SHALLOW LAND DISPOSAL AREA (SLDA) SITE
FINAL STATUS SURVEY PLAN

PARKS TOWNSHIP, ARMSTRONG COUNTY, PENNSYLVANIA

NOVEMBER 2010

U.S. Army Corps of Engineers
Formerly Utilized Sites Remedial Action Program

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Prepared by
U.S. Army Corps of Engineers, Formerly Utilized Sites Remedial Action Program

with technical assistance from
Environmental Science Division, Argonne National Laboratory

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ACRONYMS, ABBREVIATIONS, AND SYMBOLS

ac	acre(s)
Ac	actinium
AEC	Atomic Energy Commission
ARAR	applicable or relevant and appropriate requirement
Am	americium
bgs	below ground surface
BWXT	BWX Technologies, Inc.
CCQC	contractor chemical/radiological quality control
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm	centimeter(s)
cpm	count(s) per minute
CQC	chemical/radiological quality control
CSM	conceptual site model
CFR	*Code of Federal Regulations*
DCGL	derived concentration guideline level
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DQA	data quality assessment
DQCR	daily quality control reports
DQO	data quality objectives
EM	Engineer Manual
EPA	U.S. Environmental Protection Agency
FIDLER	Field Instrument for the Detection of Low Energy Radiation
FUSRAP	Formerly Utilized Sites Remedial Action Program
FSP	field sampling plan
FSS	final status survey
FSSP	final status survey plan
ft	foot (feet)
g	gram(s)
GM	Geiger-Mueller
GPS	global positioning system
GWS	gamma walkover survey
H_0	null hypothesis
ha	hectare(s)
IDW	investigation-derived waste
in.	inch(es)
kg	kilogram(s)
km	kilometer(s)
LBGR	lower bound of gray region
m	meter(s)
m^2	square meter(s)
m^3	cubic meter(s)

ACRONYMS, ABBREVIATIONS, AND SYMBOLS (Cont.)

MARSAME	Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	minimum detectable concentration
mi	mile(s)
MPB	material processing building
mrem	millirem(s)
MS/MSD	matrix spike/matrix spike duplicate
NaI	sodium iodide
NCR	nonconformance report
NRC	U.S. Nuclear Regulatory Commission
NUMEC	Nuclear Material and Equipment Company
NUREG	U.S. Nuclear Regulatory Commission Report
PADEP	Pennsylvania Department of Environmental Protection
PARCC	precision, accuracy, representativeness, comparability, and completeness
RESRAD	RESidual RADioactivity
pCi	picocurie(s)
PPE	personal protective equipment
PRGs	preliminary remediation goals
Pu	plutonium
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
Ra	radium
RESRAD	RESidual RADioactivity
RI	remedial investigation
RIR	Remedial Investigation Report
Rn	radon
ROC	radionuclide of concern
ROD	record of decision
SAP	sampling and analysis plan
SLDA	Shallow Land Disposal Area
SOP	standard operating procedure
SOR	sum of ratios
SS&HP	site safety and health plan
Th	thorium
TPP	technical project planning
U	uranium
USACE	U.S. Army Corps of Engineers
UTL	upper tolerance limit
yd^3	cubic yard(s)
VOC	volatile organic compound
WRS	Wilcoxon Rank Sum
yr	year(s)

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1 INTRODUCTION

This plan provides a framework for conducting a final status survey (FSS) of soils at the Shallow Land Disposal Area (SLDA) site in Armstrong County, Pennsylvania, about 23 miles (mi) (37 kilometers [km]) east-northeast of Pittsburgh, Pennsylvania. The 44-acre (ac) (18-hectare [ha]) site is largely undeveloped and was used for disposal of radioactive wastes between 1961 and 1970. The waste material was placed into nine trenches and a backfilled settling pit (referred to as Trench 3) (ARCO/B&W 1995). The radioactive contamination at the site is generally confined to the immediate vicinity of the trench areas, and, in addition, to a few localized pockets of contaminated surface soils outside these areas. The study area in Figure 1-1 illustrates general site characteristics and disposal areas.

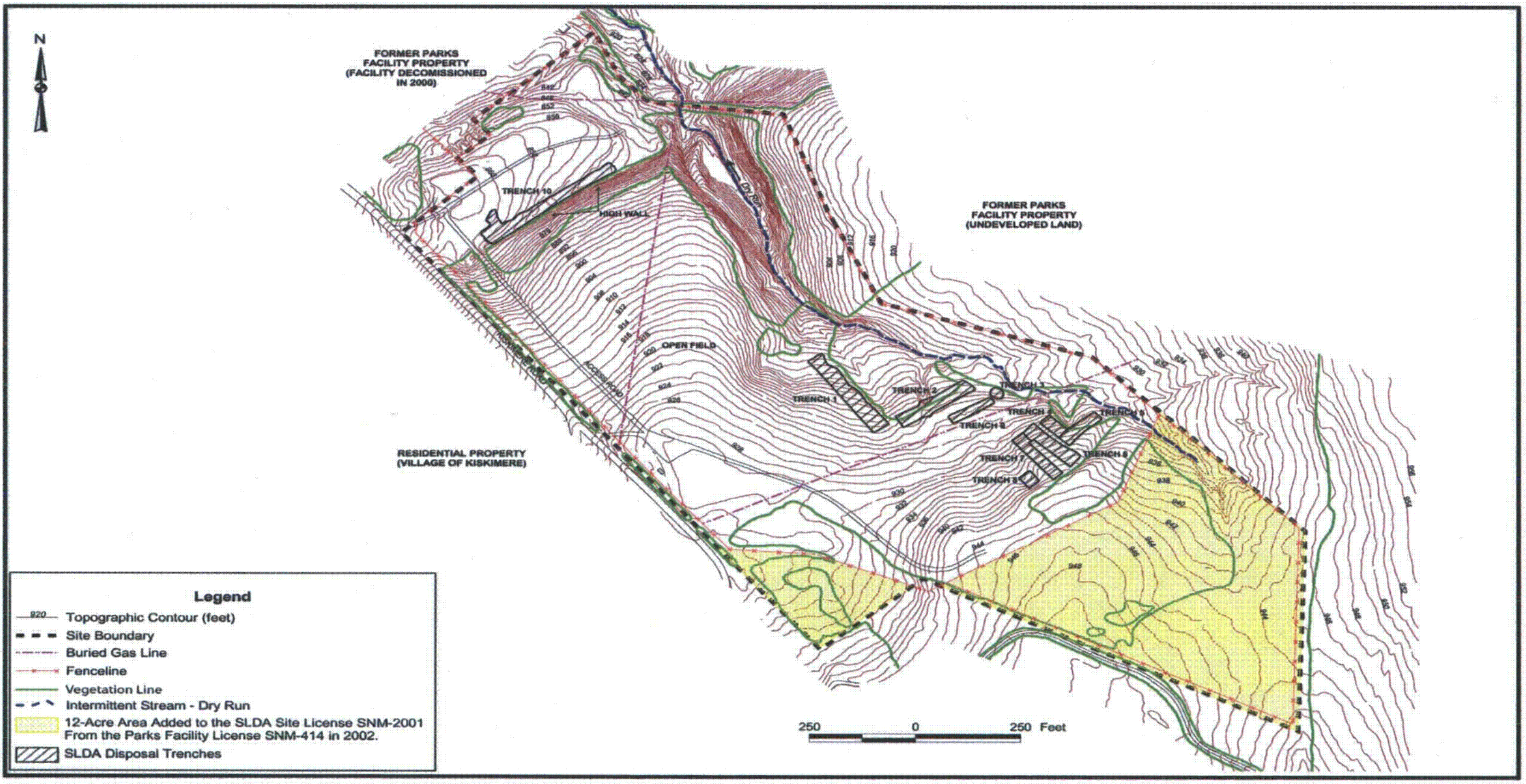
The selected remedy identified in the *Record of Decision for the Shallow Land Disposal Area (SLDA) Site, Parks Township, Armstrong County, Pennsylvania* (ROD) (USACE 2007) is the excavation of contaminated wastes and soils and off-site disposal at an appropriate and permitted disposal facility. Upon completion of this action, an FSS will be performed to identify radioisotopes that are present and determine the levels and extent of residual radiological material, if any, in the soils. The results of the survey will be compared to cleanup goals established in the ROD (USACE 2007). The guidance found in the following sources — *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)* (EPA 2000), the U.S. Army Corps of Engineers (USACE) technical project planning (TPP) process engineer manual (EM) 200-1-2) (USACE 1998), and the data quality objective (DQO) process guidance (EPA 2006) — will be used to demonstrate compliance with the ROD. This FSS plan (FSSP) includes a means to statistically evaluate soil contamination levels for residual radionuclides of concern (ROCs) by using the MARSSIM process and outlines the contents of the final status survey report for each survey unit within the study area. This document is organized into the following sections:

1. Introduction – briefly describes this document's content and purpose.
2. Site Description – contains a physical description of the site and site contaminants.
3. Data Quality Objectives – outlines a systematic procedure for defining the site criteria by which the data collection design is satisfied.

4. Testing for Compliance with Cleanup Goals – calculates the number of samples required to satisfy DQOs and field procedures.
5. Field Activities – specifies the methods used to conduct field activities.
6. Laboratory Analysis – specifies the methods for analyzing soil/sediment samples collected during the final status sampling survey.
7. Report of Survey Findings – provides an overview of the basic information to be provided in the final status sampling survey report.
8. References – lists citations.

This plan is based on information available at the time of its preparation. Sources of information used in the plan primarily include the *Remedial Investigation Report, Shallow Land Disposal Area (SLDA) Site* (RIR) (USACE 2005), *Feasibility Study for the Shallow Land Disposal Area Site* (USACE 2006a), *Proposed Plan for the Shallow Land Disposal Area Site* (USACE 2006b), and the *Record of Decision for the Shallow Land Disposal Area (SLDA) Site, Parks Township, Armstrong County Pennsylvania* (USACE 2007). Other sources of information used in the plan include the *Shallow Land Disposal Area Geophysical Investigation, Geophysical Survey Report,* Rev. 0 (SAIC 2006) and the *Final Gamma Walkover Survey Report, Shallow Land Disposal Area (SLDA) Site* (USACE 2003a). The conditions and findings that are encountered during and/or upon completion of the remedial action and at the time of the FSS implementation may trigger modifications to this plan. If modifications are deemed necessary, they will be justified and documented, including appropriate project approvals.

Figure 1-1 SLDA Study Area (Source: USACE 2005)



2 SITE DESCRIPTION

The SLDA was created for the disposal of radioactively contaminated waste generated by Nuclear Materials and Equipment Company (NUMEC) between 1961 and 1970 resulting from activities conducted at the nearby Apollo nuclear fuel fabrication facility. NUMEC operated the Apollo facility in the 1950s and 1960s, largely for the purpose of converting enriched uranium to naval reactor fuel. According to the historical record, the waste from this facility is assumed to have been disposed of in a linear series of pits (trenches) at the SLDA, reportedly in accordance with the U.S. Atomic Energy Commission (AEC) regulation in effect at the time, 10 CFR 20.304 (i.e., Title 10, Section 20.304 in the *Code of Federal Regulations* (this regulation was rescinded in 1981) (USACE 2006a).

On the basis of an examination of historical records and previous investigations and discussions with individuals familiar with disposal operations at SLDA, the waste materials were reportedly placed into a series of pits that were constructed adjacent to one another. The AEC regulation (i.e., 10 CFR 20.304) in effect at the time these disposals took place required that individual burials be separated by a minimum of 6 feet (ft) (1.8 meters [m]). Following placement in the pits, the waste materials were covered with about 4 ft (1.2 m) of clean soil. The disposals at the SLDA site were reportedly conducted in accordance with this regulation that also limited disposal quantity and frequency. These individual burials are referred to as "pits" in historical reports and also by former workers (USACE 2005, 2006a). The depths of placement of disposed materials within the "pits" are reported to have ranged from 4 ft (1.2 m) to 14 ft (4.3 m) below ground surface (bgs) (ARCO/B&W 1995). These pits were generally constructed in a linear manner, as confirmed by historical and current geophysical surveys of the site, and they are shown on site drawings and maps as a series of linear trenches (USACE 2005, 2006a; SAIC 2006).

The waste disposal areas are separated into two general areas — the upper trench area containing trenches 1 through 9, and the lower trench area composed of trench 10. The land slopes downward from the southeast (trenches 1 through 9) toward the northwest (trench 10), with a change in elevation of approximately 115 ft (35 m) over a distance of about 1,000 ft (310 m) (USACE 2005). A significant portion of this elevation drop occurs at the "high wall" area in the northwestern end of the site where a bedrock outcrop is present (see Figure 1-1). Trench 10 is located on the northwest side of the high wall.

The exact volume of waste disposed of at SLDA is not known; however, several estimates of waste and associated contaminated soil have been developed over the past three decades. On the basis of all available information about the site (i.e., historical volume estimates, information compiled by the site owners, interviews conducted with local citizens, and the results of the field investigations), the estimated volume of potentially contaminated soil and waste is 34,000 cubic yards (yd^3) (26,000 cubic meters [m^3]) in situ within and around the trench areas and approximately 800 yd^3 (600 m^3) in situ at a few surface locations outside the trench areas. An additional volume of soil will be excavated on the basis of the excavation method employed (e.g., sloped excavation sidewalls and cutbacks and the upper 3 ft (1 m) of trench cover/overburden soils). It is assumed that a percentage of these soils may exceed the cleanup criteria and require off-site disposal; however, it is expected that most of these incidental soils will have residual radionuclide activity concentrations below the cleanup criteria and would remain on site to be used as backfill material (USACE 2006a).

The SLDA site is situated on a hillside that slopes from the southeast to the northwest. Beneath the upper trench area, located on the higher ground, are abandoned deep mine workings. Trench 10 in the lower trench area was developed within the fill material left from strip mining operations. The SLDA site is predominately an open field, with wooded vegetation along most of the northeastern boundary and in the southeastern and southern corners of the site. Dry Run, a small and intermittent stream, collects surface runoff from the site and from several groundwater seeps located along the hillside. A portion of the flow in Dry Run infiltrates through the coal mine spoils in the vicinity of trench 10 and into the abandoned coal mines that underlie the majority of the site. During the times of high flow, the balance of Dry Run continues off site, northwest to the Kiskiminetas River (USACE 2005).

Numerous environmental investigations were completed at the SLDA site over the two decades prior to USACE remedial investigation (RI) activities. These investigations focused on radiological and chemical contamination from past operations, with emphasis on the 10 disposal trenches. Most of the historical soil data generated during the site investigations and post-excavation confirmation sampling were used along with the RI data to determine the nature and extent of contamination and to develop the site conceptual model. The post-excavation confirmation sampling was conducted in 1986 and 1989, in areas where soil remediation occurred to remove elevated uranium concentrations. There is no documentation available summarizing the actual site remediation; however, after remediation efforts, confirmation sampling was conducted to evaluate the effectiveness of the remediation. The results of the post-excavation confirmation samples were documented in historical reports and are included in the SLDA RIR (USACE 2005).

