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NON-TIME CRITICAL REMOVAL ACTION
MISCELLANEOUS COMPONENTS BURIAL SITE (SEAD-63)

SENECA ARMY DEPOT ACTIVITY
ROMULUS, NEW YORK

FINAL STATUS SURVEY PLAN

December 2003

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GLOSSARY OF ACRONYMS AND ABBREVIATIONS

Ac-227	Actinium-227
BGS	below ground surface
BRAC	Base Realignment and Closure
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
Cs-137	Cesium-137
Co-60	Cobalt-60
DCGL	Derived Concentration Guideline Level
$DCGL_W$	Derived Concentration Guideline Level used for Non-Parametric Statistical Test
DQA	Data Quality Assessment
DQO	Data Quality Objectives
EE/CA	Engineering Evaluation/Cost Analysis
e.g.	for example
EMC	Elevated Measurement Comparison
ESI	Expanded Site Investigation
FSS	Final Status Survey
GIS	Geographic Information System
GPS	Global Positioning System
GWS	Gamma Walkover Survey

GLOSSARY OF ACRONYMS AND ABBREVIATIONS CONTINUED

H-3	Tritium
i.e.	for example
m^2	square meters
MARSSIM	Multi-Agency Radiological Survey and Site Investigation Manual
MDL	Minimum Detectable Limit
mrem/yr	milli roentgen equivalent man per year
m/s	meters per second
N/A	not applicable or appropriate
NTCRA	Non Time-Critical Removal Action
#	number
NY	New York
NYS AWQS	New York State Ambient Water Quality Standard
NYSDEC	New York State Department of Environmental Conservation
PC	personal computer
%	percent
pCi/g	picoCuries per gram
Ra-226	Radium-226
Rad Tech	Health Physics Technician
RCRA	Resource Conservation and Recovery Act

GLOSSARY OF ACRONYMS AND ABBREVIATIONS CONTINUED

SEAD-63	Miscellaneous Components Burial Site
SEDA	Seneca Army Depot Activity
SOR	Sum of the Ratios
SSHP	Site Safety and Health Plan
TAGM	Technical and Administrative Guidance Memorandum
Th-230	Thorium-230
U-234	Uranium-234
U-235	Uranium-235
U-238	Uranium-238
US	United States
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
USEPA	United States Environmental Protection Agency
WRS	Wilcoxon Rank Sum

1.0 INTRODUCTION

Cabrera Services, Inc. (CABRERA) has been tasked under Plexus Scientific Corporation (Plexus) Purchase Order Number (#) 1967 with generating this Final Status Survey (FSS) Plan for a Non-Time Critical Removal Action (NTCRA) being performed at the miscellaneous components burial site (designated SEAD-63), Seneca Army Depot Activity (SEDA), Romulus, New York (NY). This FSS Plan describes the approach, procedures and decision-making criteria that will be used to carry out a FSS of the limits of excavation of the burial pits. The intent of the FSS is to verify that radioactivity levels at the limits of the burial pits following excavation meet the New York State Department of Environmental Conservation (NYSDEC) soil cleanup goal of 10 mrem/yr (milli Roentgen equivalent man per year) above background, consistent with *Technical and Guidance Memorandum (TAGM) # 4003, Soil Cleanup Guideline for Soils Contaminated with Radioactive Materials* (NYSDEC, 1993).

This FSS has been prepared in general accordance with TAGM # 4003, plus:

- Engineer Manual (EM) 200-1-3, *Requirements for the Preparation of Sampling and Analysis Plans*, (USACE, 2001); and
- *Multi-Agency Radiological Survey and Site Investigation Manual* (MARSSIM) (EPA, 2000).

As requested by the United States (US) Army Corps of Engineers (USACE), the FSS will focus on the burial pits area of the SEAD-63 site. The burial pits area will be classified as MARSSIM Class 3 Survey Unit(s). The final configuration of the burial pits is unknown at present. Assumptions were made as to the size and number of survey units in the Sampling and Analysis Plan for the purpose of estimating the number of samples to be collected. The final number of Survey Units will be identified in the field when the final configuration of burial pit excavation(s) is known. A background (reference) area will be established in a non-impacted area of the SEAD-63 site to collect pertinent background radiological concentration data, consistent with MARSSIM. Additional reference area data may also be obtained from previous SEDA study documents.

2.0 BACKGROUND AND OBJECTIVES

SEDA was officially closed by the Department of Defense and the United States Army and in accordance with the Base Realignment and Closure (BRAC) Act process. Portions of the depot are in the process of being released to the public and private sectors for reuse. As increased access to the depot property is afforded, the potential for exposure to low levels of residual chemical and radiological constituents that may be present at the SEAD-63 site will increase.

An *Engineering Evaluation/Cost Analysis* (EE/CA) and *Action Memorandum* for the SEAD-63 site were completed in July 2000 as part of the BRAC process. Those documents were amended in July and October 2001 in response to NYSDEC and US Environmental Protection Agency (USEPA) comments (Parsons Engineering Science, Inc., 2001a and 2000b, respectively). The *Action Memorandum* documented the Army's selection of the NTCRA at the site.

The primary objective of the NTCRA for SEAD-63 is to remove buried debris (miscellaneous military components) from the burial pits. Soil containing relatively low concentrations of chemical constituents in and immediately surrounding the burial pits (primarily cadmium) and a small quantity of surface material in portions of drainage ditches adjacent to the SEAD-63 site will also be excavated during the Removal Action. Monitoring wells will be installed in overburden materials for future ground-water monitoring (by others).

