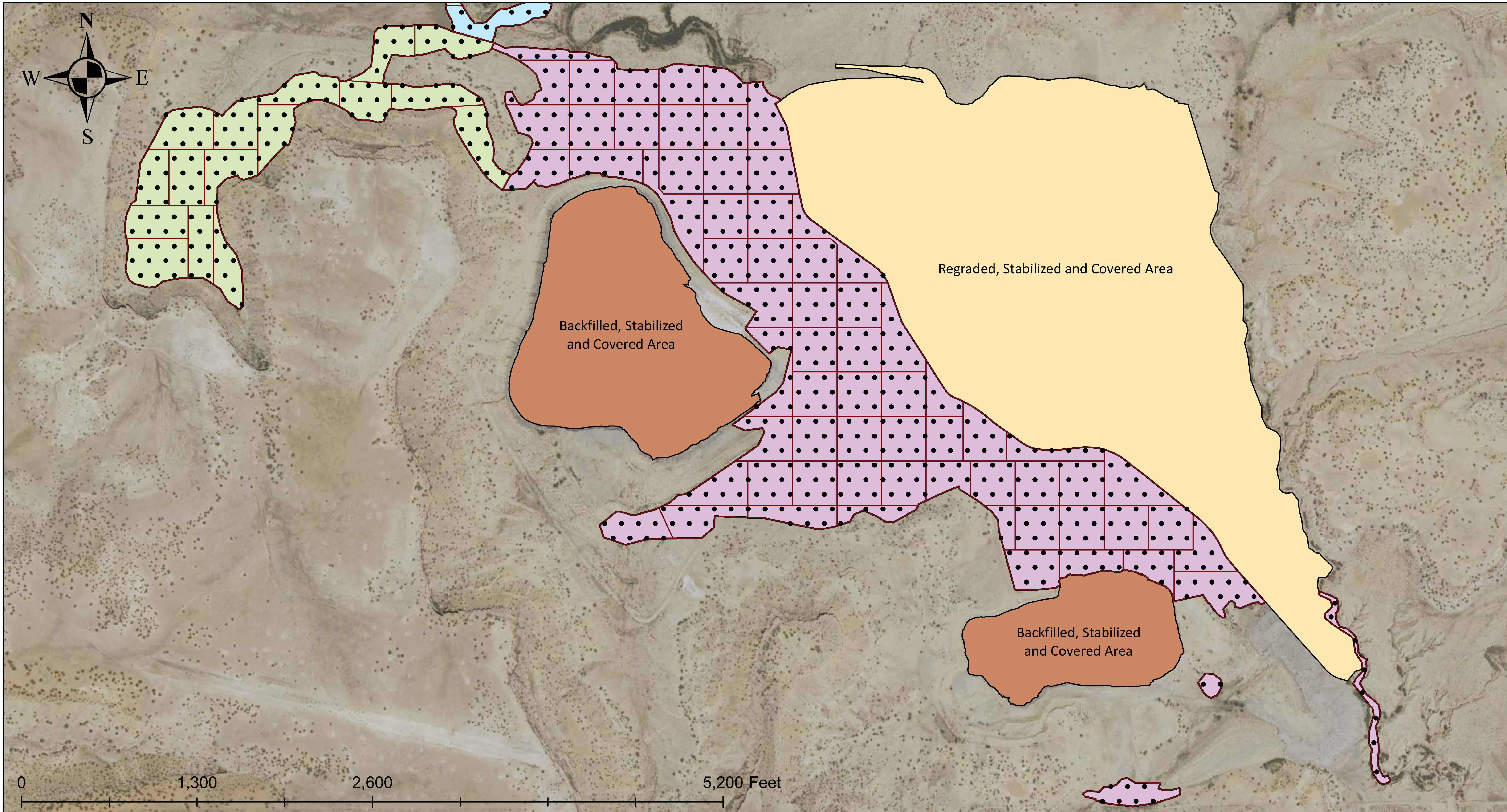
June 2022



AVM Environmental Services, Inc.