Between 1981 and 2000, there were six soil sampling efforts that resulted in more than 800 discrete surface and subsurface samples collected with radiological results. The majority of the historical surface soil samples were analyzed for uranium-235 (U-235), uranium-238 (U-238), total uranium, and americium-241 (Am-241), while the majority of historical subsurface soil samples were analyzed for total uranium, U-235, and U-238 (USACE 2005). In addition, a small number of the subsurface samples (i.e., 46 samples) collected in 1993 were analyzed for uranium-234 (U-234), U-235, U-238, Am-241, plutonium-238 (Pu-238), plutonium-239/240 (Pu-239/240), and plutonium-242 (Pu-242). A summary of these previous investigations and sample results can be found in the *Remedial Investigation Report, Shallow Land Disposal Area (SLDA) Site* (USACE 2005). For detailed descriptions of the pre-RI historical soil sampling activities, please see the following SLDA site field investigation reports:

- *Radiological Assessment of the Parks Township Burial Site (Babcock & Wilcox), Leechburg, Pennsylvania,* Oak Ridge Associated Universities (ORAU 1982);
- *Survey of Remediated Areas – Parks Township Burial Site (Babcock and Wilcox), Leechburg, Pennsylvania* (ORAU 1987);
- *Survey of Remediated Areas – Parks Township Burial Site (Babcock and Wilcox), Leechburg, Pennsylvania* (ORAU 1990);
- *Parks Shallow Land Disposal Facility Site Characterization Report* (ARCO/B&W 1995);
- *1995 Field Work Report* (ARCO/B&W 1996); and

- *Inspections 07000364/2000002 and 07003085/2001001, BWXT Services, Inc. Parks Township Facility, and Shallow Land Disposal Area, Vandergrift, Pennsylvania* (NRC 2001) (field investigations completed by Oak Ridge Institute for Science and Education).

The USACE RI field activities were conducted from August 2003 through January 2004 and included characterization and background surface and subsurface sampling and radiological analyses. Background surface and subsurface samples were collected from Gilpin/Leechburg Community Park, located on Pennsylvania State Route 66, approximately 3 mi (4.8 km) northwest of the SLDA site. The park location was selected for background sample collection because of the presence of soil types similar to those at SLDA; the park has no adverse environmental impacts, and was assumed to be free of any potential impacts from SLDA. Surface and subsurface samples were collected from 18 different locations and analyzed for the same radionuclides as were the characterization soil samples. The spatial coordinates for the 18 background sample locations are listed in Table C-3 of Appendix C.

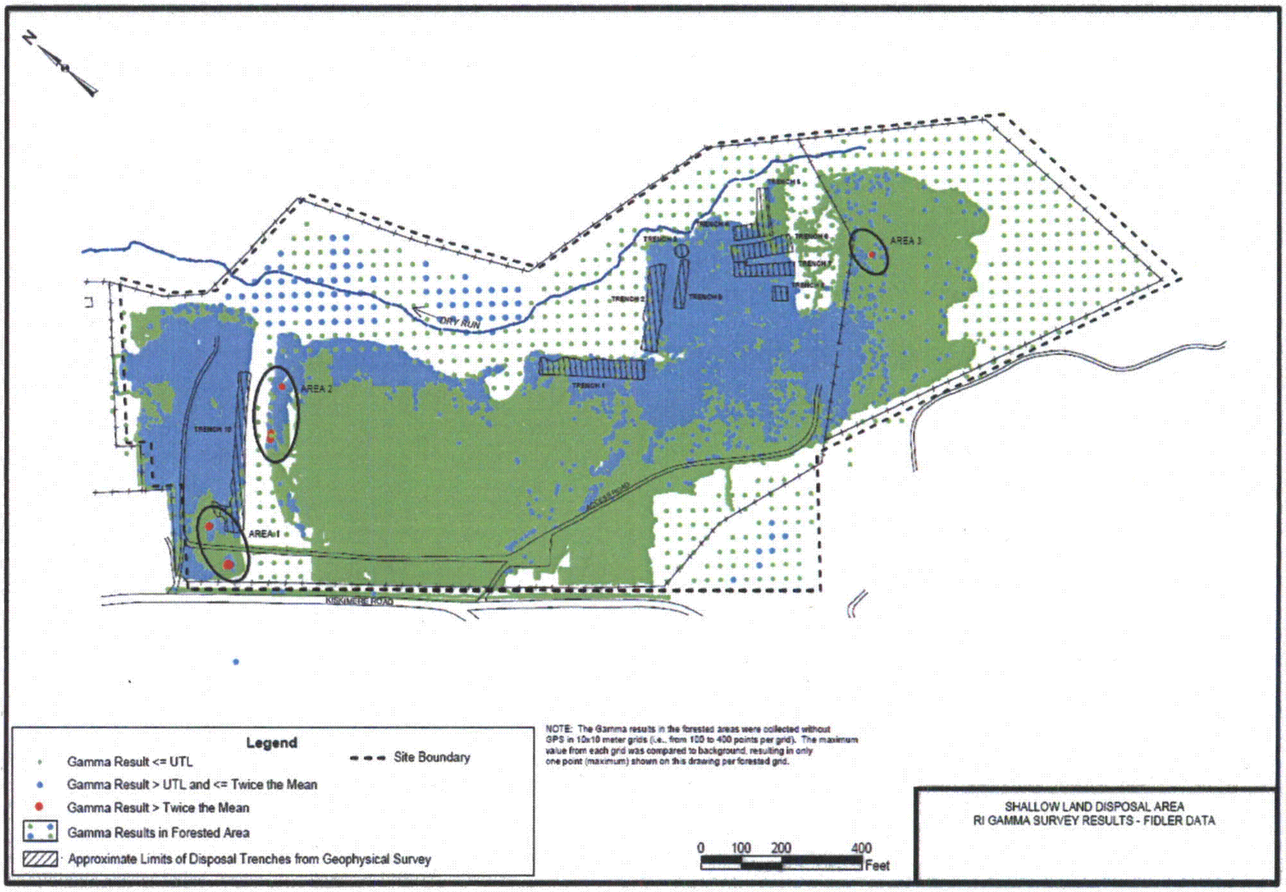
For the USACE RI soils characterization activities, 304 soil samples were collected from 103 soil borings outside the trench areas, and 47 samples were collected from 44 borings within the trench areas. Each retrieved soil/rock core and each soil/waste sample was surveyed for the presence of gross radioactivity through field screening. The survey was performed by using a Ludlum Model 44-9 pancake Geiger-Mueller (GM) detector, "microR" meter (Ludlum Model 19 or Bicron microRem), and a Field Instrument for the Detection of Low Energy Radiation (FIDLER) coupled with a Ludlum Model 2221 count-rate meter. In addition to field screening done by the FIDLER, microR meter, and GM, an evaluation of the potential for the presence of environmental contamination was also made through field screening by using a calibrated multigas indicator to measure volatile organic compounds (VOCs) and by visual/olfactory observations (i.e., staining/odors or visible evidence of waste material) prior to the collection of subsurface soil and trench samples.

In addition, a calibrated multigas indicator was used along with visual/olfactory observations (i.e., staining/odors or visible evidence of waste material) prior to the collection of subsurface soil and trench samples. Biased samples were collected from intervals where potential contamination was observed, and for those borings without elevated field screening measurements and/or visual/olfactory evidence of contamination, samples were collected at regularly spaced 2-ft (0.61-m) subsurface intervals. At each boring location, a surface soil sample from ground surface to a depth of 0.5 ft (15 centimeters [cm]) was collected. The plan was to advance each boring to a depth of 20 ft (6.1 m) bgs or until refusal. The majority of the soil borings completed encountered refusals at depths of less than 12 ft (3.7 m). As a result of the refusal problems, the depth of the deepest sample interval was often modified. The samples were analyzed for U-234, U-235, U-238, plutonium-239 (Pu-239), plutonium-241 (Pu-241), radium-228 (Ra-228), thorium-232 (Th-232), and Am-241. The methods used to analyze these eight radionuclides are presented in Table 3-1 of the *Remedial Investigation Sampling and Analysis Plan Part II – Quality Assurance Project Plan* (USACE 2003b).

Prior to the USACE RI soil sampling activities, a thorough site-wide gamma walkover survey (GWS) was completed at the SLDA site. Gross gamma measurements were collected with three 3×3 sodium iodide (NaI) scintillation detectors and three FIDLERs. In open areas where a global positioning system (GPS) signal could be obtained, the rate measurements from the detectors were recorded in conjunction with GPS coordinates. In the wooded areas of the site where GPS was not reliable, the locations of the gamma measurements were tied to site grid nodes that were marked in the field. The gamma walkover data from both types of detectors were compared to background data obtained from a nearby reference area. The mean values of data collected from the background (or reference area) for the three 3×3 NaI detectors were 25,100, 25,200, and 25,900 counts per minute (cpm), and the mean values of the background data collected with the three FIDLERs from the reference area was 11,300, 12,500, and 12,800 cpm.

The data collected at the SLDA site were compared to the walkover data collected at the background location. To provide a relative comparison of the measurements collected from the site with the background levels, the mean and the upper tolerance limit (UTL) of the background data were determined for each instrument used. Figure 2-1 shows a comparison of the FIDLER results to the walkover background results. Shown in green are measurements below or equal to the background UTL; in blue are measurements above the UTL but below twice the mean of the walkover data; and in red are measurements greater than twice the background mean.

Figure 2-1 RI Gamma Survey Results – FIDLER Data (Source: USACE 2005)



As shown in Figure 2-1, the data collected using the FIDLER identified five relatively small areas in three different locations that were above twice the background means (USACE 2003a). The RI soil sampling activities included collecting surficial soil samples from these five areas shown in Figure 2-1. Sample results from two of the areas in one general location (near trench 10) had the highest activity concentrations reported for Am-241 (320 picocuries per gram [pCi/g]), for Pu-239 (325 pCi/g), and for Pu-241 (628 pCi/g). The results of the samples collected from the other three areas had low detectable activity concentrations in comparison to the cleanup requirements identified in the ROD. All the data collected with the 3×3 NaI detector were less than twice the background means (as determined from the measurements collected from the background area).

The ROCs identified in the ROD for the SLDA site were based on the results of the RI. The RI assessed the nature and extent of contamination and evaluated risks to human health and the environment, in addition to evaluating historical information regarding activities at the SLDA site. The ROCs are Th-232, U-234, U-235, U-238, Am-241, Pu-239, Pu-241, and Ra-228. Of the eight ROCs, the primary radioactive contaminants at the site are uranium and its isotopes on the basis of the sampling results to date. The uranium isotopes of concern are those associated with natural uranium (i.e., U-234, U-235, and U-238). Results of sampling completed at the SLDA site indicated that the uranium in the uranium-contaminated materials placed in the trenches range from depleted to enriched. Sampling and analysis efforts indicate that the radioactive contaminants at the site are generally confined to the immediate vicinity of the trenches; however, some localized areas of contaminated soil were detected outside these areas, specifically in the southwest end of trench 10 and northwest of trench 4. Localized areas of soil near trench 10 contained plutonium (Pu-239 and Pu-241) and Am-241 activity concentrations as noted above; these transuranic radionuclides were not found at concentrations greater than the site-specific derived concentration levels (see Table 3-1) at depths greater than 6 inches (in.) (15 cm) during the RI characterization program. There is no evidence to indicate transuranic radionuclides were buried at the site. This localized contamination is speculated to have resulted from the previous storage of surface contaminated materials and equipment on the northwest portion of the site (near trench 10), as documented in Section 4.5 of the *Parks Shallow Land Disposal Facility Site Characterization Report* (ARCO and B&W 1995) and in *Shallow Land Disposal Area Historic Photographic Analysis* (TEC 2003).

The conceptual site model (CSM) for the SLDA site is as follows. Contamination found at the SLDA site originated from waste materials generated from activities conducted at the nearby NUMEC Apollo nuclear fuel fabrication facility. The Apollo facility was located south of the SLDA site. Process uranium waste and, to a lesser extent, thorium waste were generated at the Apollo facility. The waste materials were disposed of into a series of pits constructed adjacent to one another between 1961 and 1970. On the basis of the AEC regulation in effect at the time, the pits were separated by a minimum of 6 ft (1.8 m), and the waste was placed at depths ranging from 4 ft (1.2 m) to 14 ft (4.3 m). After waste was disposed of in the pits, about 4 ft (1.2 m) of clean soil was placed as cover over it. This disposal practice of placing clean fill over waste materials was supported by subsurface borings, where the waste was present in isolated pockets surrounded with significant quantities of soil. On the basis of geophysical surveys conducted at the site, the pits appear as linear trenches. The geophysical anomalies were labeled as trenches 1 through 10, where trench 1 was the oldest and trench 9 was the most recently constructed trench in the upper trench area. Trench 10, in the lower trench area, was excavated in coal strip mine spoils on the northwest side of the high wall and was used for disposal purposes throughout the 1960s and during 1970.

On the basis of the historical and RI characterization data, the contamination at the site is primarily within the footprints of the 10 trenches. From this, it is reasonable to assume that the contaminated soil and debris are confined to the footprints of the trenches and located beneath clean overburden soil. This assumption was confirmed by information collected during the RI for the site. The only contaminated soils exceeding the derived concentration guideline levels (DCGLs) outside the trench areas were in small, localized areas near trench 10 and trench 4. While low concentrations of plutonium and Am-241 were detected at depth, the only DCGL exceedances in these limited areas were in surface soils (i.e., within the upper 6 in. [15 cm]) near trenches 10 and 4. On the basis of the disposal records and results of site characterization activities, subsurface contamination is not expected to be present in areas outside the trench areas.

To be consistent with the assumption in the *Site Operations Plan* (Cabrera Services, Inc. 2009a), this FSSP assumes the majority of the upper 3 ft (1 m) of trench cover/ overburden soils and the bench/side slope soils (to be removed to ensure trench stability) will be below the DCGLs and also meet the Pennsylvania Department of Environmental Protection (PADEP) *Management of Fill Policy* (PADEP 2004). Soils meeting the DCGLs and the clean fill requirements identified in PADEP (2004) will be stockpiled for reuse on the site; the soils that do not meet one or both of these requirements will be segregated and managed as waste. However, during the removal, if there is an indication of buried waste and/or soil contamination within the upper 3 ft (1 m) of overburden and/or in the bench/side slope soils on the basis of visual observations and/or sample results, these soils will be excavated and characterized.