3.0 FACILITY AND SITE INFORMATION

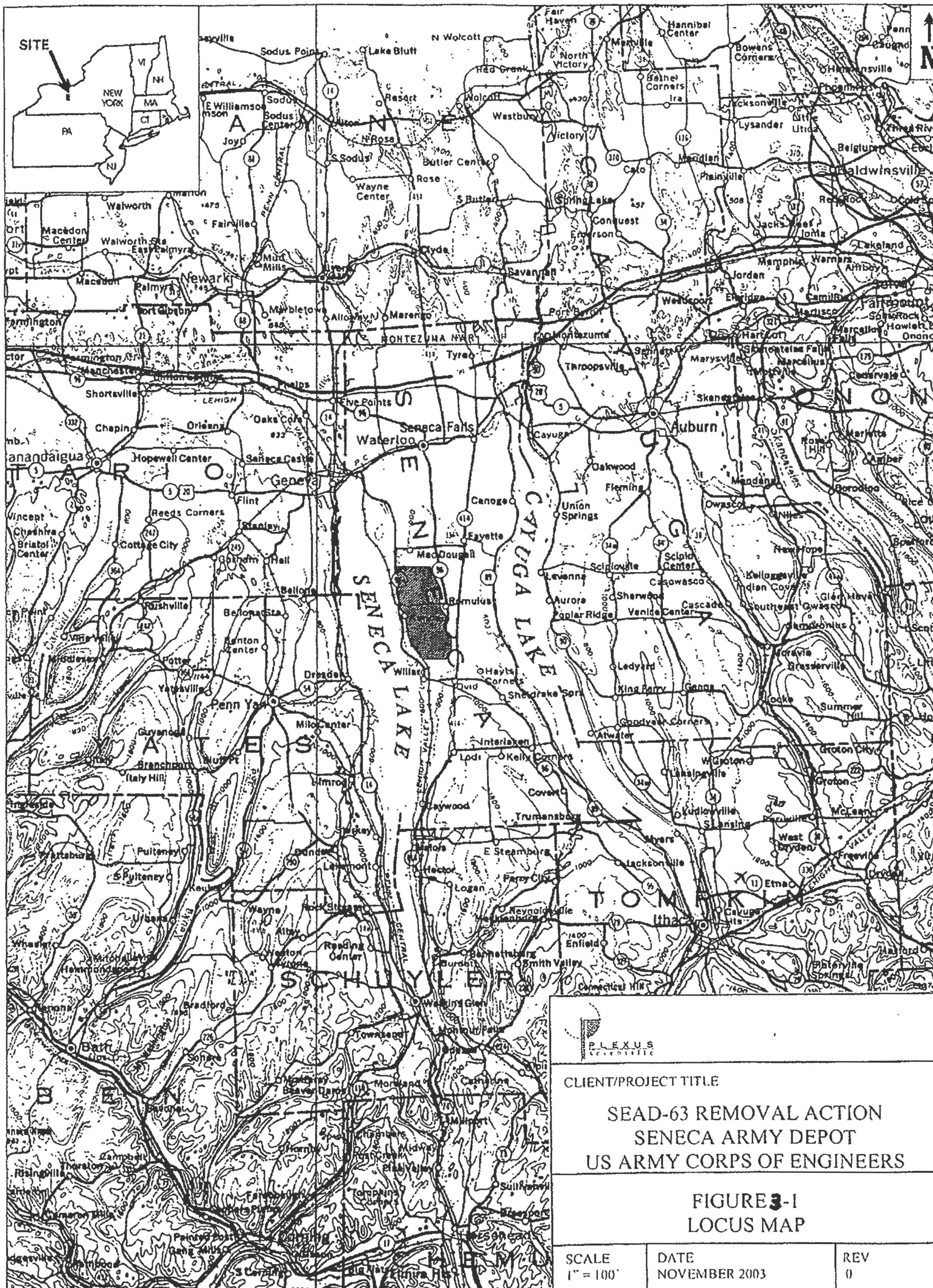
3.1 FACILITY LOCATION

SEDA is a US Army facility located in Seneca County, NY, occupying approximately 10,600 acres. It is bounded on the west by State Route 96A and on the east by State Route 96. The cities of Geneva and Rochester are located to the northwest (14 and 50 miles, respectively); Syracuse is 50 miles to the northeast and Ithaca is 31 miles to the south. The surrounding area is generally used for farming. A locus map is presented as Figure 3-1.

3.2 Facility Description

The SEDA facility is situated on the western flank of a topographic high between Cayuga and Seneca Lakes in the Finger Lakes region of central New York. SEDA was constructed in 1941 and has been owned by the US Government and operated by the Department of the Army since that time. The depot generally consists of an elongated central area formerly used for storage of ammunitions and weaponry in Quonset-style buildings, an operations and administration area in the eastern portion, and a former army barracks area at the north end of the depot. The depot was later expanded to encompass a 1,524-meter airstrip, formerly the Sampson Air Force Base.

The mission of SEDA has primarily been the management of munitions. SEDA was used for: (1) receiving, storing, and distributing ammunition and explosives, (2) providing receipt, storage, and distribution of items that support special weapons, and (3) performing depot-level maintenance, demilitarization, and surveillance on conventional ammunition and special weapons.



CLIENT/PROJECT TITLE

SEAD-63 REMOVAL ACTION
SENECA ARMY DEPOT
US ARMY CORPS OF ENGINEERS

FIGURE 3-1
LOCUS MAP

SCALE	DATE	REV
1" = 100'	NOVEMBER 2003	0

SEDA was included on the USEPA National Priorities List in 1989. Consequently, all work on this project will be performed in accordance with Comprehensive Environmental Response and Liability Act (CERCLA) guidance and the *Federal Facilities Agreement Under CERCLA Section 120, Seneca Army Depot, Romulus, New York* (USEPA, US Department of the Army, and NYSDEC, 1993).