Figure 2
Verification Survey Areas
St. Anthony Mine Site Verification Survey Plan

June 2022



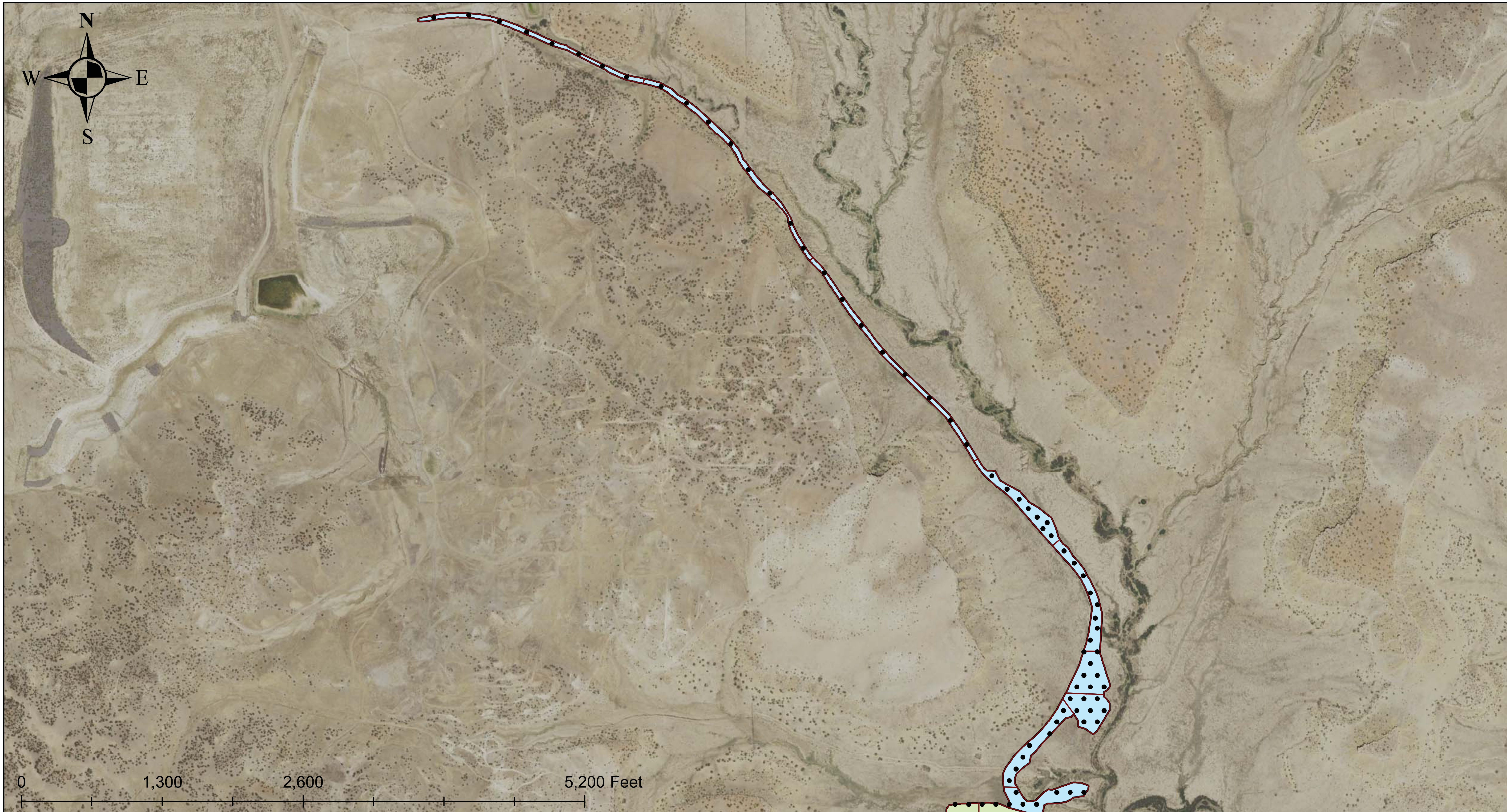
AVM Environmental Services, Inc.

Figure 3
Verification Survey Area 2 and 3
Survey Units with Data Points
St. Anthony Mine Site Verification Survey Plan

Legend

- 125ft Triangular Data Point
- Survey Unit Boudary
- Verification Survey Area 1
- Regraded, Stabilized and Covered Area
- Verification Survery Area 2
- Backfilled, Stabilized and Covered Area
- Verification Survery Area 3

June 2022



AVM Environmental Services, Inc.

Figure 4
Verification Survery Area 1
Survey Units with Data Points
St. Anthony Mine Site Verification Survey Plan

Legend

- 125ft Triangular Data Point
- Survey Unit Boudary
- Verification Survey Area 1
- Verification Survey Area 2

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