The ROCs identified in the ROD are Pu-241, Pu-239, Am-241, Th-232, U-234, U-235, U-238, and Ra-228. Am-241, Pu-239, and Pu-241 were not detected in any of the trench samples analyzed, whereas Ra-228, Th-232, U-234, U-235, and U-238 were detected in nearly every RI trench sample analyzed. The uranium isotopes (U-234, U-235, and U-238) and Th-232 were present in wastes generated at the Apollo facility and were disposed of at the SLDA site; these radionuclides were detected in soil samples in the upper trench area (i.e., trenches 1 through 9) and the lower trench area (trench 10). The radionuclide activity concentrations detected in most soil samples were generally comparable to background levels. The maximum surface soil activities measured at the SLDA site were for Am-241 (320 pCi/g), Pu-239 (325 pCi/g), and Pu-241 (628 pCi/g) near trench 10. The presence of the americium and plutonium contamination in the trench 10 area was attributed to the storage of contaminated equipment used at the former Parks Township nuclear fuel fabrication facility located adjacent to the SLDA site. Other than isolated areas near trench 10, which showed elevated activities of americium and plutonium in surface soil, U-234 was generally the radionuclide with the highest detected soil and trench material activity concentrations, which is indicative of the material contaminated with enriched uranium that was disposed of at the site. A maximum U-234 subsurface soil activity concentration of 508 pCi/g was detected in the upper trench area. In addition, the maximum trench sample was also U-234 with an activity concentration of 2,200 pCi/g. The maximum U-235, U-238, and Th-232 activity concentrations were 220, 580, and 2.60 pCi/g, respectively; these activity concentrations were detected in samples collected from the upper trench area.

3 DATA QUALITY OBJECTIVES

The DQOs for the SLDA site FSS sampling are provided below to establish a systematic procedure for defining the criteria that must 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 decision errors for the study, and how many samples to collect. The DQO process consists of the seven steps listed below (EPA 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 SLDA site FSS.

3.1 STATE THE PROBLEM

This FSSP will be used to determine whether residual radionuclide concentrations in soils at the SLDA site comply with cleanup criteria as defined in the ROD (USACE 2007). This FSSP is consistent with MARSSIM, which uses two activity concentration cleanup requirements known as derived concentration guideline levels or DCGLs. The DCGLs for the SLDA site are derived from dose goals; they are developed on the basis of limiting the annual dose to a hypothetical subsistence farmer to 25 millirems per year (mrem/yr) (USACE 2005). The first, the $DCGL_w$, refers to a wide area average that must be met for areas the size of a survey unit. The second, the $DCGL_{emc}$, refers to an elevated measurement comparison that addresses more localized elevated areas that may exceed the $DCGL_w$ at specific locations but not when averaged over a survey unit. The DCGLs are developed so that post-remediation residual activity concentrations are consistent with the dose goals derived for the site. For excavated soils intended for reuse (i.e., overburden soils and cutback/bench soils), sampling will be conducted to establish the chemicals' compliance with the PADEP clean fill requirements (PADEP 2004) after the excavated soils have been determined to meet the ROD criteria. The sampling and analysis planned to demonstrate compliance with the PADEP clean fill requirements for chemicals is described in the *Final Sampling and Analysis Plan Part 1 – Field Sampling Plan, Shallow Land Disposal Area, FUSRAP Site Remediation, Parks Township, Armstrong County, Pennsylvania* (Cabrera Services, Inc. 2009b).

The key elements for showing compliance with the ROD are described in Section 3.2. Compliance with the ROD will be demonstrated by using guidance found in MARSSIM (EPA 2000). Specifically, compliance will be demonstrated by performing gamma surface scans, where possible, and collecting systematic soil samples (i.e., samples associated with a grid) and biased soil samples (i.e., samples targeting specific areas of concern) consistent with MARSSIM guidance. Upon completion of excavation in the Class 1 trench areas, geophysical surveys will be conducted before gamma surface scans are performed and soil samples are collected to determine if there are anomalies potentially indicating remaining buried materials in the subsurface. However, if, during the excavation and removal of radiologically contaminated soil and waste, there are areas where weathered bedrock is reached, then the geophysical surveys will not be implemented in those areas. The geophysical surveys are warranted because of the assumed clean soils that were placed between waste burials within each trench.

3.2 IDENTIFY THE GOALS OF THE STUDY

This plan assumes that upon the completion of the selected remedy – the excavation and off-site disposal of contaminated soil and waste – residual concentrations of the ROCs will meet the criteria associated with the ROD. The intent of this plan is to use FSS data to determine whether site contaminants are present at activity concentrations above or below cleanup levels in the ROD. The ROD requirements are the following:

1. Excavate radiologically contaminated soil and waste that exceed the radiological criteria stated in the ROD (USACE 2007). Since there are multiple ROCs, the comparison to the ROD criteria will be conducted by using a sum of ratios (SOR) calculation, based on the

wide area average $DCGL_w$ and elevated measurement criteria ($DCGL_{emc}$). The $DCGL_w$ and $DCGL_{emc}$ values are presented in Table 3-1.

2. Remove and dispose of all impacted soil and excavated waste to achieve cleanup goals, as discussed in item 1 above, for the ROCs (USACE 2007).

Table 3-1 Derived Concentration Guideline Levels for the SLDA Site

Radionuclide	Average Soil Background Value (pCi/g)[a]		$DCGL_w$ (pCi/g)	$DCGL_{emc}$ (pCi/g)
	Surface	Subsurface	Survey Unit Area	100 square-meter (m^2) Area
Am-241[b]	0	0	28	420
Pu-239[c]	0.01	0	33	570
Pu-241[b]	0	0	890	13,000
Th-232	1.1	1.5	1.4	5.3
U-234	0.94	1.1	96	240
U-235	0.10	0.12	35	110
U-238	0.98	1.0	120	520

[a] The average background values were calculated from the surface and subsurface sample results collected from 18 surface (top 6 in. [15 cm] of soil) and subsurface (soil at depths of 2 ft [60 cm] to 4 ft [1.2 m]) locations at Gilpin/Leechburg Community Park as part of the RI (USACE 2005).

[b] The activity concentrations of these radionuclides (which are not naturally occurring) were below the minimum detectable activities.

[c] The Pu-239 subsurface activity concentration was below the minimum detectable activity. (The detected Pu-239 surface activity concentration is likely due to atmospheric fallout from previous aboveground nuclear weapons tests.)

Table 3-1 shows the $DCGL_w$ values for the SLDA site as documented in the ROD (USACE 2007). Although eight ROCs are identified in the ROD, cleanup criteria (i.e., DCGLs) are expected to be needed for only seven of the eight ROCs to meet the dose limit of 25 mrem/yr. Ra-228 is included as an ROC in the ROD, but DCGLs are not expected to be needed for this radionuclide on the basis of site-specific considerations for the SLDA site. Table 3-1 also provides the $DCGL_{emc}$ for the seven radionuclides of interest in this FSSP.

The radioactive wastes were disposed of at the SLDA site more than 40 years ago. Most of the waste was disposed of in the 1960s. The half-life of Ra-228 is 5.8 years, so this radionuclide would be expected to be in secular equilibrium with Th-232 at this time. In wastes that initially had higher concentrations of Ra-228 than Th-232, the excess Ra-228 would have since decayed, so its radioactive concentration (in pCi/g) would be expected to be similar to that of Th-232. For wastes that initially had lower concentrations of Ra-228 than Th-232, Ra-228 ingrowth over the intervening years would have occurred such that these two radionuclides would now be in secular equilibrium. While it is possible that these two radionuclides could have been physically separated as a result of differential leaching, this is not expected to be significant in terms of performing this FSS.

The situation described above is identical to that for which the Th-232 DCGL was calculated (i.e., with Ra-228 in secular equilibrium with Th-232). Hence, a comparison of the Th-232 concentration to its DCGL already addresses the presence of Ra-228. This means that there is no need to use the Ra-228 DCGL to confirm that the dose limit of 25 mrem/yr has been met. This situation is specific to the conditions at the SLDA site.

Data collected during the RI process for these two radionuclides were not definitive in terms of confirming secular equilibrium between Ra-228 and Th-232 (see Section 3.3.5 of the *Remedial Investigation Report, Shallow Land Disposal Area (SLDA) Site* [USACE 2005]). However, these data were largely associated with soil having concentrations near background values, for which there is natural variability. To determine if the approach described here is valid for the FSS process, additional data will be collected for Ra-228 and Th-232 as the wastes are excavated from the trenches to determine if a definitive conclusion can be reached as to the existence of secular equilibrium between these two radionuclides. The concentrations of these two radionuclides would be larger in the wastes than in the soil, which should reduce the variability in the calculated concentration ratios.

If these additional data support the conclusion that Ra-228 and Th-232 are in secular equilibrium, Ra-228 will be dropped from the SOR calculation because its presence is already accounted for in the DCGL for Th-232. In this case, gamma spectroscopy will be used to determine the concentration of actinium-228 (Ac-228), which will be used for Th-232 in the SOR calculation. The background concentration of Th-232 will be taken to be that reported for

Ra-228 as presented in the RIR (USACE 2005), which was also determined by using gamma spectroscopy for the concentration of Ac-228.

If these new data do not support the conclusion of secular equilibrium between Ra-228 and Th-232, Ra-228 will be included in the SOR calculation. In this case, the $DCGL_w$ of 1.7 pCi/g as given in the ROD will be used in this calculation. Note that this value is comparable to and slightly larger than that for Th-232, as most of the dose for Th-232 is attributable to Ra-228 and its short-lived decay products. A separate $DCGL_{emc}$ will be calculated for Ra-228 in a manner consistent to that used to develop values for the other seven radionuclides (summarized in Appendix A) and used in the corresponding SOR calculation.

In this case, the concentration of Ra-228 will be determined by gamma spectroscopy (to give the concentration of Ac-228), and the concentration of Th-232 will be determined by alpha spectroscopy. The background concentrations of these two radionuclides will be the values reported in the RIR (USACE 2005), which were determined by using the same analytical techniques.

This approach for addressing Ra-228 in this FSSP adds flexibility to the FSS process to ensure that the dose criteria of 25 mrem/yr given in the ROD is met in a cost-effective manner.

To ensure that no localized areas of elevated radioactivity remain at the site that could potentially produce an unacceptable risk, the $DCGL_{emc}$ values listed in Table 3-1 were developed by using methodologies and assumptions consistent with those used to derive the $DCGL_w$ values. The RESRAD model input parameters used to calculate the $DCGL_w$ values are provided in Appendix B. The derivation of the $DCGL_{emc}$ values and the RESRAD input parameters that were adjusted to calculate the $DCGL_{emc}$ values are provided in Appendix A. The DCGLs are incremental to background activity concentrations. As mentioned previously, since there are multiple ROCs, the DCGLs will be evaluated by using a SOR calculation.

For the purposes of the FSS effort, the ROD requirements can be distilled into the following MARSSIM-consistent requirements for determining whether or not the site meets the

25-mrem/yr dose limit specified in the applicable or relevant and appropriate requirement (ARAR):

1. Compliance with the $DCGL_W$ values will be determined by using results of soil samples and calculated SOR values. Soil samples will be collected ex situ from the upper 3 ft (1 m) of overburden and bench/side-slope soils after they have been excavated from the Class 1 trench excavation areas and deposited into 1-ft (0.3-m) layers. Upon completion of the excavations, soil samples will be collected in situ from the exposed wall and floor surfaces (as represented by samples from the top 6 in. [15 cm] of exposed soil), prior to backfilling. SOR calculations for $DCGL_W$ comparisons will be developed by using activity concentration guidelines for the seven ROCs listed in Table 3-1. In the unexcavated Class 2 and Class 3 units, in situ FSS samples will be collected from the surface (as represented by samples from the top 6 in. [15 cm] of surface soil) to determine compliance with DCGL requirements, since contamination was not found to be present at depths outside the trench areas. The soil activity concentration for each of the seven ROCs will be divided by its respective $DCGL_W$, and the resulting ratios will be summed to calculate a SOR value at each sample location. The calculated SOR values will be compared to background sample results to determine compliance with the $DCGL_W$ requirement by using the Wilcoxon Rank Sum [WRS] test, as described in Appendix C. Note that when using a WRS test to evaluate the SOR $DCGL_W$, background is not subtracted from individual sample activity concentrations.

   The WRS test SOR formula for use with the FSS sample results and $DCGL_W$ values in Table 3-1 is shown below. To calculate the WRS SOR $DCGL_W$ value of a sample, the FSS sample results are the numerator values, and the $DCGL_W$ values are the denominator values. If the sample results are non-detect values (i.e., less than the minimum detectable concentration), the reported activity concentration will be used in the SOR calculation. Specifically, if the results of the laboratory analysis indicate negative activity concentrations, the negative value will be used in the SOR equation. Note that as activity concentrations approach zero, negative results are possible and simply reflect measurement error. For a radionuclide that is not naturally occurring and is not present in the sample, any measurement would have a 50% chance of resulting in a negative value. Arbitrarily truncating negative values to zero will bias any statistics conducted with the FSS data sets. The statistical tests recommended by MARSSIM (i.e., Sign and WRS) automatically address measurement uncertainty (and consequently the possibility of negative results) by the way they are formulated. Preserving negative values in the SOR calculations will ensure that the WRS test returns an unbiased conclusion as to whether $\mathrm{DCGL_w}$ requirements have been met.

$$SOR_{DCGLw} = \frac{Am\,241}{28\ pCi\ /\ g} + \frac{Pu\,239}{33\ pCi\ /\ g} + \frac{Pu\,241}{890\ pCi\ /\ g} + \frac{Th\,232}{1.4\,pCi\ /\ g} + \frac{U\,234}{96\ pCi\ /\ g} + \frac{U\,235}{35\ pCi\ /\ g} + \frac{U\,238}{120\ pCi\ /\ g}$$

2. Compliance with the 100-$\mathrm{m^2}$ $\mathrm{DCGL_{emc}}$ will be determined by calculating SOR values by using the results of ex situ soil samples collected from the top 6 in. (15 cm) of overburden and excavated bench/side-slope soils following removal and placement in the stockpile area. Compliance with the 100-$\mathrm{m^2}$ $\mathrm{DCGL_{emc}}$ will also be determined by calculating SOR values by using the results of in situ samples collected from the top 6 in. (15 cm) of soil from the exposed wall and floor surfaces within the excavation areas and from areas outside the excavations. Where excavation has occurred, samples will be collected prior to backfilling. Biased soil samples may also be collected from excavation wall and floor surfaces and from the overburden and bench/side slope soils (either prior to or after excavation) if it is determined by scans or visual observations that soils could potentially exceed the $\mathrm{DCGL_{emc}}$ standards. SOR calculations for $\mathrm{DCGL_{emc}}$ comparisons will be developed by using relevant activity concentration guidelines for the seven ROCs listed in Table 3-1, after adjusting for background activity concentrations. The mean subsurface background activity concentrations will be used to calculate $\mathrm{DCGL_{emc}}$ SOR values from samples collected in the excavation areas (including the overburden and bench/side slope soils). For the surficial composite soil samples collected from the unexcavated Class 2 and Class 3 units, mean surface background values will be used to calculate the SORs. The SOR $\mathrm{DCGL_{emc}}$ values must be less than or equal to one for every soil sample. Each soil sample will be required to comply with the 100-$\mathrm{m^2}$ $\mathrm{DCGL_{emc}}$ standard.