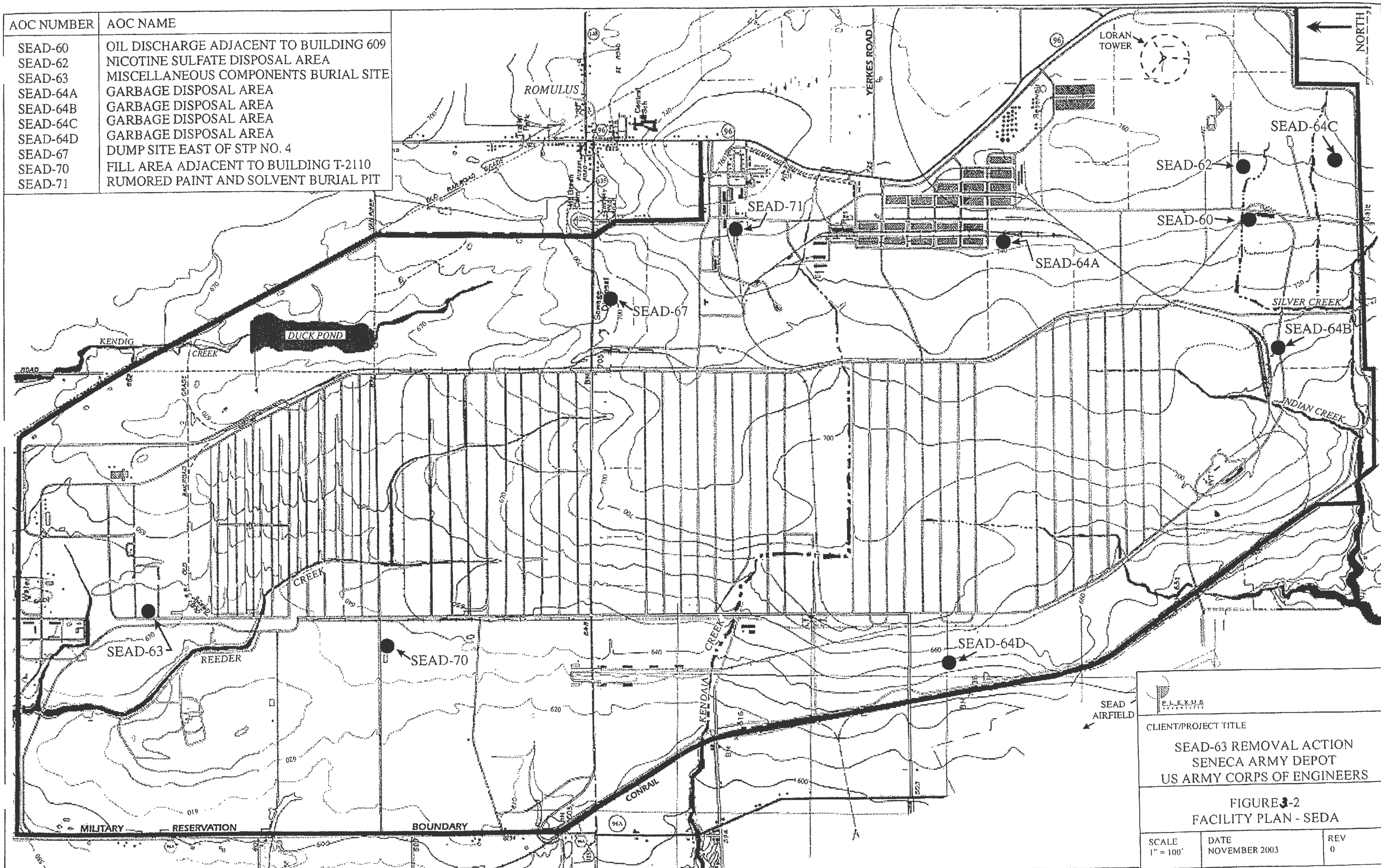
3.3 Site Location

SEAD-63 is located on the east side of North-South Baseline Road in the northwestern part of SEDA (Figure 3-2). The site is approximately 480 by 300 feet and is bounded by paved roads on the north, south and west and by open grassland to the east (Figure 3-3). The SEAD-63 site is mostly undeveloped except for a grass-covered bunker in the southeast corner and an elevated soil area in the northwest corner that formerly supported a machine-gun turret. A crushed shale road enters the site via Patrol Road. In general, the western half of the site is less vegetated and has been physically worn by vehicular traffic. The site is located within a secure, double-fenced area within SEDA.

3.4 Previous Radiological Studies

Previous studies, including the performance of radiological analyses, were conducted at SEAD-63 in support of the EE/CA and *Action Memorandum.* Results of studies and conclusions presented in the EE/CA and *Action Memorandum* indicated gross alpha and gross beta radiation in surface water at levels greater than background, and gross alpha exceeding New York State Ambient Water Quality Standards (NYS AWQS) and federal drinking water criteria. Radioactivity levels in ground-water samples collected from downgradient monitoring wells also exceeded that in a single upgradient monitoring well. Since some ground-water samples previously collected from SEAD-63 monitoring wells were characterized as very turbid, it is possible the high turbidity contributed to these elevated gross alpha/beta results.

Results and conclusions presented in the *Action Memorandum* and EE/CA also indicate a number of radionuclide-specific results as being elevated in SEAD-63 surface-water and surficial material samples collected from the drainage ditches at levels greater than that identified in background samples, but all less than the associated radionuclide-specific soil clean up goals presented in the EE/CA. Upon evaluation of these sample results, it is Cabrera's opinion that variation in background radioactivity may have contributed to many of the statistically elevated radionuclide-specific results. Results of soil samples collected at SEAD-63 did not identify radionuclide activity distinguishable from background. Therefore, soils at SEAD-63 did not exhibit a dose equivalent above the NYSDEC TAGM # 4003 cleanup goal of 10 mrem/yr above background.



AOC NUMBER	AOC NAME
SEAD-60	OIL DISCHARGE ADJACENT TO BUILDING 609
SEAD-62	NICOTINE SULFATE DISPOSAL AREA
SEAD-63	MISCELLANEOUS COMPONENTS BURIAL SITE
SEAD-64A	GARBAGE DISPOSAL AREA
SEAD-64B	GARBAGE DISPOSAL AREA
SEAD-64C	GARBAGE DISPOSAL AREA
SEAD-64D	GARBAGE DISPOSAL AREA
SEAD-67	DUMP SITE EAST OF STP NO. 4
SEAD-70	FILL AREA ADJACENT TO BUILDING T-2110
SEAD-71	RUMORED PAINT AND SOLVENT BURIAL PIT