The SOR formula for use with the final status sample results and $\mathrm{DCGL}_{\mathrm{emc}}$ values (provided in Table 3-1) is shown below.

$$SOR_{DCGLemc}=\frac{Am241}{420\,pCi/g}+\frac{{}^{*}Pu239-bkg}{570\,pCi/g}+\frac{Pu241}{13{,}000\,pCi/g}+\frac{Th232-bkg}{5.3\,pCi/g}+\frac{U234-bkg}{240\,pCi/g}+\frac{U235-bkg}{110\,pCi/g}+\frac{U238-bkg}{520\,pCi/g}$$

* The Pu-239 mean background value will only be used for the $\mathrm{DCGL}_{\mathrm{emc}}$ SOR calculations for surface soils.

This equation is used with the FSS sample results in the numerators and with the $\mathrm{DCGL}_{\mathrm{emc}}$ values in the denominators to calculate the $\mathrm{DCGL}_{\mathrm{emc}}$ SOR of a sample. If the sample results are non-detect values (i.e., less than the minimum detectable concentration), the reported activity concentration will be used in the SOR calculation. Specifically, if the results of the laboratory analysis indicate negative activity concentrations, the negative value will be used in the SOR equation. The background activity concentrations for Pu-239 surface soils and Th-232, U-234, U-235, and U-238 surface/subsurface soils to be used in the SOR calculations are provided in Table 3-1. These concentrations are the statistical mean values calculated from the reported surface and subsurface sample results collected from 18 locations at Gilpin/Leechburg Community Park as part of the RI (USACE 2005). For Am-241, Pu-239 subsurface soils, and Pu-241, the background activity concentrations are zero; these radionuclides, which are not naturally occurring, have background activity concentrations that are not statistically different from zero. If one or more of the terms in the SOR equation result in a negative number (e.g., the reported sample activity concentration is less than the mean background), the negative value will be included in the SOR sum.

An analysis of data obtained to date from the SLDA site indicates that the uranium isotopes U-234, U-235, and U-238 are the primary ROCs at the site. These radionuclides are generally present in the greatest concentration (especially U-234) and represent the greatest residual risk to human health and the environment at the site. A review of the soil sample results for the SLDA site indicates that the average U-235 enrichment is about 10%, which is consistent with historical information. Hence, U-234 is expected to be the major radionuclide (in terms of activity) in the trench areas.

The PADEP requirements for clean fill can be found in the *Management of Fill Policy* (PADEP 2004); these clean fill requirements focus on potential chemical constituents of concern. The PADEP clean fill requirements will be applied only to excavated soils that have been stockpiled for potential reuse and have met the ROD criteria. Details regarding the PADEP clean fill verification sampling to be performed are provided in the *Final Sampling and Analysis Plan Part 1 – Field Sampling Plan* (Cabrera Services, Inc. 2009b).

3.3 IDENTIFY INFORMATION INPUTS

Guidance provided in MARSSIM (EPA 2000) is the basis for this final status sampling survey. The MARSSIM guidance was developed collaboratively by the U.S. Nuclear Regulatory Commission (NRC), U.S. Environmental Protection Agency (EPA), U.S. Department of Energy (DOE), and U.S. Department of Defense (DoD) for use in designing, implementing, and evaluating final status radiological surveys. This guidance emphasizes the use of DQO and data quality assessment (DQA) processes, along with a sound program of quality assurance/quality control (QA/QC). The "graded approach" concept is also used to assure that survey efforts are maximized in those areas with the highest probability for residual contamination or greatest potential for adverse impacts of residual contamination. The use of a graded approach is primarily reflected by the categorization of a site into survey unit classes, with the level of data collection dependent on the survey unit classification.

Information on radiological ROCs must be collected from four key components in the field for the FSS sampling: (1) overburden and bench/side slope soils, (2) soils from the walls and floors of the excavated areas, (3) surficial excavation areas, and (4) soils in unexcavated areas outside the vicinity of the trenches. A more detailed discussion of specific field activities is included in Section 5.1. Two techniques will be used in the field to generate information pertinent to the FSS requirements: surface gamma scans and soil sampling combined with an appropriate laboratory analytical techniques (e.g., gamma and alpha spectrometry). In addition, upon completion of excavation in Class 1 trench areas, geophysical surveys will be conducted to determine if there are anomalies that potentially indicate buried materials or waste remaining in the subsurface. The geophysical surveys will be used primarily in excavation areas that did not reach weathered bedrock.

In addition to these quantitative methods, visual observations will also be used to determine if there is an indication of contamination or buried waste during the excavation, including the excavation of the upper 3 ft (1 m) of trench cover/overburden, and during removal of the cutback/benching soils required for slope stability as the excavation of the trench material proceeds.

3.3.1 Surface Gamma Scans

Surficial scans, where possible, are effective at identifying spatial trends in surficial contamination and potential DCGL concerns. In the Class 1 trench areas, gamma scans will be collected from the trench overburden surficial soils and along the face of the bench/side slope soils of the trench excavations. Upon completion of excavation, surficial gamma scans will be collected through systematic surveys of the floors and walls by using a FIDLER or an equivalent gross gamma detector. Surfical gamma scans will also be conducted in construction operation areas after the remedial action is complete. For example, construction operation areas, such as the haul road and the area beneath the material processing building, will be scanned, and if there are anomalous rate measurements, then samples will be collected. Locations for the mobile scans will be logged by using a GPS unit or some equivalent technique.

The detection sensitivity of a FIDLER for natural thorium (Th-232 in equilibrium with its decay products) is about 15 times greater than for natural uranium without its decay products when contamination is present on the surface (see Section 8.2.4.8 of the Multi-Agency Radiation Survey and Assessment of Materials and Equipment [MARSAME] Manual [EPA 2009]). While this situation does not exactly match that to be expected at the site following remediation, it is generally comparable. Since experience has shown that a FIDLER can detect natural uranium at a concentration of about 60 pCi/g of total uranium in soil under field conditions, the scan minimum detectable concentration (MDC) for Th-232 under similar conditions would be expected to be about 4 pCi/g. When the background concentration of Th-232 is subtracted from this value, the FIDLER could be expected to detect net soil concentrations of Th-232 of about 2 to 3 pCi/g. This exceeds the DCGL_w but is significantly less than the DCGL_{emc} in Table 3-1. The primary objective of gamma walkover surveys from MARSSIM's perspective is to identify DCGL_{emc} exceedances; in the case of Th-232, the FIDLER will achieve this objective.

Thus it will not be possible to confirm that the cleanup objectives for Th-232 have been met solely on the basis of surface gamma scans. This can be done only by using laboratory analyses of soil samples collected at the site. As noted in MARSAME (EPA 2009), a FIDLER is the proper instrument to use in this situation because of its ability to detect low-energy gamma radiation, which makes up the majority of radiation from these radionuclides.

A complete surficial GWS was conducted at the SLDA site in 2003 by using a FIDLER and a 3×3 NaI detector (USACE 2003a). The GWS using a FIDLER identified five small areas of potential concern when compared with background levels; these areas were sampled, and two resulted in DCGL_w exceedances. There were no elevated areas found relative to background levels when the 3×3 NaI detector was used. Since uranium and its isotopes are the primary contaminants of concern, a FIDLER or equivalent detector is recommended for the FSS gamma scans at the SLDA site.

The FIDLER has been shown to be capable of detecting total uranium at a concentration of about 60 pCi/g in soil under conditions typically encountered in the field. This scan MDC is for uranium that is present in its naturally occurring concentration ratios. As shown in Table 6.7 of MARSSIM, the scan MDC increases as the uranium enrichment increases (EPA 2000). (The information presented in this table is for two different NaI detectors, but the same trend would apply for a FIDLER.) When the information from Table 6.7 is used, the scan MDC for 10% to 20%-enriched uranium would be expected to be 30% higher than that for natural uranium. This result indicates that the scan MDC for a FIDLER at the SLDA site would be expected to be about 80 pCi/g for total uranium. Section 4.1.7, Table 4-1, provides estimated FIDLER MDC values based on past experience with the ROCs at other sites and compares the estimated MDC values with DCGL requirements.

A FIDLER (or equivalent detector) investigation level for soils will be developed by determining background count rates for a set of locations at or near the SLDA site area of concern, determining an average background response and its variability, and developing a field investigation level indicative of gross activity not consistent with background. This investigation level will be used for further investigation/biased sampling during excavation support, to scan construction operation areas (e.g., haul road) after remediation is complete, and for FSSs. The FSS contractor will calculate scan MDCs for the selected detector and for those ROCs that can be detected.

Both the remediation and FSS contractors will conduct surface gamma scans. The remediation contractor will primarily use field instrumentation such as gamma scans to ensure that trench overburden and cutback soils are not radiologically impacted; these data will be collected as the excavation proceeds. The FSS contractor will collect and document gamma walkover survey data (as well as discrete soil samples) to demonstrate that the residual soil complies with the ROD requirements.

3.3.2 Soil Samples

Composite soil samples will be collected from the trench overburden and bench/side slope soils placed in the stockpile area (following surficial gamma scans and any associated biased soil sampling deemed necessary) to verify that these soils can be used as backfill material. When excavation is complete, composite samples of exposed soil from the excavation floors will be collected to verify that the DCGLs or cleanup criteria have been met. Composite samples will be collected from excavation walls/benches (removed for slope stability) to confirm there are no DCGL exceedances. Composite samples will be collected from surface soils in the unexcavated areas outside the vicinity of the trench and surficial excavations to support the MARSSIM FSS process. All composite soil samples collected will be representative of the top 6-in. (15-cm) interval of soil and will be submitted for alpha spectrometry analysis of Pu-239, U-234, U-235, and U-238; gamma spectrometry analysis of Am-241 and Th-232; and liquid scintillation analysis of Pu-241. Additional discussion regarding composite soil sampling and analytical requirements for soil samples is provided in Sections 4.1.5 and 5.1.2.

3.3.3 Geophysical Surveys

Upon completion of excavation in Class 1 trench areas, a geophysical survey will be conducted to determine if there are anomalies potentially indicating remaining buried metallic debris in the subsurface (if the excavation does not appear to have reached weathered bedrock). A focused, high-sensitivity metal detector survey will be conducted, similar to the EM61-MK2 pre-excavation geophysical survey that was conducted at the SLDA site to identify buried metallic material in the subsurface and to assist in defining the disposal pits as a series of linear trenches (SAIC 2006). The geophysical survey will be logged by using GPS instrumentation (integrated with the geophysical survey) or civil survey methods in order to map the geophysical survey data. The geophysical surveys will be performed by the remediation/construction contractor prior to declaring that the area is ready for FSS sampling.

3.4 DEFINE THE BOUNDARIES OF THE STUDY

The study area boundary consists of trenches and the surrounding soils within the SLDA site. Figure 1-1 provides the boundary for the SLDA site. The site is composed of three components: the upper trench area that includes trenches 1 through 9, the lower trench area that includes trench 10, and the regions surrounding the upper and lower trench areas.

The study area will be divided into Class 1, Class 2, and Class 3 survey units consistent with MARSSIM guidance. (Section 4.1.1 provides more discussion on classifying the survey units at SLDA, and the proposed layout of survey unit areas is illustrated in Figure 4-1). Class 1 units will include areas that have been identified for remediation/excavation as defined in the SLDA *Final Site Operations Plan* (Cabrera Services, Inc. 2009a). For the SLDA site, excavation is expected to include all of the trench areas and the localized surficial areas of contamination southwest of trench 10 and northwest of trench 4. In general, Class 1 units will conform to the floors of the excavation footprints (excluding the exposed bench/side slope soil surfaces). Each Class 1 unit will be limited to a maximum area of 2,000 m^2.

Class 2 survey units will be areas where there is evidence of the potential presence of elevated levels of residual radionuclides but no evidence that the levels exceed DCGL requirements. Class 2 units may be as large as 10,000 m^2 and will likely surround the Class 1 units. Dry Run will be a separate Class 2 unit. The exposed bench/side slope wall surfaces of the excavations will be considered Class 2 units. The upper 3 ft (1 m) of overburden soils (removed to access the contaminated trench material) and the bench/side slope soils (removed to ensure trench stability) will be placed into the stockpile area and spread into a 1-ft (0.3-m) layer, and the soils will be sampled at a density comparable to that of a Class 2 unit.

The SLDA Class 3 unit will include any impacted area that is not expected to contain any residual radioactivity or is expected to contain levels of residual radioactivity at a small fraction of the $DCGL_w$ as defined in Section 4.4 of MARSSIM (EPA 2000). The SLDA Class 3 area was selected on the basis of the disposal history, geophysical and gamma walkover surveys, the historical aerial photo analysis, and historical and RI samples with no evidence of significant contamination above DCGL levels. The Class 3 unit includes all areas of the site that have not been classified as Class 1 or Class 2 areas. The Class 3 unit will have no size restrictions.

The general survey unit boundaries described above are for planning purposes only. The actual layout of units and individual unit boundaries will be defined upon completion of the excavation activities and may be subsequently modified on the basis of FSS data. Class 2 unexcavated areas and the Class 2 cutback walls/benches will be reclassified as Class 1 units if unexpected contamination that exceeds DCGL requirements is encountered (as determined by sampling) or if buried objects that indicate disposal took place are discovered. Likewise, contamination above DCGL levels that may be unexpectedly encountered in the Class 3 unit will require remediation and reclassification of the affected areas as Class 1 units. The remediation of the SLDA trenches is expected to be sequenced on the basis of annual funding; remediation plans for each construction season will be developed until remediation is complete (Cabrera Services, Inc. 2009a). The survey unit boundaries of the Class 1 excavation areas and the adjacent Class 2 cutback walls/benches will also be dependent on the remediation plan for each construction season; these units will likely be smaller than the upper size limits of 2,000 m^2 and 10,000 m^2 for Class 1 and Class 2 units, respectively.

3.5 DEVELOP THE ANALYTIC APPROACH

At the SLDA site, the Class 1 survey units include the floors of the trench excavation areas and surface soil excavation areas. Figures 4-2 through 4-6, provided later in this document, are flow diagrams that illustrate the general sequence of events and decision-making process for the SLDA FSS. Figure 4-2 describes the general process for the surface area excavations, and Figure 4-3 depicts the process for the trench area excavations. Figures 4-4 and 4-5 are flow diagrams that explain the general course of action for the trench overburden soils and bench/side slope soils, respectively. These soils will be sampled in a manner similar to a MARSSIM Class 2 unit. Figure 4-6 is a flow diagram that illustrates the general sequence of events and the decision-making process for the Class 2 survey units including Dry Run, which will be addressed as an individual Class 2 unit. The Class 3 survey unit will follow a sequence of events similar to the adjacent Class 2 units (i.e., Figure 4-6); therefore, a Class 3 flow diagram is not included in this plan.

The flow of events is consistent with MARSSIM guidance and is intended to determine whether a survey unit and stockpiled soil unit are ready for release or whether other actions are required. The primary point of comparison for decision-making is the DCGL SOR value derived for the ROCs. If contamination potentially above DCGL requirements is encountered in a survey unit or a stockpiled soil unit, including small areas of elevated activity, the USACE will either determine whether excavation is necessary by collecting additional information or simply excavate the area of concern. This determination may be made by performing surface scans with FIDLER detectors or comparable radiation detectors or by collecting soil samples and testing sample results against statistical criteria (as described in Appendix I, Section 11 of MARSSIM).

For the SLDA site, the WRS test will be used for $DCGL_W$ statistical evaluations of soil sample results, as described in Appendix C. Uranium exists naturally in soil, and the background activity levels for its isotopes are low relative to the $DCGL_W$ requirements. However, for Th-232, the mean background activity concentration is comparable to the $DCGL_W$ (see Table 3-1). The difference between the Th-232 subsurface background level and the $DCGL_W$ is 0.1 pCi/g, and the difference between the Th-232 surface background concentration and $DCGL_w$ is 0.3 pCi/g. Because background concentrations for Th-232 may be a concern, the WRS test will be implemented under the MARSSIM closure process. The WRS test is used at sites where one or more of the ROCs are present in background media and their background concentrations are close to relevant $DCGL_w$ values. As mentioned previously in Section 3.2, when using a WRS test to evaluate the SOR $DCGL_w$, background is not subtracted from the sample activity concentrations.

When sample results are compared to the $DCGL_{emc}$ values, the SOR calculation will include subtracting the background activity concentrations from the FSS sample results. The background values to be used for the ROCs are the mean values calculated from the surface and subsurface samples collected as part of the RI activities. These values are listed in Table 3-1. The background soil samples were collected at 18 locations at Gilpin/Leechburg Community Park (USACE 2005). The zero surface and subsurface background activity concentrations for Am-241 and Pu-241 and subsurface Pu-239 (which are not naturally occurring) reflect sample results that were below the minimum detectable activities. The 0.01 pCi/g Pu-239 background surface activity concentration is likely due to atmospheric fallout from previous aboveground nuclear weapons tests.

In summary, if the DCGLs are met within a survey unit, then the survey units passes, and the soils meet the ROD criteria. If the DCGLS are not met, then the survey unit fails, and additional excavation will be required. A detailed discussion of testing for DCGL compliance is presented in Section 4 of this plan.

3.6 SPECIFY PERFORMANCE OR ACCEPTANCE CRITERIA

As part of the DQO process, the null hypothesis (H_0) for demonstrating compliance of data with cleanup goals must be stated. The H_0 tested is that residual contamination exceeds the acceptance criterion (cleanup requirement). If the H_0 is rejected, the alternative hypothesis must be accepted, and the finding of the evaluation is that the site satisfies the cleanup requirement. The WRS test will be used, as described in MARSSIM, to test the H_0 for $DCGL_w$ compliance. For the

$DCGL_{emc}$ requirements, scan results will be compared against a scanning/screening investigation level derived for that purpose, and sample results will be compared directly to $DCGL_{emc}$ requirements.

To enable testing of data relative to the cleanup criteria, there are two types of fundamental decision errors. The Type I (alpha) decision error to be used in data testing is 0.025 or 2.5%. The Type I error rate determines the minimum number of sample analyses required for each survey unit for establishing compliance with the $DCGL_W$. The Type II (beta) decision error may range between 0.01 (or 1%) and 0.25 (or 25%). Initial Type II decision errors to be used for soils to be sampled in situ is 0.05 (or 5%) and 0.10 (or 10%) for soils to be sampled ex situ from the stockpile layers. The acceptable probability of a Type II error is used to determine additional sample numbers necessary for controlling Type II errors during a $DCGL_W$ evaluation. Type II errors do not adversely impact public safety and health; however, they can impact the schedule and budget.

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 a sample analysis; the objective will be a relative percent difference of 30% or less at 50% of the DCGL values.
- Accuracy is the degree of agreement with the true or known; the objective for this parameter will be ±30% at 50% of the criterion value.
- Representativeness and comparability are ensured through the selection and proper implementation of systematic sampling and measurement techniques.
- Completeness refers to the portion of the data that meets acceptance criteria and is therefore usable for statistical testing. The objective is 90% for this project.

The generic PARCC criteria that focus on activity concentration results and analytical performance around the DCGL requirements may not be meaningful if no contamination is encountered, which will likely be the case during FSS work; thus, other factors should be taken into account when evaluating the quality and usability of the produced data sets.

3.7 DEVELOP THE PLAN FOR OBTAINING DATA

Field screening techniques, soil sampling, soil sample analysis, geophysical surveys, gamma measurements, and the DQA process will be used, as appropriate, throughout the final status sampling survey to focus efforts and minimize cost. As data are collected and analyzed, the assumptions in this plan should be reviewed for accuracy. If data from early survey units indicate that conditions are significantly different than those represented by the historical and RI data sets, the sample density and survey unit class may be adjusted for subsequent units.

4 TESTING FOR COMPLIANCE WITH CLEANUP GOALS

The number of samples necessary to statistically demonstrate compliance with $DCGL_w$ requirements can be calculated by using MARSSIM guidance. Section 4.1 lists the steps and describes the calculation method. The data used for the preliminary calculations are based on Th-232 RI data from the SLDA site, and the number of samples per survey unit is calculated in Section 4.1.5. Th-232 was selected because its $DCGL_w$ requirement is closest to background activity concentrations.

4.1 CALCULATION METHOD FOR SAMPLE NUMBERS

This section presents the equations and methods used to estimate the number of samples required for each survey unit to determine whether the unit may be released without radiological restrictions in accordance with MARSSIM guidance for radionuclides. Sample numbers provided here may be modified on the basis of additional information. There are eight basic steps for calculating the number of samples. Each of the steps that follows is described in detail in the following sections.

1. Classify survey units.
2. Specify decision error.
3. Determine $DCGL_w$.
4. Determine relative shift.
5. Obtain the number of samples per survey unit.
6. Estimate the sample grid spacing.
7. Address small areas with elevated radioactivity.
8. Determine if the number of samples is reasonable.

4.1.1 Classification of Survey Units

MARSSIM defines impacted areas as areas that have some potential for contamination. Impacted areas are subdivided into three classes:

- Class 1 units have, or had prior to remediation, radionuclide contamination that exceeded the $DCGL_W$.
- Class 2 units have a potential for radioactive contamination or known contamination, but levels are not expected to exceed the $DCGL_W$.
- Class 3 units are expected to contain no residual radioactivity or to contain levels of residual activity at only a small fraction of the $DCGL_W$.

By definition, any area requiring excavation will be encompassed by Class 1 units (excluding the bench/side slopes). For soils, MARSSIM suggests that a Class 1 unit be limited to a maximum area of 2,000 m^2. The Class 2 units will include the remaining unexcavated areas surrounding the excavations, the bench/side slope excavation walls, and Dry Run. The upper 3 ft (1 m) of trench overburden soil and the bench/side slope soil, removed for trench excavation stability, will be stockpiled and spread into 1-ft (0.3-m) layers; these soils will be addressed as Class 2 units (i.e., the stockpiled soil will be sampled at a density comparable to a MARSSIM Class 2 survey unit). There will be one Class 3 unit, and there is no limitation to the size of Class 3 units. Figure 4-1 shows the proposed layout of the Class 1, Class 2, and Class 3 areas. The layout of the actual survey areas may deviate from this initial design depending on the final footprint of remediation. Section 3.4 discusses the definition and layout of FSS units for the SLDA site in more detail.

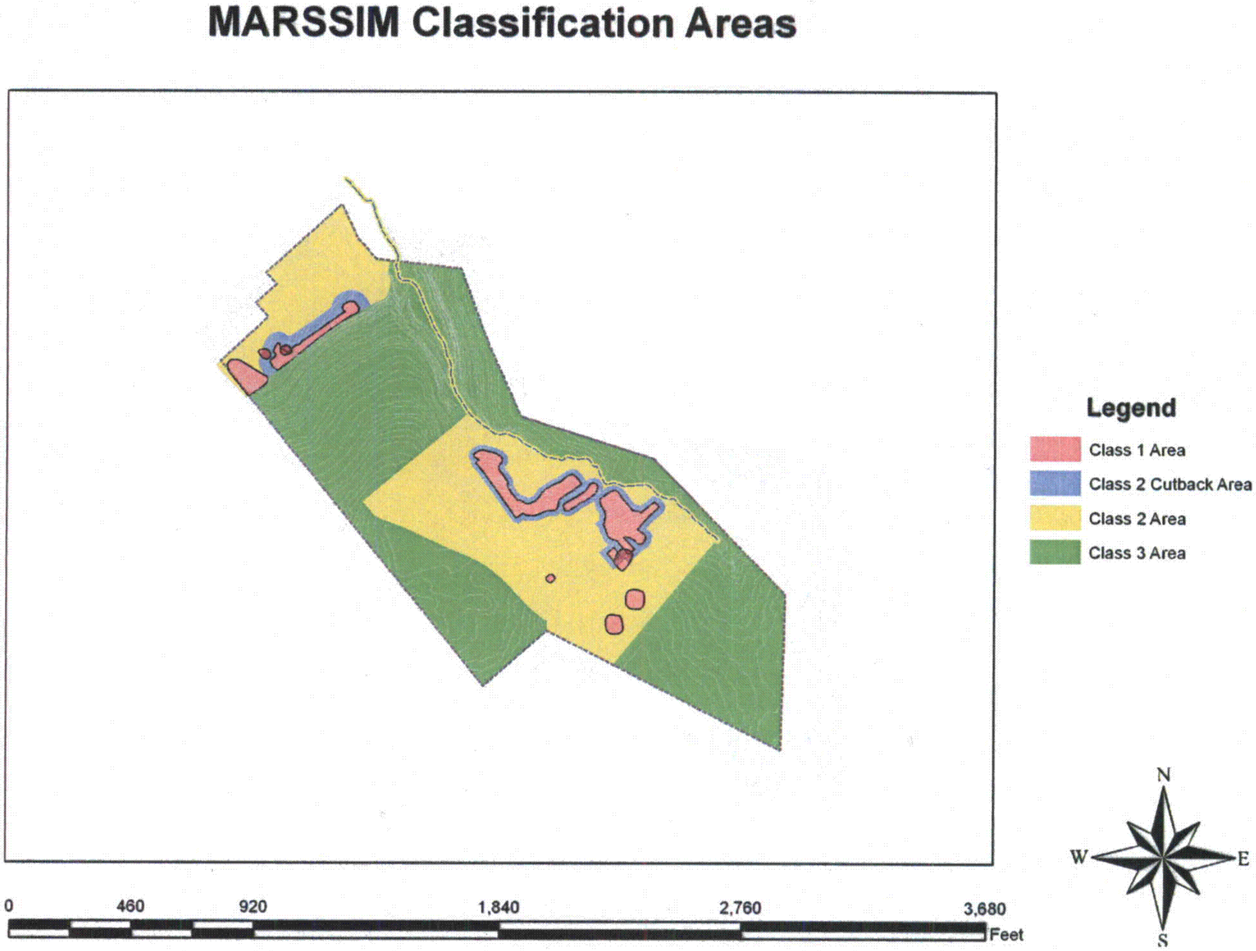
4.1.2 Decision Error

The probability of making decision errors can be controlled by adopting an approach called hypothesis testing. The H_0 is treated like a baseline condition and is defined as follows:

H_0 = residual radioactivity in the survey unit exceeds the release criteria.

This means that survey units are assumed to be contaminated above criteria until proven otherwise. A Type I decision error occurs when an area is determined to be below the criteria when it is really above the criteria (survey unit is incorrectly released). A Type II decision error occurs when an area is determined to be above the criteria when it is really below the criteria (survey unit is incorrectly not released).

Figure 4-1 Estimated Layout of Final Status Survey Unit Areas



For a given test that will statistically evaluate whether the H_0 is true or false, Type I and Type II decision error rates may be specified. Sample numbers can then be calculated so that the desired Type I and Type II decision error rates are achieved. For a fixed Type II decision error rate, lowering Type I decision error rates increases the number of samples required. Likewise, for a fixed Type I decision error rate, lowering the acceptable Type II decision error rate also increases the number of samples required. Type I decision error rates are important from the perspective of limiting residual risk. Type II decision error rates are important from the perspective of remediation costs. The Type I decision error rate for the SLDA site is set at 0.025 (2.5%). The acceptable Type II decision error rate may range between 0.01 (1%) and 0.25 (25%). An initial Type II error rate was set at 0.05 (5%) – an error rate used for previous FUSRAP FSSPs – for planning purposes for the survey units with soils that will be sampled in situ. For the overburden and bench/side slope soils to be sampled ex situ from stockpiles spread into the 1-ft (0.3-m) layers, an initial Type II error rate was set at 0.10 (10%). These Type II error rates were used in combination with historical Th-232 sampling results to determine, per survey unit, the sample number required to demonstrate $\mathrm{DCGL_w}$ compliance. Sample numbers may be adjusted up or down by the USACE during the FSS process if residual contamination conditions in soils are significantly different from the historical Th-232 results. Soil sample numbers will always be sufficient to guarantee a Type I error rate no greater than 0.025 (2.5%).

4.1.3 Derived Concentration Guideline Limit

The DCGL is defined in MARSSIM as the radionuclide-specific activity concentration within a survey unit corresponding to the release criterion. DCGLs are of two types: $\mathrm{DCGL_w}$ (wide area average criteria, applied to areas the size of survey units) and $\mathrm{DCGL_{emc}}$ (elevated area criteria, applied to areas much smaller than a survey unit). Site compliance with the $\mathrm{DCGL_w}$ is demonstrated by using discrete samples and a nonparametric statistical test. By using appropriate equations, one can determine the sample numbers required per survey unit to achieve desired Type I and Type II error rates for a particular statistical test.

Site compliance with the $\mathrm{DCGL_{emc}}$ is demonstrated through a combination of scanning and sampling. When a suitable scanning technology that is sensitive enough to detect $\mathrm{DCGL_{emc}}$ exceedances exists, and when this scanning technology can be implemented for 100% of a survey unit's surface, $\mathrm{DCGL_{emc}}$ compliance may be demonstrated with scans alone. For situations in which either a suitable scanning technology does not exist or it is not practical to obtain complete coverage with a scanning technique, $\mathrm{DCGL_{emc}}$ compliance demonstration may also require discrete sampling. In the course of $\mathrm{DCGL_w}$ compliance sampling, sufficient systematic samples may also be collected to demonstrate $\mathrm{DCGL_{emc}}$ compliance (or vice versa).