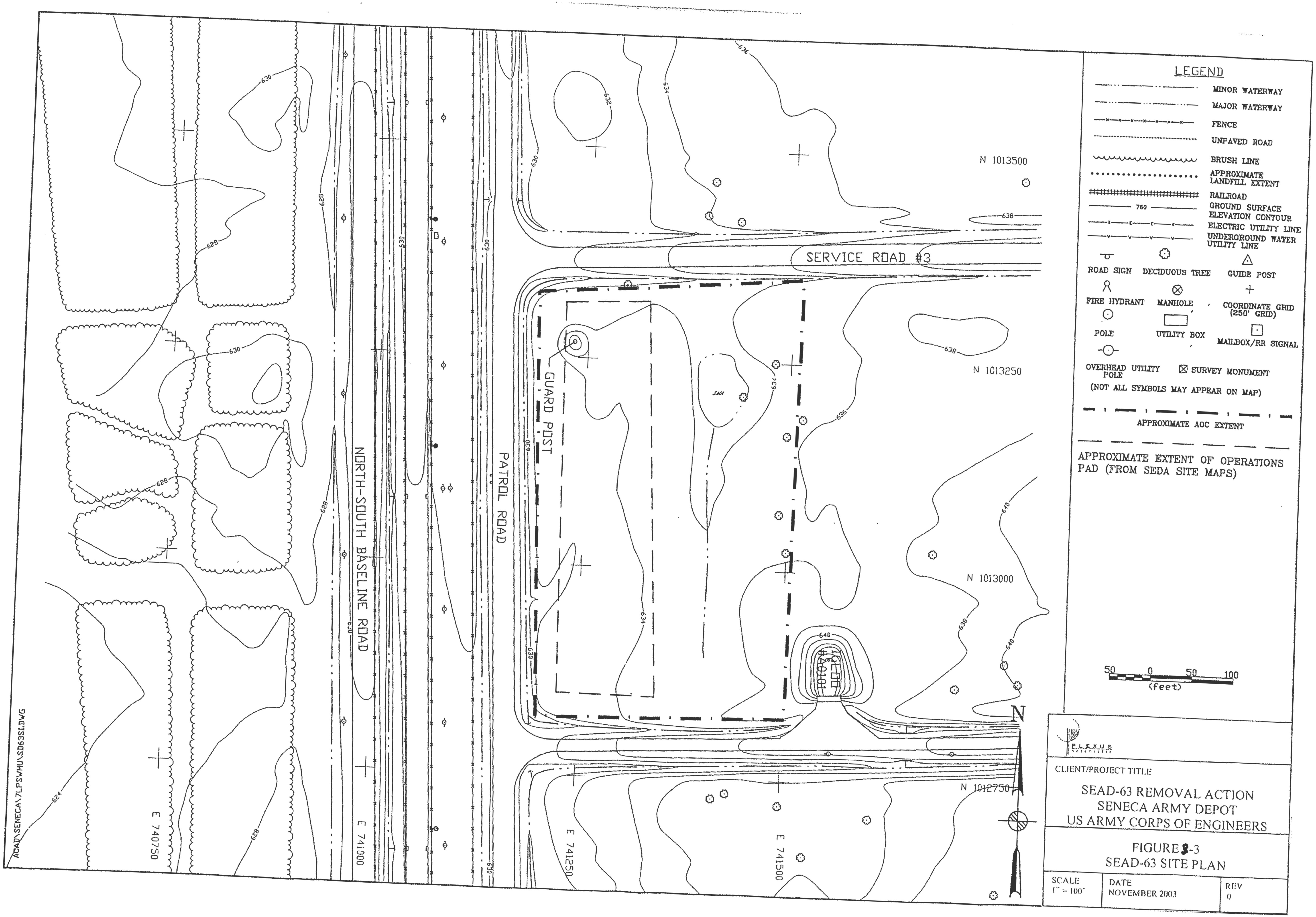
PLEXUS

CLIENT/PROJECT TITLE

SEAD-63 REMOVAL ACTION
SENECA ARMY DEPOT
US ARMY CORPS OF ENGINEERS

FIGURE 3-2
FACILITY PLAN - SEDA

SCALE	DATE	REV
1" = 100'	NOVEMBER 2003	0



LEGEND
MINOR WATERWAY
MAJOR WATERWAY
FENCE
UNPAVED ROAD
BRUSH LINE
APPROXIMATE LANDFILL EXTENT
RAILROAD
GROUND SURFACE ELEVATION CONTOUR
760
ELECTRIC UTILITY LINE
UNDERGROUND WATER UTILITY LINE
ROAD SIGN
DECIDUOUS TREE
GUIDE POST
FIRE HYDRANT
MANHOLE
COORDINATE GRID (250' GRID)
POLE
UTILITY BOX
MAILBOX/RR SIGNAL
OVERHEAD UTILITY POLE
SURVEY MONUMENT
(NOT ALL SYMBOLS MAY APPEAR ON MAP)
APPROXIMATE AOC EXTENT
APPROXIMATE EXTENT OF OPERATIONS PAD (FROM SEDA SITE MAPS)
50 0 50 100
(feet)
SERVICE ROAD #3
NORTH-SOUTH BASELINE ROAD
PATROL ROAD
GUARD POST
N 1013500
N 1013250
N 1013000
N 1012750
E 740750
E 741000
E 741250
E 741500
N
ACAD\SENECA\7LPSWHU\SD63SI.DWG
PLEXUS
CLIENT/PROJECT TITLE
SEAD-63 REMOVAL ACTION
SENECA ARMY DEPOT
US ARMY CORPS OF ENGINEERS
FIGURE 3-3
SEAD-63 SITE PLAN
SCALE
1" = 100'
DATE
NOVEMBER 2003
REV
0

4.0 FINAL STATUS SURVEY

Activities to be performed in support of a FSS of the limits of the burial pits following excavation will encompass gamma walkover surveys (GWS), and the collection and laboratory analysis of soil samples. These activities will be performed for each Survey Unit.

4.1 Soil Clean-Up Goals

As previously mentioned, the NSYDEC TAGM # 4003 cleanup guideline for radioactivity in soil is 10 mrem/yr above background (NYSDEC, 1993). The EE/CA established preliminary radiological clean-up goals, also known as Derived Concentration Guideline Levels (DCGLs) for this project in accordance with MARSSIM and consistent with TAGM # 4003. The preliminary DCGLs utilized presented in the EE/CA are based on a construction worker future-use scenario. The construction worker future use scenario was selected by the US Army to be the most conservative of the relevant future use scenarios.

Preliminary DCGLs presented in the EE/CA were based on the results of radiological laboratory analyses conducted on samples collected during previous SEAD-63 studies. Cabrera has revised the Preliminary DCGLs by selecting, for the purpose of conducting the FSS, only those radionuclides the EE/CA reported as being present at levels greater than background. This is consistent with the NYSDEC's TAGM # 4003 cleanup criteria for radioactivity in soil, which is based on exceeding background concentrations (NYSDEC, 1993). Cabrera has selected the following radionuclides of concern for the FSS: Actinium-227 (Ac-227), Cesium-137 (Cs-137), Cobalt-60 (Co-60), Radium-226 (Ra-226), Thorium-230 (Th-230), tritium (H-3), Uranium-234 (U-234), Uranium-235 (U-235) and Uranium-238 (U-238). Some of these radionuclides will be measured for comparison to cleanup goals by performing gross alpha analyses and others by performing gamma spectroscopy analyses. For those radionuclides being measured by gross alpha analyses, the total number of alpha decays for each particular radionuclide decay chain must be multiplied by the DCGL to establish an effective alpha DCGL. Table 4-1 summarizes the radionuclides, DCGLs and minimum detectable limits (MDLs) that will be used in conducting the MARSSIM-compliant FSS to evaluate whether the SEAD-63 burial pits may be released for unrestricted use following the NTRCA. A sum of the ratios (SOR) value will be calculated for each of the radionuclides of concern, as presented in Section 4.6, to establish the effective FSS $DCGL_W$ (DCGL used for Wilcoxon Rank Sum statistical test) to maintain the NYSDEC TAGM cleanup guideline of 10 mrem/yr above background when measuring multiple radionuclides of concern.

TABLE 4-1
RADIONUCLIDES, DCGLs AND MDLs FOR SOIL
NON-TIME CRITICAL REMOVAL ACTION, SEAD-63 BURIAL PITS
SENECA ARMY DEPOT, ROMULUS, NEW YORK

Radionuclide	Preliminary DCGL[1] pCi/g	Alphas per Decay	Effective Alpha DCGL	Approximate Gamma Spec MDL
Ac-227	3.4	5.5	18.7	NA
Cs-137	6.8	0	NA	0.2
Co-60	1.4	0	NA	0.2
Ra-226	2	1 (1)	2.0	1
Th-230	111	1	111	NA
H-3	52,020	0	NA	NA
U-234	24.9	1	24.9	NA
U-235	27	1	27.0	0.5
U-238	104	1	104	1

Preliminary DCGLs from EE/CA (Parsons Engineering Science, Inc., 2001a)

(1) Ra-226 alphas per decay are based on the assumption that daughter progeny ^{222}Rn escapes precluding the deposition of ^{222}Rn progeny

NA = not applicable or appropriate

4.2 Area Classification Based on Contamination Potential

As discussed in MARSSIM, areas of sites undergoing FSSs should be classified according to their potential for residual radioactivity. Section 2.2 of MARSSIM provides the following definitions for classifying areas:

Non-impacted Areas: Areas that have no reasonable potential for residual contamination.