Section 3.2 described in detail the derivation of DCGL values for the SLDA site. DCGL values are listed in Table 3-1.

4.1.4 Relative Shift

The relative shift is defined in MARSSIM as the Δ/σ, where Δ is the DCGL minus the lower bound of the gray region (LBGR) and σ is the standard deviation of the contaminant distribution in the survey unit. The relative shift is actually a measure of the probability of an individual FSS sample result being below the $DCGL_W$. The larger the relative shift, the easier it is to demonstrate compliance with a $DCGL_W$. Relative shift values that are below one result in relatively large sampling requirements to demonstrate $DCGL_w$ compliance. In general, relative shift values that exceed four no longer have an impact on the number of samples required to show $DCGL_w$ compliance.

At the SLDA site, the mean background activity concentration for Th-232 is comparable to the $DCGL_w$ (see Table 3-1), thus requiring the use of the WRS test. Since the Th-232 $DCGL_w$ is close to background, it is expected that the Th-232 will drive the WRS analysis. More than 330 RI Th-232 sample results were used to determine FSS sample numbers. The average RIR Th-232 result – 1.3 pCi/g and an associated standard deviation of 0.36 – provides a basis for calculating a conservative number of FSS samples. The LBGR is 0, reflecting the fact that Th-232 activity concentrations in the excavations are expected to be near background levels. In the case of the WRS test, the LBGR is the difference between the expected average residual activity concentrations and the average background values. The relative shift calculated for this data set was approximately four.

4.1.5 Number of Samples per Survey Unit for $DCGL_w$

Table 5.3 in MARSSIM was used to determine the range of FSS composite samples per survey unit. A relative shift of four and a Type I error rate of 0.025 (or 2.5%) resulted in acceptable composite sample numbers that range between 6 and 15 per survey unit, depending on the Type II error rate. An initial Type II error rate of 0.05 (or 5%) was selected for the survey units (excluding the overburden and bench/side slope soil stockpiles), which equates to 11 composite samples per survey unit. Sample numbers may be adjusted up or down by the

USACE during the FSS process if residual contamination conditions in soils are significantly different from the historical Th-232 results. For the trench overburden and bench/side slope soils, Type II error rates are not believed to be a significant concern; for these soils, a Type II error rate of 0.10 (or 10%) was selected, which equates to 9 composite samples per survey unit. As discussed previously, the overburden and bench/side slope soils will be removed from the trench areas, placed into stockpiles, and shaped into 1-ft (0.3-m) layers for FSS sampling. For a conventional Class 2 unit, samples are typically collected from the surface to a depth of 15 cm (6 in.) in a 10,000-m^2 area; thus, the volume of soil sampled is 2,000 yd^3. To be consistent with the volume of soil that is sampled from a representative Class 2 unit, the stockpiled 1-ft (0.3-m) soil layers will be divided into survey units up to 2,000 yd^3 in volume for ex situ sampling.

All systematic FSS and biased samples collected will be composited as discussed in Section 5.1.2. Depending on the setting, each composite sample will be composed of three to five soil increments collected in the vicinity of a grid node location. Composite sampling will be conducted so that each in situ composite sample is representative of a 100-m^2 area, if possible; consequently, in situ composite sample results will be consistent with the $DCGL_{emc}$ definition. Sufficient soil mass will be collected for each increment to support the formation of a composite sample and to allow archiving the remaining soil mass for potential analysis if required. An example of a requirement to analyze sample increments is as follows: If a composite sample result from a Class 2 or 3 area suggests that contamination might be present at levels inconsistent with the assumptions justifying a Class 2 or 3 area designation.

Composite sampling provides two distinct advantages for the proposed FSS data collection. Composite sampling will yield a sample result that is more representative of $DCGL_{emc}$ 100-m^2 areas than will collecting a single discrete sample. The use of composite sampling will significantly lower $DCGL_w$ Type II error rates for a given number of composite sample results; consequently, the actual Type II error rate is expected to be significantly lower than the 0.05 (5%) used for planning purposes. Type II error rates are driven by the relative shift. The relative shift present is a function of the LBGR, the $DCGL_w$, and the level of variability to be expected in systematic sample results drawn from FSS units. The type of incremental composite sampling proposed will produce a set of analytical results with the same average activity concentration as a set of discrete soil samples, but with lower variability; consequently, it will increase the relative shift.

Background surface and subsurface soil sample results collected from a nearby unimpacted community park as part of the RI data collection activities (as discussed in Section 2.0) will serve as a source of reference area background activity concentrations that can be used with the WRS test to determine if $DCGL_W$ compliance can be achieved. Eighteen surface and subsurface samples were collected, and the data results are presented in Appendix C. The surface sample results will be used to demonstrate $DCGL_W$ compliance for the unexcavated Class 2 and Class 3 units. The subsurface background samples will be used to demonstrate $DCGL_W$ compliance for the Class 2 excavation wall samples, for the Class 1 excavation floor samples, and for the samples collected from the stockpiles composed of the trench overburden and bench/side slope soils.

4.1.6 Sample Grid Spacing

The grid spacing is estimated in one of two ways, depending on the shape of the grid. If a triangular grid is used (preferred), the grid spacing is estimated as follows:

$$L = \sqrt{\frac{A}{0.866 \times n}} \qquad \text{Eq. 1}$$

where A = the surface area in the survey unit and n = the number of samples required. If a square grid is used, the spacing is estimated as follows:

$$L = \sqrt{\frac{A}{n}} \qquad \text{Eq. 2}$$

In the event that a portion of the study area is long and narrow (e.g., Dry Run – a separate Class 2 unit), the sample grid will extend linearly and not in a square or triangular grid. For these areas, the width of the study area is less than the distance between grid nodes. Under this condition, the spacing between samples is calculated as follows:

$$\frac{A}{width} = total\ length \qquad \text{Eq. 3}$$

$$\frac{total\ length}{\#\, samples + 1} = L\,(length\ between\ \ samples) \qquad \text{Eq. 4}$$

The "+ 1" term in Equation 4 is added to the denominator so that sample locations do not overlap when long and narrow units lie end to end. Systematic grids will always make use of a randomly selected initial starting point.

As discussed in Section 5.1.2, composite samples will be collected, and in situ composite samples will be representative of 100-m^2 areas. The grid nodes obtained from the equations above should be considered the centers of the sampling areas from which soil increments contributing to each composite sample will be collected.

4.1.7 Small Areas of Elevated Activity

Elevated area concerns are assumed to be primarily associated with the Class 1 areas (i.e., excavation floors). At the SLDA site, small, isolated, and elevated areas may be encountered in the soils from the floors of the excavation. MARSSIM and this FSSP address these areas through the definition of the $DCGL_{emc}$ requirement. The historical and RI characterization data results suggest that U-234 (and, to a lesser degree, U-235) are the ROCs with detected concentrations that would pose the most concern from the perspective of the $DCGL_{emc}$ values. The locations with elevated uranium concentrations are in the Class 1 areas and are expected to be remediated before FSS work begins. For the SLDA site, it is expected that these types of areas would be initially identified by the scan results as being above background and that this finding would be confirmed on the basis of soil sample results.

MARSSIM requires verifying that the systematic sampling densities in Class 1 areas are sufficient to also address $DCGL_{emc}$ concerns, given the expected scan MDC values. Table 4-1 compares estimated FIDLER scan MDC values with the 100-m^2 $DCGL_{emc}$ requirements. Table 4-1 also provides estimated $DCGL_{emc}$ values for areas that are 20-m^2 in size; this is the size of an area that would be represented by each increment contributing to a five-increment composite sample. In addition, the derived investigation levels to be applied to a five-increment composite sample to ensure that none of the contributing increments could have exceeded their $DCGL_{emc}$ values for 20-m^2 areas are provided in Table 4-1. For the SLDA site, the types and mixtures of ROCs are such that gamma scanning techniques (i.e., surficial surveys) with a FIDLER or equivalent detector should be adequate to detect 100-m^2 $DCGL_{emc}$ exceedances. This satisfies MARSSIM's sample density requirement; as Table 4-1 also indicates, satisfying the 100-m^2 $DCGL_{emc}$ requirement with the composite sample also guarantees that none of the five increments contributing to the composite could have exceeded their 20-m^2 $DCGL_{emc}$ requirements.

In excavation areas, surficial scans of excavation benches/walls and floors will be used to complement discrete soil sampling. Prior to soil excavation and placement into stockpiles, surficial scans of trench overburden soil and the bench/side slope soils will be conducted to identify soils that could pose a potential elevated concentration concern. Scans of overburden soils and bench/side slope soils will also be performed after the soils are placed in the stockpile area. The presence of residual concentrations of Am-241 and the uranium isotopes U-234, U-235, and U-238 that exceed the 100-m^2 $DCGL_{emc}$ should be identifiable by using a FIDLER (or equivalent detector). The FIDLER-detector (or equivalent-detector) investigation level for $DCGL_{emc}$ compliance determination will be developed prior to the detector's use in the field. The primary purpose of defining the investigation level is to identify an appropriate investigation level for the instrument in the context of the SLDA site that does not yield unacceptable false positive rates. An investigation level based on gross gamma count rates will be used to identify small areas of elevated activity inconsistent with background activity concentrations that may require additional investigation or remediation. The investigation level for soils will be developed by determining background count rates for a set of surface soil locations at/or near the SLDA site area of concern, determining an average background response and its variability, and developing a field investigation level indicative of gross activity not consistent with background.

Table 4-1 Estimated FIDLER MDC Values

ROC	DCGLs for the Various Contaminated Areas (pCi/g)				Expected FIDLER Scan MDC (pCi/g)[b]	Derived Investigation Levels for Class 1 Systematic Composites (pCi/g)[c]
	$DCGL_w$	$DCGL_{emc}$ (100 m^2)	$DCGL_{emc}$ (20 m^2)[a]	$DCGL_{emc}$ (1 m^2)		
Am-241	28	420	5,172	6,300	30	1,034
Pu-239	33	570	10,614	13,000	200[d]	2,123
Pu-241	890	13,000	180,273	220,000	160[e]	36,055
Th-232	1.4	5.3	41	49	2	8
U-234	96	240	10,551	13,000	80[f]	2,110
U-235	35	110	740	890	30	148
U-238	120	520	3,736	4,500	30	747

[a] The 20-m^2 $DCGL_{emc}$ activity concentrations were derived by interpolating between the 1-m^2 $DCGL_{emc}$ and 100-m^2 $DCGL_{emc}$ values (provided in Appendix A).

[b] The expected FIDLER scan MDCs are the estimated net values.

[c] ROC investigations levels are 1/5 of the 20-m^2 $DCGL_{emc}$ activity concentrations.

[d] While a scan MDC of 20 pCi/g is reported for Pu-239 in Appendix H of MARSSIM, larger values were reported elsewhere. The value given here is expected to be reasonably achievable under field conditions.

[e] Assumes 40 years of in-growth of Am-241.

[f] Assumes 10–20% enrichment; would be lower for natural uranium.

The DCGL derivation for the SLDA site included a $DCGL_{emc}$ requirement, one that applies to areas equal to 100 m^2. $DCGL_{emc}$ requirements are typically handled as "respond-to" requirements during FSSs. In other words, if any contamination is encountered that exceeds this type of standard, remediation typically will be required.

If an area of elevated activity is detected with gamma scanning surveys, the boundary of this area will be delineated, and the size will be estimated. If the area exhibits an average count rate that indicated the 100-m^2 $DCGL_{emc}$ could potentially be exceeded, then either further compliance evaluation or remediation will be required. The compliance evaluation will involve the collection of at least five sample increments systematically distributed over a 100-m^2 area.

These sample increments will be composited and analyzed for Am-241, Pu-239, Th-232, U-234, U-235, and U-238 with gamma or alpha spectroscopy for final confirmation; Pu-241 will be analyzed by using liquid scintillation. (See Section 5.1.2 for an additional discussion on composite sampling.) The composite sample's SOR value will be compared with the 100-m^2 $DCGL_{emc}$. Since there is a range of uranium enrichments in the previously disposed-of waste, the investigation level may not be definitive in all cases. Soil samples will be used to verify the adequacy of remediation activities, with gamma scanning techniques serving as a more qualitative guideline for identifying areas that require further investigation or remediation.

As discussed in Section 2, a sitewide GWS was conducted in 2003 as part of the pre-RI characterization activities. The walkover survey, conducted with a FIDLER, identified five relatively small, isolated areas with rate measurements that were elevated when compared to rate measurements collected from background reference areas. (The elevated areas were sampled as part of the RI activities.) Therefore, a component of an elevated area evaluation has already taken place for the unexcavated Class 2 and Class 3 areas that was based on the results of the 100% sitewide GWS. In addition to the soil samples, the survey data collected in 2003 will be used as part of the FSS data set for Class 2 and Class 3 units. The densities of the 2003 GWS data collected in Class 2 and Class 3 areas are within the 10–100% scanning coverage rate for Class 2 units recommended in MARSSIM guidance. In the unexcavated Class 2 and Class 3 areas, additional GWS data will be collected to support the FSS process on an as-needed basis.

4.1.8 Reasonable Number of Samples

For the SLDA site, the number of FSS samples per survey unit can range from 6 to 15 on the basis of historical site data and error tolerances described in the proceeding sections. The initial number of composite samples per survey unit was calculated to be 11 (excluding the overburden and bench/side slope soils stockpile soils). On the basis of the site conceptual model, it is assumed that the contamination is primarily limited to the trench areas and that the excavation of these areas will include removal of the contaminated debris and soils. However, as information and knowledge are gained from the excavation, the number of FSS composite samples per survey unit selected may be increased or decreased to reflect the actual residual activity concentrations that are encountered.

Based on 11 samples in each Class 1, Class 2, and Class 3 survey unit, the initial estimate for the total number of in situ systematic composite closure samples for the site is 231, as shown in Table 4-2. This estimate was based on the assumption that the size of the Class 1 and Class 2 survey units would be smaller than 2,000 m^2 and 10,000 m^2, respectively, since the remediation will be segmented throughout several construction seasons. For the purpose of this FSSP, Table 4-2 provides an estimate of the expected number of FSS composite samples that will be collected in situ from the Class 1 excavation areas, the Class 2 cutback areas (i.e., side slopes/benches), and the surficial soils from the surrounding Class 2 (including Dry Run) and Class 3 areas. There are two Class 1 units assumed for the surface remediation areas: one noncontiguous unit for the upper trench area, and another noncontiguous unit for the lower trench area. For the trench area excavations, four Class 1 units are estimated for the upper trench area (i.e., trenches 1–9), and one Class 1 unit is estimated for the lower trench area (i.e., trench 10). Table 4-2 also includes an estimated total of 14 biased samples, which was based on a contingency measure to address possible $DCGL_{emc}$ concerns within the Class 1 units and Class 2 cutback/bench soil units. The 14 biased samples were allocated on the basis of an estimate of 10% of the total number of approximated systematic samples.