Impacted Areas:	Any area not classified as non-impacted. Areas with a possibility of containing residual radioactivity in excess of natural background or fallout levels.
Class 1 Areas:	Impacted areas that have, or had prior to remediation, a potential for contamination (based on site operating history) or known contamination (based on previous radiological surveys) above the $DCGL_W$.
Class 2 Areas:	Impacted areas that, prior to remediation, are not likely to have concentrations of residual radioactivity that exceed the $DCGL_W$.
Class 3 Areas:	Impacted areas that have a low probability of containing residual radioactivity.

The SEAD-63 burial pits will be classified as Class 3 areas (FSS 'Survey Units') based on the low probability of this area containing radioactivity at concentrations exceeding background. Previous studies, summarized in the EE/CA, have not indicated the presence of radioactivity in the burial pits soils at levels exceeding background.

4.3 FSS Reference Coordinate System

A FSS reference coordinate system will be developed and installed early in the FSS process. All coordinates will be referenced to the State Plane Coordinate System. At a minimum, the corners of the Survey Unit will be identified and clearly marked. Additionally, to facilitate the GWS, intermediate markings may be installed using pin flags to mark the start and end points of planned survey lines. The use of a global positioning system (GPS) obviates the need for marking small grid intervals.

4.4 FSS Unit Size

MARSSIM Class 3 Survey Units may be any size. The estimated footprint of the proposed burial pits excavation is approximately 13,400 square meters (m^2) in size (Parsons Engineering Science, Inc., 2001a). As such, the excavation may be considered as a single Class 3 Survey Unit.

4.5 Number of Sample Locations for FSS Unit and Reference Area

MARSSIM discusses a method to determine the number of sample locations required in a given Survey Unit. A minimum number of sample locations are required in each Survey Unit to obtain sufficient statistical confidence that the conclusions drawn from the measurements are correct. For the purpose of this FSS, the minimum required number of measurements is based on expected radionuclide concentrations in site areas that may be suitable for release for unrestricted use. The following sections describe the bases for and derivation of the minimum required measurement locations per Survey Unit.

4.6 Estimation of Relative Shift

The minimum number of sample locations required is dependent on the distribution of site residual radionuclide concentrations relative to the DCGL and acceptable decision error limits (α and β) established in Section 5.6. When multiple contaminants are present on a site, such as the SEAD-63 site, radiological conditions are evaluated using the sum of the ratios and a $DCGL_w$ of SOR =1.0. The SOR is calculated as follows:

$$SOR = \frac{C_1}{\mathrm{DCGL}_1} + \frac{C_2}{\mathrm{DCGL}_2} + \frac{C_3}{\mathrm{DCGL}_3} + \ldots \frac{C_n}{DCGL_n}$$

Where: C_n.= Measured activity concentration for a given nuclide

$DCGL_n$ = $DCGL_w$ pCi/g for the given nuclide

The relative shift describes the relationship of site residual radionuclide concentrations to the DCGL and is calculated using the following equation, found in Section 5.5.2.3 of MARSSIM. Based on available site data and the assumptions described below, the relative shift used to determine the minimum number of samples is 1.0.

$$\Delta/\sigma = \frac{\mathrm{DCGL}_w - \mathrm{LBGR}}{\sigma}$$

Where: $DCGL_w$ = Derived concentration guideline level [that is (i.e.), release limit]

LBGR = Concentration at the lower bound of the gray region. The LBGR is the concentration to which the survey unit must be remediated to have an acceptable probability of passing the statistical tests. The LBGR effectively becomes the FSS action level

σ = An estimate of the standard deviation of the concentration of residual radioactivity in the Survey Unit (which includes real spatial variability in the concentration as well as the precision of the measurement system)

(1) $DCGL_w$

As described previously, the $DCGL_w$ is equal to an SOR of 1.0.

(2) LBGR

The LBGR is typically used as a clean-up guideline (or action level), as discussed above. This application of the LBGR is not directly applicable to the survey design, because the remediation goal is to effectively remove all residual radioactivity. MARSSIM suggest using one-half of the $DCGL_w$ for the LBGR. The LBGR for an SOR of 1 is then 0.5.

(3) Sigma (σ)

Considering the Removal Action goal is to ensure no residual radioactivity exists following excavation and removal of the burial pits, the standard deviation of Survey Unit activity concentration estimates is assumed to be approximately equal to background. The assumed standard deviation must also consider the expected variability in the measurement techniques. Standard deviation values have been collected for each radionuclide presented in Table 4-1 from SEAD-63 soil sample data presented in Table 2-5 of the EE/CA. Standard deviations for Co-60 and H-3 were not reported for SEAD-63 sample results and are based instead on reference area background data presented in Table 2-5 of the EE/CA. The standard deviations and calculated standard deviation SORs are presented in Table 4-2. Radionuclide-specific standard deviation SORs presented in Table 4-2 were calculated by dividing each standard deviation by the respective radionuclide specific $DCGL_w$. The average standard deviation SOR of 0.29 was then developed by calculating the square root of the sum of the squares of each radionuclide-specific standard deviation SOR.

The resulting relative shift is 1.75 after subtracting the LBGR from the $DCGL_w$ and dividing by 0.29. This value was re-calculated with 20 percent (%) added to the average standard deviation SOR for conservatism (0.34) and the resulting relative shift is calculated to be 1.46.

Table 4-2

Determination of Standard Deviation SORs

Analysis	Radionuclide(s)	FSS DCGL	Standard Deviation	Standard Deviation SOR
Gross Alpha	Ac-227, Th-230, U-234	18.7	2.79	0.149
Gamma Spectroscopy	Cs-137	6.8	0.22	0.032
	Ra-226	2	0.47	0.235
	Co-60	1.4	0.08	0.057
	U-235	27	0.08	0.003
	U-238	104.2	0.32	0.003
H-3 (Tritium)	H-3	52020	10.05	0.0002

* Standard Deviations for Co-60 and H-3 are based on BKG results

Average Standard Deviation SOR	0.29
Relative Shift	1.75
-Add 20% -	
Average Standard Deviation SOR	0.34
Relative Shift	**1.46**

4.6.2 Determination of N (Number of Required Sample Locations)

The Wilcoxon Rank Sum (WRS) statistical test will be used to determine whether portions of the site are suitable for release for unrestricted use. The minimum number of systematic measurement locations required in each FSS unit for the WRS statistical test is determined using the calculated relative shift in Table 4-2 and MARSSIM Table 5.3.