The estimated number of Class 2 cutback units surrounding the trench excavations is five. Again, this estimate was based on the assumptions that the remediation would be segmented throughout several construction seasons and that each of the Class 1 trench excavation areas would have Class 2 cutback soils requiring sampling to attain closure. The total number of Class 2 units surrounding the trench area excavations, including Dry Run (which will be addressed as a separate Class 2 unit), is eight. There will be one Class 3 unit.

The sample numbers presented in Table 4-2 are estimates only and should be reviewed to determine if they are reasonable as the excavation proceeds. For example, the number of FSS samples could be higher or lower, depending on how the excavation is implemented, which itself will depend on the annual funding. The trench excavations will be sequenced to match the available funding; consequently, there could potentially be more Class 1 and Class 2 cutback units, resulting in more samples than the number presented in Table 4-2. The Table 4-2 estimated sample numbers may also be too high in circumstances in which FSS unit sizes are small, as might be the case for Class 1 units that conform to small, localized excavation footprints. A small-area protocol for identifying the sample density for small-area final survey units will be developed for small Class 1 units (i.e., areas less than 1,000 m^2), if deemed necessary. It is the responsibility of the site managers and health physicists to evaluate whether the number of samples is reasonable. If it is determined that the number of samples is inadequate or excessive, the DQOs should be reevaluated.

Table 4-2 Estimated Number of In Situ Composite Soil Samples

Class	Number of Units	Number of Systematic Composite Surface Samples per Survey Unit	Total Number of Systematic Composite Surface Samples	Number of Biased Surface Samples	Total Number of Samples[a]
Class 1 surface excavations	2	11	22	2	24
Class 1 trench excavations	5	11	55	6	61
Class 2 cutback areas	5	11	55	6	61
Class 2	8	11	88	–	88
Class 3	1	11	11	–	11
Total	21	–	231	14[b]	245[a]

[a] Includes surface samples for Class 1, Class 2, and Class 3 units. Sample numbers will be adjusted after excavation is complete.

[b] As a contingency measure to address possible $DCGL_{emc}$ concerns, an additional 14 total biased samples (10%) have been allocated for the Class 1 survey units and the Class 2 cutback area units.

The initial number of composite samples per survey unit for the trench overburden and bench/side slope soil stockpile is nine, on the basis of the historical site data and error tolerances described in the preceding sections. For the purpose of this FSSP, Table 4-3 provides an estimate of the expected number of FSS samples that will be collected from the soil stockpile layers, based on the expected volume of overburden and bench/side slope soils to be removed from the trench excavation areas, as documented in the feasibility study for the SLDA site (USACE 2006a). Nine composite samples will be collected from each 2,000-yd^3 volume of soil (equivalent to collecting samples from the top 6 in. [15 cm] of surface soil from a 10,000-m^2 area Class 2 survey unit); the volume of soil per composite sample is 220 yd^3. On the basis of this volume of soil per sample, 223 systematic samples is an initial estimate for the ex situ overburden and bench/side slope stockpiled soils. (The ex situ soil volume includes a 20% over-excavation factor and an ex situ 30% bulking factor [USACE 2006a]). In addition, Table 4-3 also includes 22 biased samples as a contingency measure to address possible $DCGL_{emc}$ concerns that may be detected from the gross gamma survey. The 22 biased samples were allocated on the basis of an estimate of 10% of the total number of estimated systematic composite samples.

Table 4-3 Estimated Number of Ex Situ Composite Class 2 Samples

Soil Type	In Situ Soil Volume with 20% Over-Excavation Factor (yd^3)	Ex Situ Soil Volume with 30% Bulking Factor (yd^3)	Number of Systematic Composite Samples – One Sample per 220 yd^3 of Soil	Number of Biased Samples[a]
Overburden	10,000	13,000	59	6
Bench	27,600	36,000	164	16
Total	37,600	49,000	223	22

[a] As a contingency measure to address possible $DCGL_{emc}$ concerns, an additional 22 biased samples (10%) have been allocated for the overburden and bench/side slope soils.

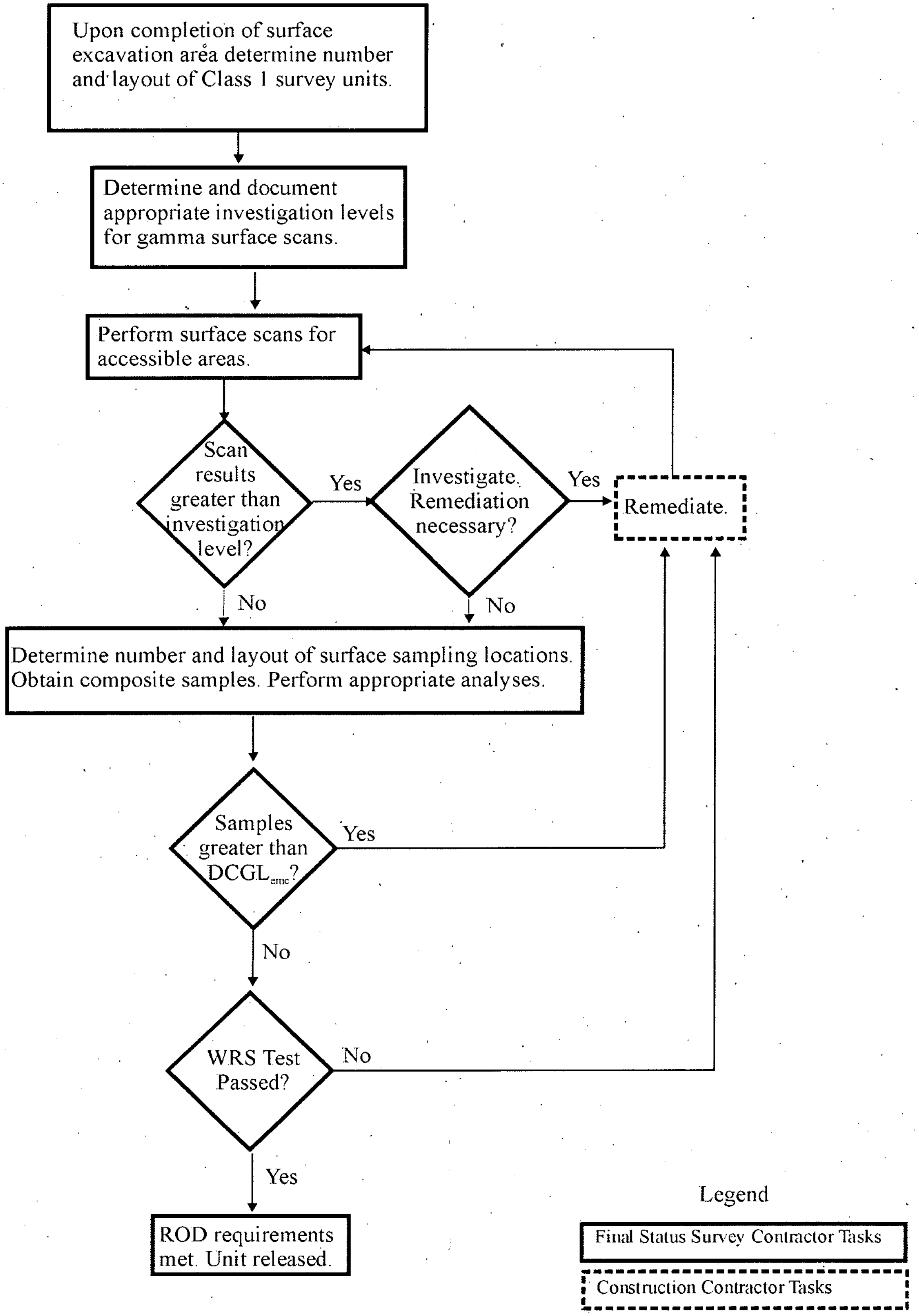
The density of sample collection described above is consistent with the sampling density requirements as described by PADEP for demonstrating compliance with the clean backfill criteria (PADEP 2004).

4.2 DECISION RULES FOR CLASS 1 AND CLASS 2 UNITS – EXCAVATION AREAS

Class 1 survey units will encompass the surface soil excavation areas and the excavation floors of the remediated trench areas. Within the excavation areas, Class 2 survey units include the cutback walls and/or benches. Figure 4-1 includes an initial layout of Class 1 areas and the surrounding Class 2 cutback areas based on the excavation design footprints. Figure 4-2 provides a flow diagram of the decision logic for FSS data collection and decision-making applied to the subset of Class 1 units that include remediated surface soil contamination areas. Each activity listed in the flow diagram is identified as a task that is expected to be performed by either the FSS contractor or the construction contractor. The following text describes the decision logic in Figure 4-2.

1. A technically defensible gross activity investigation level will be developed for surface scans by using a FIDLER or equivalent detector. This investigation level will be derived to indicate a contamination level that is not equivalent or consistent to background. (Since some of the ROCs are not detectable at their DCGL standards using field scanning, a FIDLER or equivalent detector investigation level will be defined as readings that are inconsistent with background conditions.)
2. After remediation, the number of Class 1 FSS units and the layout will be determined on the basis of final surficial excavation footprints.
3. After remediation, surface scans will be performed over 100% of the accessible areas of the excavation floors by using a FIDLER or equivalent detector. Gamma scan data from these Class 1 survey units will be obtained by walking the surface soil area of each unit in parallel paths at a traverse spacing of 1 m and traverses will also be performed orthogonal to the original traverses. The goal is to have a data density of approximately one measurement per square meter. Surface gamma scan results will be compared to the derived investigation level discussed above, and locations where the data indicate an anomaly was discovered will be flagged. Composite biased sampling will be conducted at these locations to confirm $DCGL_{emc}$ compliance, and/or additional

Figure 4-2 Decision Flow Diagram for Class 1 Units – Surface Area Excavations



remediation will take place. In the case of composite sampling, a sufficient soil mass will be collected to support the formation of the composite sample and to allow archiving of each individual increment for future analysis, if required. (An additional discussion on composite sampling is provided in Section 5.1.2.) It is assumed that there will not be a need to systematically scan the walls of the shallow surface excavations. However, if surface area excavations extend to depths requiring benching or sidewalls, the Class 1 units in these areas will be scanned and sampled in the same manner as trench area excavations (i.e., scanning and sampling of the excavation walls will be included).

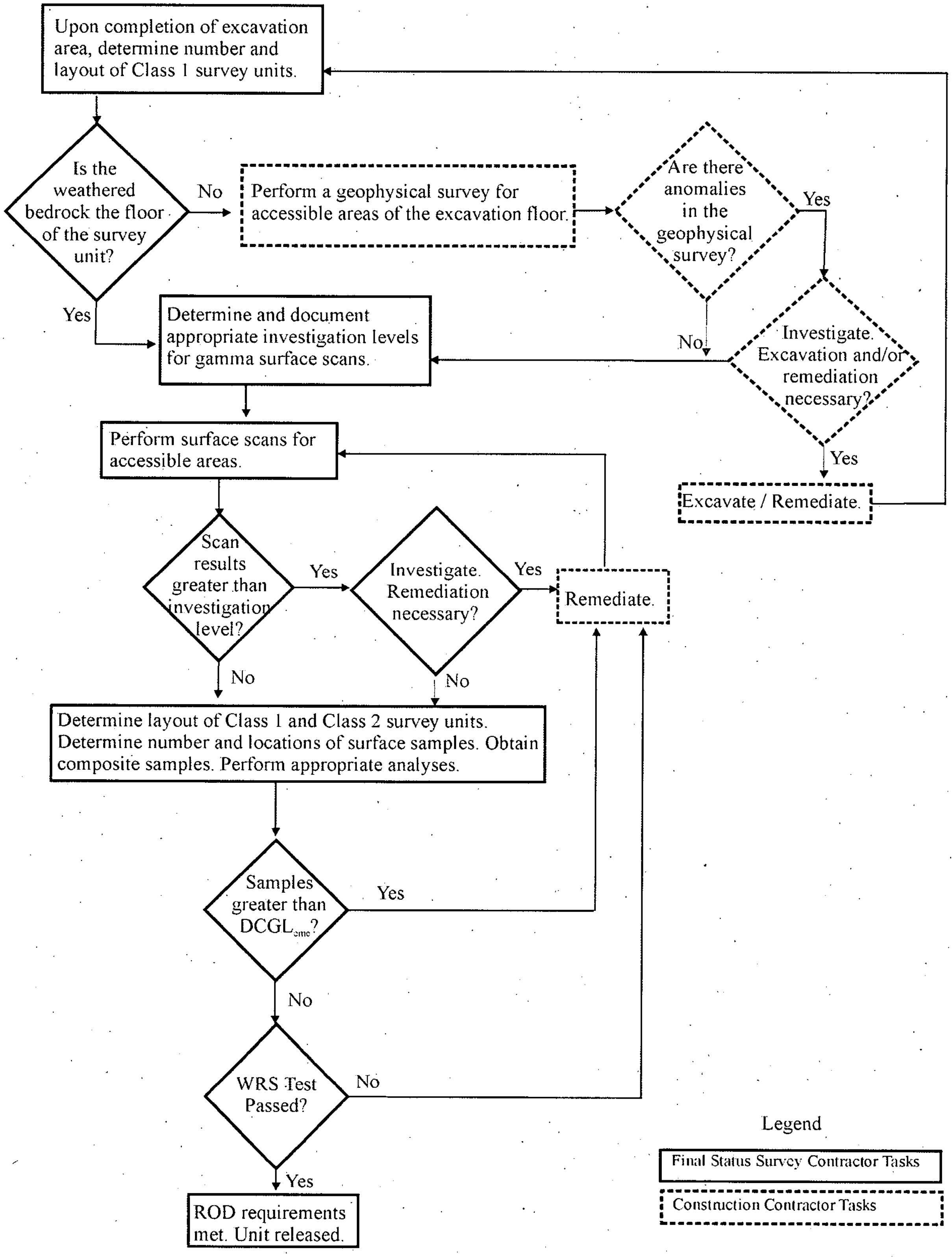
4. The number of systematic surface composite samples will be determined for each unit. The number of systematic composite samples will be determined by $DCGL_w$ (WRS test) requirements. On the basis of the Th-232 RI data and Type I (alpha) error tolerance of 0.025 (or 2.5%) and an initial Type II (beta) error tolerance of 0.05 (or 5%), the expected number of in situ composite samples per survey unit is 11. Sampling locations will be laid out on triangular grids, where possible.
5. Composite samples representative of the top 6 in. (15 cm) of soil will be collected from the floors of the excavations. In the case of composite sampling, a sufficient soil mass will be collected to support the formation of the composite sample and to allow archiving of each individual increment for future analysis, if required. (An additional discussion on composite sampling is provided in Section 5.1.2.) These samples will be analyzed for Am-241, Pu-239, Th-232, U-234, U-235, and U-238 by either gamma or alpha spectrometry. Liquid scintillation is the analytical method that will be used to analyze for Pu-241. The resulting SOR scores will be first compared to $DCGL_{emc}$ requirements. If a result is greater than a $DCGL_{emc}$, then additional remediation will take place. The results will be used to calculate $DCGL_w$ SOR values at individual sample locations within each FSS location, and these values will be evaluated for compliance with the $DCGL_w$ requirement by using the WRS test, as described in Appendix C. If the unit fails the WRS test, additional investigation may be undertaken to determine the cause, and/or additional remediation may be required.