Section 4.6 establishes the acceptable decision errors to be α=0.05 and β=0.05. Based on these acceptable decision errors, and the relative shift of 1.46 established in the previous section, the minimum number of measurement locations in each FSS unit, N, is 19. MARSSIM includes 20% additional samples in the sample number values presented in Table 5.3 to protect against the possibility of lost or unusable data.

4.6.3 Biased Sample Measurements

If areas of elevated radioactivity are identified during the GWS, biased samples will be collected to facilitate evaluation of elevated area radionuclide concentrations against MARSSIM elevated measurement comparison (EMC) criteria. At a minimum, one biased soil sample will be collected in each Survey Unit at the location of the highest gamma walkover reading. Biased samples may also be collected at locations where GWS data "Z" Scores exceed three.

4.7 Establishing Sample Locations

MARSSIM requires the establishment of random sampling locations for Class 3 Survey Units. These random coordinates will be established using Microsoft Excel® or other computer program. The random sample location coordinates will then be located in the Survey Unit using a GPS and measuring tape, as necessary. A GPS will be used for locating the reference area sample locations.

5.0 DATA QUALITY OBJECTIVES

5.1 Step 1: Sate the Problem

5.1.1 Problem Description

The objective of FSS activities is to obtain data of sufficient quality and quantity to support unrestricted release of the SEAD-63 burial pits. The problem will be identifying the potential presence of residual radioactive material from former US Army operations at the limits of the burial pit excavation.

5.1.2 Planning Team Members

FSS planning will be performed by a team of Plexus and their health physics subcontractor personnel, with input and direction from the USACE.

5.1.3 Primary Decision Maker

The ultimate decision regarding site disposition will rest with the USACE. As such, the USACE, in consultation with Plexus' Project Manager and health physics subcontractor, will make decisions for the FSS activities.

5.1.4 Available Resources

Sufficient resources are available through the combined staff of Plexus and their health physics subcontractor to perform and complete all work required to achieve FSS objectives.

5.2 Step 2: Identify the Decision

5.2.1 Principal Study Question

Do concentrations of radionuclides of concern at the site exceed background (reference area) levels by more than the $DCGL_w$ (SOR of 1.0) following remedial activities and, if so, where are elevated concentrations located?

5.2.2 Decision Statement

The following statements assume that ROC concentrations in Class 3 Survey Units will be found to exceed an SOR of 1.0, after Removal Action activities. Decision statements should be evaluated sequentially, as shown below.

(A) Determine whether Survey Unit SORs exceed background SORs by more than the $DCGL_w$

(B) Based on sample results, if Survey Unit SORs exceed background SORs by more than the $DCGL_w$, recommend whether further excavation is required at the Survey Unit and/or the Survey Unit should be reclassified (i.e., to a Class 1 FSS Survey Unit).

5.3 Step 3: Identify Inputs to the Decision

A variety of data are required to resolve the decision statements listed in Section 5.2. This section lists data needs, describes the sources of that data, and discusses the means of obtaining the required data points.

5.3.1 Information Inputs:

The following site characteristics must be determined to resolve applicable decision statements:

(A) Concentrations of residual radioactive material in the Survey Unit:

This information will allow determination as to whether or not a Survey Unit is likely to be suitable for release for unrestricted use. Obtaining these data will facilitate cost effective decision-making regarding the project's direction and duration.

(B) Information Sources:

The GWS and volumetric sample analysis, gamma spectroscopy data will provide sufficient information to enable estimation of Survey Unit radionuclide concentrations.

5.4 Step 4: Define the Study Boundaries

5.4.1 Population of Interest Defining Characteristics

The population of interest for the site is the concentration of radionuclides of concern and their associated SORs in surface and shallow subsurface soils.

5.4.2 Spatial Boundaries of the Decision Statement

The population of interest is horizontally limited to land areas located within the SEAD-63 burial pits. The vertical study area extends from the land surface to the depth of up to six inches below ground surface (BGS).

5.4.3 Temporal Boundaries of the Decision Statement

(A) Time frame to which the decision applies:

$DCGL_W$ values are based on risks to an average member of the Critical Group over a 1,000-year period following the study. The Critical Group is based on the construction worker future-use scenario.

(B) Time for data collection:

Data collection and analysis should be performed as soon as practical, as timely completion of the site restoration is contingent upon the results of the FSS.

5.4.4 Scale of Decision Making:

Decisions will be made for small areas that may exhibit elevated levels of radioactivity, then for individual Survey Unit(s) regarding whether or not they meet the criteria for unrestricted release.

5.4.5 Constraints on Data Collection:

Data collection activities can be constrained due to excessive moisture or rain, which can have an adverse effect on field instrumentation.

5.5 Step 5: State the Decision Rules

5.5.1 Parameter of Interest

Parameters of interest are the mean, median, and standard deviation of data collected during the study. Based on the data distribution characteristics resulting from FSS data collection, the preceding parameters may be transformed to equivalent descriptive measures (e.g., logarithms, etc.) to allow more representative statistical testing. By using a graded approach to data testing as discussed below, decisions will be made according to the decision rule stated at the end of this section.

5.5.2 Scale of Decision Making

Decisions are made on two fundamental scales, the Survey Unit and smaller localized areas of elevated activity. Localized areas of elevated radiation levels are evaluated on an ongoing basis throughout the field effort. In cases where clear indications of elevated measurements are observed, decisions on remediation, Survey Unit subdivision, etc., may be taken as appropriate. On a larger scale, and as a final determination, data will be evaluated on a Survey Unit-specific basis.

5.5.3 Action Level

Decisions on a Survey Unit's acceptability for release are based on comparison of the $DCGL_w$ to the difference between measured residual radioactivity concentrations in Survey Unit and measured radioactivity in the reference area, subject to applicable statistical analyses specified in MARSSIM. Inputs to this decision will be based on a graded approach to data analysis intended to avoid unnecessary analytical and/or remediation efforts, while also ensuring that project DQOs are met.

5.5.4 Decision Inputs

Geospatial modeling of position-correlated GWS data will provide a graphical view of surface gamma radiation levels and will be updated as the FSS progresses. These data will serve as the primary decisions input during performance of the fieldwork because data will be reduced soon after collection, in comparison to the longer turn around time associated with laboratory sample analysis.

Assessment of soil sample data will be as simple as visually inspecting data to identify obvious indicators that the action level has or has not been met. If all sample SORs are below the $DCGL_w$ of SOR = 1.0, the FSS unit will meet the release criteria. If not, the WRS test will be applied to the data.

(A) Field Measurements of Survey Unit Dimensions

The dimensions of the survey unit will be measured using a measuring tape, GPS, or other accurate means of measurement, once the boundaries are established. At a minimum, the corners of the Survey Unit will be logged using the GPS system. The area of the Survey Unit will then be calculated in units of m^2; GPS data will be entered into a CAD program to support Survey Unit area calculations. These data will be used to determine sampling locations.

(B) Gamma Walkover Survey in Reference Area

Soon after the background (reference) area is established, a GWS will be performed. These data will be used, in part, to make decisions regarding the radiological status of the SEAD-63 burial pits Survey Unit. Reference area GWS data will be reduced and evaluated as follows:

- The average and standard deviation of the GWS data will be calculated. This will be used to evaluate Survey Unit data
- The measurement results will be plotted and color-coded for visual review and evaluation
- The "Z" score for each data point (i.e., number of standard deviations from the average) will be plotted and color-coded for visual review and evaluation
- These data will be reviewed for obvious anomalies to determine if the chosen reference area is acceptable

(C) Gamma Walkover Survey in Survey Unit

GWS of the Survey Unit will begin after completion of the GWS on the reference area, calculation of the mean and standard deviation, and determination that the reference area is acceptable. Survey Unit GWS data will be reduced and evaluated as follows:

- The measurements will be plotted and color-coded for visual review and evaluation. The average and standard deviation of each Survey Unit will also be calculated. The coordinates of the highest measurement will be identified.
- The "Z" score for each data point (i.e., number of standard deviations from the average) will be plotted and color-coded for visual review and evaluation. All areas exceeding three standard deviations above the average (i.e., Z-score ≥ 3) will be identified. The frequency of these occurrences and the maximum measurement in these areas will be compared to the reference area. The geospatial plot will also be visually inspected to identify anomalies in the distribution of measurement data.
- These data will be reviewed to make a preliminary determination of whether a Survey Unit has a low probability of passing the MARSSIM statistical tests.

(D) Volumetric Results: Wilcoxon Rank Sum Statistical Test

Comparison of reference area (background) radionuclide concentrations with Survey Unit concentrations will be performed using the two-sample WRS statistical test. This test is selected because the some of the radionuclides of concern are present in natural background. The two-sample WRS test assumes the reference area and Survey Unit data distributions are similar except for a possible shift in the medians. When the data are severely skewed, the value for the mean difference between Survey Unit measurements and reference measurements may be above the $DCGL_W$, while the median difference is below the $DCGL_W$. In such cases, the Survey Unit does not meet the release criterion regardless of the result of the statistical test. On the other hand, if the difference between the largest Survey Unit measurement and the smallest reference area measurement is less than the $DCGL_W$, the WRS test will always show that the Survey Unit meets the release criterion.

In using this test, the hypotheses being tested are:

> *Null Hypothesis (H_0)*: The median concentration in the Survey Unit exceeds that in the reference area by more than the $DCGL_W$.
>
> versus the alternative:
>
> *Alternative Hypothesis (H_a)*: The median concentration in the Survey Unit exceeds that in the reference area by less than the $DCGL_W$.

The WRS should be applied to sample data via the following sequential steps:

1) Reduce Reference Area and Survey Unit isotopic data to SORs using the equation presented in Section 2.
2) Add the $DCGL_W$ value (i.e., 1.0) to each reference area SOR value, Xi, to obtain the adjusted reference area SORs, Zi. (Zi = Xi + 1.0).
3) The *m* adjusted SORs, Z_i, from the reference area and the *n* SORs, Y_i, from the FSS unit are pooled and assigned a rank in order of increasing measurement value from *l* to *N*, where $N = m + n$.
4) If several SORs are tied (have the same value), they are all assigned the average rank of that group of tied measurements.
5) Sum the ranks of the adjusted SORs from the reference area, W_r. since the sum of the first *N* integers is *N* (*N*+1)/ 2, one can equivalently sum the ranks of the SORs from the Survey Unit, W_s, and calculate $W_r = (N\ (N+1)/\ 2)-W_s$.
6) Compare W_r with the critical value given in Table I.4 in MARSSIM for the approximate values of *n*, *m*, and [illegible]. If W_r is greater than the tabulated value, reject the null hypothesis that the Survey Unit exceeds the release criterion.

5.5.5 Decision Rules

(A) Gamma Walkover Survey in Reference Area

If review of reference area GWS data indicates that the chosen area exhibits excessive variance or appears to be impacted by radiological or non-radiological activities (e.g., phosphate fertilizer, fossil fuel wastes, etc.), biased sample measurements will be performed to support the area's non-impacted designation.

(B) Gamma Walkover Survey in Survey Unit

- A biased soil sample will be collected at the location where the highest GWS data point is observed.
- If areas exceeding three standard deviations above the average are observed (i.e., a Z-score greater than or equal to 3.0), additional biased soil samples may be collected at the discretion of Plexus' Project Manager, or designee.

(C) Volumetric Results: Wilcoxon Rank Sum Statistical Test

- If all sample results for the Survey Unit have associated SORs that are less than the $DCGL_w$ (i.e., SOR = 1.0), the Survey Unit is deemed to meet the release criterion.
- If any of the SORs for the Survey Unit exceeds the $DCGL_w$, perform the WRS test:
- If W_r, the sum of the adjusted reference area ranks from the WRS test, is greater than the applicable critical value, then the median value for residual radioactivity in the Survey Unit is less than the $DCGL_w$ to the specified confidence level. In this case, the null hypothesis (H_o) is rejected and the Survey Unit meets the release criterion. If W_r is less than the critical value, the null hypothesis is accepted and the Survey Unit does not meet the release criteria.

5.6 Step 6: Define Acceptable Decision Errors

US Nuclear Regulatory Commission (NRC) guidance (NRC, 1998) provides a discussion regarding decision errors. This discussion includes the concept that acceptable error rates, which balance the need to make appropriate decisions with the financial costs of achieving high degrees of certainty, must be specified.

> *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 mean and median 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 β. Considered in light of H_0 used for this site (discussed above), this error could result in 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 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 the FSS, the acceptable error rate for both Type I and Type II errors is five percent (i.e., $\alpha = \beta = 0.05$).

6.0 METHODOLOGY AND APPROACH TO PERFORMING SURVEYS

6.1 Gamma Walkover Survey Utilizing GPS

MARSSIM Section 5.5.3 indicates that for a Class 3 Survey Unit, a scan survey is recommended for areas with the highest potential for contamination. There are no particular areas at SEAD-63 where contamination is expected to be identified; however, a GWS will be performed across 100% of the bottom of the Class 3 Survey Unit to provide conservatism to the FSS Plan. It should be noted that some of the radionuclides presented in Table 4-1, including tritium, Th-230, and Ac-227 will not be detected by the GWS.

The FSS will be performed following MARSSIM protocol by walking straight parallel lines over an area while moving the detector in a serpentine motion, two-inches to four-inches above the ground surface. Survey passes will be approximately one meter apart. A one-meter path length will be used to perform the survey. The side-to-side motion of the detector must be 0.5 meters per second (m/s) to meet the design criteria. Therefore, each detector pass will take two seconds (i.e., 1m ÷ 0.5 m/s).

Data from the ratemeter/scaler will be automatically logged into the GPS unit every two seconds. After completion of the GWS, the data will be downloaded from the GPS into a personal computer (PC) file and entered into a geospatial software program. After completion of data processing, a contour map will be generated to aid in the visual identification of areas of elevated radiological activity.

6.1.1 GWS Equipment

Equipment required for performing the GWS includes the following:

- GPS Base Station: Trimble Universal Reference Station (or equivalent, as necessary)
- GPS Rover: Trimble Pathfinder Pro - XR (or equivalent)
- Hardware: IBM-compatible Pentium (minimum) PC, color printer, large capacity data storage device (e.g., zip drive), modem, large format plotter, (note that some hardware may not be site-based)
- Software: Trimble Pathfinder, AutoCAD (or equivalent CAD software) with coordinate geometry capability, ARCInfo (or equivalent GIS software), access to GIS spatial information data files (via the World Wide Web)

6.1.2 GPS Setup

The GPS system will provide high quality, precision geospatial positioning data to support data verification, and remediation. The rate-meter/scalars used for this work plan will be configured to output directly to the GPS unit. The GPS unit will perform data logging functions.

Differential position correction is necessary for the GPS unit to achieve sub-meter accuracy. Two methods for doing this are: (1) post-processing differential correction and (2) real-time differential correction. Essentially, the difference between the two is the time during which the corrections are made. Real-time differential correction is possible if the site being considered is located within range of a United States Coast Guard (USCG) GPS differential correction beacon. These beacons are located in coastal areas of the US. Real-time correction does not require a GPS base station. Based upon manufacturers' recommendations, the Site is likely to be within range of a USCG beacon, allowing for real-time differential correction. However, if for some reason the USCG beacon cannot be received by the GPS system, post-processing differential correction will be used.

6.1.3 Survey Limitations

Although the GPS unit identifies its position using the signals from several satellites, GPS positioning may be affected by overhead obstructions. A loss of satellite signal due to these obstructions may prevent collection of location data, depending on the severity of the loss and the positional filter settings in use in the GPS unit. If this occurs, data collection will not resume until satellite lock is regained (usually by moving past the obstruction) and the positional filter requirements are satisfied. If the signal is lost during a GWS, the operator shall continue to walk at constant velocity in a straight line until satellite lock has been reestablished or until a boundary is reached. In such cases, due to positional filter settings in the GPS unit, no gamma logging occurs. In that event, gamma readings must be taken by hand. The surveyor will need to inform the data processing specialist if the gamma count rates between pairs of GPS positional data changes considerably. Such information will be logged in project logs as appropriate.

Extrapolation of gamma data positions beyond good GPS locations requires additional post-processing programs or hand editing of data. It is desirable, therefore, to begin and end a survey path with good GPS positions. The GWS crew shall extend the beginning or end of a survey path (in a straight line) beyond a designated boundary in order to obtain satellite lock, if necessary. On occasion, it may not be possible to get a good satellite lock because of satellite positions in the sky or technical problems with the satellite system. In this case, a short wait (e.g., one-half hour) is usually sufficient to regain satellite lock. If necessary, survey paths without good satellite locks will be repeated and/or hand surveyed and located.

6.2 Soil Sampling

The FSS area, which is the burial pits, will encompass one or more Class 3 Survey Units, as determined by the actual location of the burial pits. The final configuration of the burial pits is unknown at present. The sidewalls and bottom of each Survey Unit will be randomly sampled to determine the presence of residual radioactive contamination. Samples will be collected from the exposed surface to six inches BGS. The number of samples to be collected in each survey unit is specified in Section 4.6.2. Soil samples will be delivered to an off-site laboratory for gamma spectroscopy, gross alpha, gross beta, and tritium analysis. Off-site laboratory analyses will be performed using analysis and quality control methods as presented in the project Sampling and Analysis Plan.

6.3 Data Processing

6.3.1 Field Records

Project data will be recorded in a Project Log Book. Field Log Book records will be sufficient to allow data transactions to be reconstructed after the project is completed. One designated Project Log Book will be used during the field effort. The field Health Physics Technician (Rad Tech) is responsible to ensure logbook entries are made as necessary and appropriate. The Rad Tech will review the Project Log Book at least daily and will report significant issues to Plexus' on-site Contractor Quality Control (CQC) Systems Manager or Plexus' Project Manager.

Field Log Books are used for each survey team and/or equipment used during the field effort. Multiple field data logbooks are acceptable to use, as long as they are assigned to individual FSS teams and/or equipment. The Rad Tech is responsible to ensure logbook entries are made as necessary and appropriate. The Rad Tech will review Field Log Book(s) at least daily and will report significant issues to Plexus' CQC Systems Manager or Project Manager.

Field Log Books are considered legal records. Log Books will be permanently bound and the pages will be numbered. Pages may not be removed from Log Books under any circumstances. Entries will be legible, factual, detailed, and complete and will be signed and dated by the individual(s) making the entries. If a mistake is made, the error shall be denoted by placing a single line through the erroneous entry and initialing the deletion. Under no circumstances will any previously entered information be completely obliterated. Use of whiteout in Log Books is not permitted for any reason.

6.3.2 Electronic Data

Electronic data collected during the day will be backed-up at the end of the same day in the field (e.g., to tape or zip drive) and before processing or editing. This is an archive of the raw data and, once created, will not be altered. More than one day's data may go on a single tape or zip disk. Field computer(s) used to store GPS data will be backed up weekly. Raw archived data will be stored in a different location from weekly backups. Electronic GPS data will be provided daily to off-site data processing specialists. The time and date that data files are transmitted will be recorded in the data logbook. File names will be verified by comparison with field notes and corrected if necessary, following approval by the Rad Tech.

6.3.3 Post Processing

Post-processing specialists will convert daily GWS/GPS data to state plane coordinates, as necessary, and review the data for errors to fluctuations/interferences in the GPS signal. Post-processing specialists will inform the Project Engineer of any identified deficiencies and will make corrections as directed. All conversions, errors, corrections and/or adjustments to project data shall be documented in the data logbook.

7.0 FSS QUALITY ASSURANCE/QUALITY CONTROL

Quality Assurance and Quality Control activities associated with this project performance shall be performed in accordance with the provisions of the project Sampling and Analysis Plan.

8.0 REFERENCES

Multi-Agency Radiological Site and Survey Investigation Manual (MARSSIM). NUREG-1975. EPA 402-R-97-016). August 2000.

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