6. If a survey unit satisfies all DCGL requirements, the unit will be considered to be in compliance with ROD requirements and ready for release. If a survey unit fails one or more of the DCGL requirements and requires additional remediation, the affected areas of the FSS unit will be subjected to additional FSS data collection to verify compliance with DCGL requirements.

Figure 4-3 provides a flow diagram of the decision logic for FSS data collection and decision-making applied to the subset of Class 1 and Class 2 units that include remediated subsurface trench contamination areas. The excavation floors will be addressed as Class 1 survey units, and the cutback walls and benches will be sampled at a density of a Class 2 unit. Each activity listed in the flow diagram is identified as a task that is expected to be performed by either the FSS contractor or the construction contractor. The following text describes the decision logic in Figure 4-3.

1. A technically defensible gross activity investigation level will be developed for surface scans by using a FIDLER or equivalent detector. This investigation level will be derived to indicate a contamination level that is not equivalent or consistent to background. (Since some of the ROCs are not detectable at their DCGL standards via field scanning, a FIDLER or equivalent detector investigation level will be defined as readings that are inconsistent with background conditions.)
2. After remediation, the number of Class 1 FSS units and the layout will be determined on the basis of final trench excavation footprints. Class 1 survey units should encompass the floors of the remediated trench areas and side walls or benches where contamination has been excavated.
3. After remediation of the trench areas, a geophysical survey will be performed with a focused, high-sensitivity metal detector, similar to the EM61-MK2 pre-excavation geophysical survey that was conducted at the SLDA site. The geophysical survey will be conducted over accessible areas of the excavation floor and only in areas where the floor of the survey unit is soil rather than weathered bedrock. The geophysical survey will be used to determine if there are anomalies potentially indicating remaining buried metallic

Figure 4-3 Decision Flow Diagram for Class 1 Units – Trench Area Excavation Floors and Class 2 Units – Cutback Walls/Benches



debris in the subsurface soils. The geophysical survey will be logged by using GPS instrumentation (integrated with the geophysical survey) or civil survey methods in order to map the geophysical survey data. If geophysical anomalies are identified, an additional investigation will be conducted at these locations, and/or additional remediation will take place.

4. Surface scans will be performed over 100% of the accessible surficial areas, including cutback benches and/or side walls and excavation floors, by using a FIDLER or equivalent detector. Gamma scan data from Class 1 excavation floor survey units will be obtained by walking the excavation floor of each unit in parallel paths at a traverse spacing of 1 m, and traverses will also be performed orthogonal to the original traverses. Excavation sloped walls and/or the cutback benches will also be scanned in parallel paths, if possible. The goal is for the floors and walls/benches of the excavation survey units to have a data density of approximately one measurement per square meter; both the Class 1 excavation floors and Class 2 cutback walls and benches will be scanned at the same density. Surface gamma scan results will be compared to the investigation level discussed above, and locations where the data indicate an anomaly (defined as a contamination level that is not equivalent or consistent to background) will be flagged. Composite biased sampling will be conducted at these locations to confirm $DCGL_{emc}$ compliance, and/or additional remediation will take place. In the case of composite sampling, a sufficient soil mass will be collected to support the formation of the composite sample and to allow archiving of each individual increment for future analysis, if required. (An additional discussion on composite sampling is provided in Section 5.1.2.)
5. The number of systematic composite surface samples will be determined for each unit. The number of systematic composite samples will be determined by $DCGL_W$ (WRS test) requirements. On the basis of the Th-232 RI data and Type I (alpha) error tolerance of 0.025 (or 2.5%) and an initial Type II (beta) error tolerance of 0.05 (or 5%), the expected number of in situ composite samples per survey unit is 11. Sampling locations will be laid out on triangular grids, where possible. The cutback walls/benches will be sampled at a density of a Class 2 unit if during the remediation there is no indication of the removal of contaminated soil. However, if, during the remediation, contaminated soil or debris is

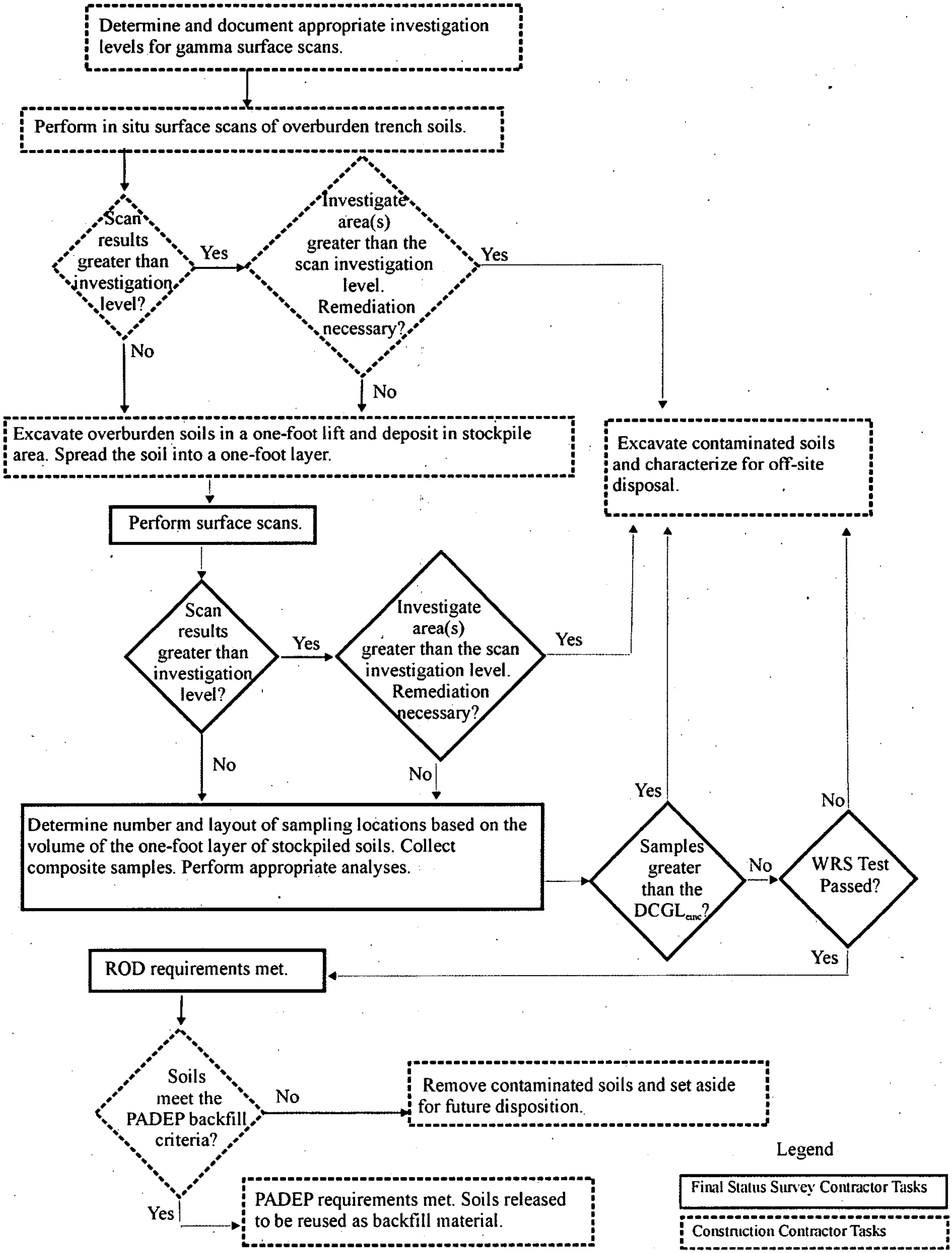
removed from a cutback wall/bench or there is a possibility that the excavation cutbacks/benching occurred in adjacent trenches, then the wall and/or benches will be sampled at the density of a Class 1 unit.

6. Composite samples representative of the top 6 in. (15 cm) of soil will be collected from the floors and cutback walls and/or benches of the excavation. In the case of composite sampling, a sufficient soil mass will be collected to support the formation of the composite sample and to allow archiving of each individual increment for future analysis, if required. The wall samples will be treated like vertical floor samples (i.e., composite sampled from a length of 0 to 6 in. [0 to 15 cm] into the wall), or, if the cutback walls are benched, the samples will be collected from the benches in the same manner as were the excavation floors. (An additional discussion on composite sampling is provided in Section 5.1.2.) These samples will be analyzed for Am-241, Pu-239, Th-232, U-234, U-235, and U-238 by either gamma or alpha spectrometry. Liquid scintillation is the analytical method that will be used to analyze for Pu-241. The resulting SOR scores will first be compared to $\mathrm{DCGL}_{\mathrm{emc}}$ requirements. If a result is greater than a $\mathrm{DCGL}_{\mathrm{emc}}$, then additional remediation will take place. The results will be used to calculate $\mathrm{DCGL}_{\mathrm{w}}$ SOR values at individual sample locations within each FSS location, and these values will be evaluated for compliance with the $\mathrm{DCGL}_{\mathrm{w}}$ requirement using the WRS test, as described in Appendix C. If the unit fails the WRS test, additional investigation may be undertaken to determine the cause, and/or additional remediation may be required.
7. If a survey unit satisfies all DCGL requirements, the unit will be considered to be in compliance with ROD requirements and ready for release. If a survey unit fails one or more of the DCGL requirements and requires additional remediation, the affected areas of the FSS unit will be subjected to additional FSS data collection to verify compliance with DCGL requirements.

4.3 DECISION RULES FOR CLASS 2 UNITS – EX SITU SOILS AND IN SITU SOILS SURROUNDING EXCAVATION AREAS

Figure 4-4 provides a flow diagram of the decision logic for FSS data collection and decision-making applied to ex situ trench overburden soils to be addressed as Class 2 units. Each

Figure 4-4 Decision Flow Diagram for Class 2 Units – Trench Overburden Soils



activity listed in the flow diagram is identified as a task that is expected to be performed by either the FSS contractor or the construction contractor. For planning purposes, it is assumed that the upper 3 ft (1 m) of overburden material will be sampled as outlined in Figure 4-4 and in the following text.

1. A technically defensible gross activity investigation level will be developed for surface scans by using a FIDLER or equivalent detector. This investigation level will be derived to indicate a contamination level that is not equivalent or consistent to background. (Since some of the ROCs are not detectable at their DCGL standards via field scanning, a FIDLER or equivalent detector investigation level will be defined as readings that are inconsistent with background conditions.)
2. Before excavation of the overburden soils, in situ surficial surface scans will be collected at an appropriate density from trench overburden soil by the construction contractor using a FIDLER or equivalent detector. These data will be used to identify potential areas of surfical soil contamination before removal of the soil to the stockpile area for ex-situ FSS sampling. Surface gamma scan results will be compared to the investigation level discussed above, and locations where the data indicate an anomaly (defined as a contamination level that is not equivalent or consistent to background) will be flagged. Composite biased sampling will be conducted at these locations, and/or the soils will be excavated and further characterized for off-site disposal. In the case of composite sampling, a sufficient soil mass will be collected to support the formation of the composite sample and to allow archiving of each individual increment for future analysis, if required. (An additional discussion on composite sampling is provided in Section 5.1.2.)
3. The 3-ft (1-m) layer of overburden soil will be removed and transported to the stockpile area. The soil will be spread into 1-ft (0.3-m) layers for scanning and sampling. Scans of 100% of the surface will be conducted for the 1-ft (0.3-m) layer of overburden soil by using a FIDLER or equivalent detector. Gamma scan data will be obtained by walking the designated layer of soil in parallel paths at a traverse spacing of 1 m, and traverses will also be performed orthogonal to the original traverses. The goal is to have a data density of approximately one measurement per square meter. Surface gamma scan results

will be compared to the investigation level discussed above, and locations where the data indicate an anomaly (defined as a contamination level that is not equivalent or consistent to background) will be flagged. Composite biased sampling will be conducted at these locations to confirm $DCGL_{emc}$ compliance, and/or the soils in the area will be excavated and further characterized for off-site disposal. In the case of composite sampling, a sufficient soil mass will be collected to support the formation of the composite sample and to allow archiving of each individual increment for future analysis, if required. (An additional discussion on composite sampling is provided in Section 5.1.2.) These gamma walkover surveys will be used (in addition to the soil sample results) to demonstrate DCGL compliance.

4. The number of systematic samples will be determined on the basis of the volume of the stockpiled material. Each Class 2 layer will have a maximum volume of 2,000 yd^3 of soil, equivalent to the volume of soil analyzed by collecting surface samples to a 6-in. (15-cm) depth from a 10,000-m^2 area conventional Class 2 survey unit. On the basis of the RI Th-232 data and Type I (alpha) error tolerance of 0.025 (or 2.5%) and an initial Type II (beta) error tolerance rate of 0.10 (or 10%), the expected number of samples per survey unit is nine. Nine samples will be collected from each overburden Class 2 unit up to 2,000 yd^3 in volume, resulting in a sample density of at least one sample per 220 yd^3 Sampling locations will be laid out on triangular grids, where possible.
5. Composite samples representative of the top 6 in. (15 cm) of soil will be collected from a 1-ft (0.3-m) soil layer unit up to 2,000 yd^3 in volume. In the case of composite sampling, a sufficient soil mass will be collected to support the formation of the composite sample and to allow archiving of each individual increment for future analysis, if required. (An additional discussion on composite sampling is provided in Section 5.1.2.) These samples will be analyzed for Am-241, Pu-239, Th-232, U-234, U-235, and U-238 by either gamma or alpha spectrometry. Liquid scintillation is the analytical method that will be used to analyze for Pu-241. The resulting SOR scores will first be compared to 100-m^2 $DCGL_{emc}$ requirements. If a result is greater than a $DCGL_{emc}$, the contaminated soil will be removed and characterized for off-site disposal. If all of the SOR values are less than the 100-m^2 $DCGL_{emc,}$ the results will then be used to calculate $DCGL_W$ SOR values, and the WRS test, as described in Appendix C, will be applied to sample results. If the unit

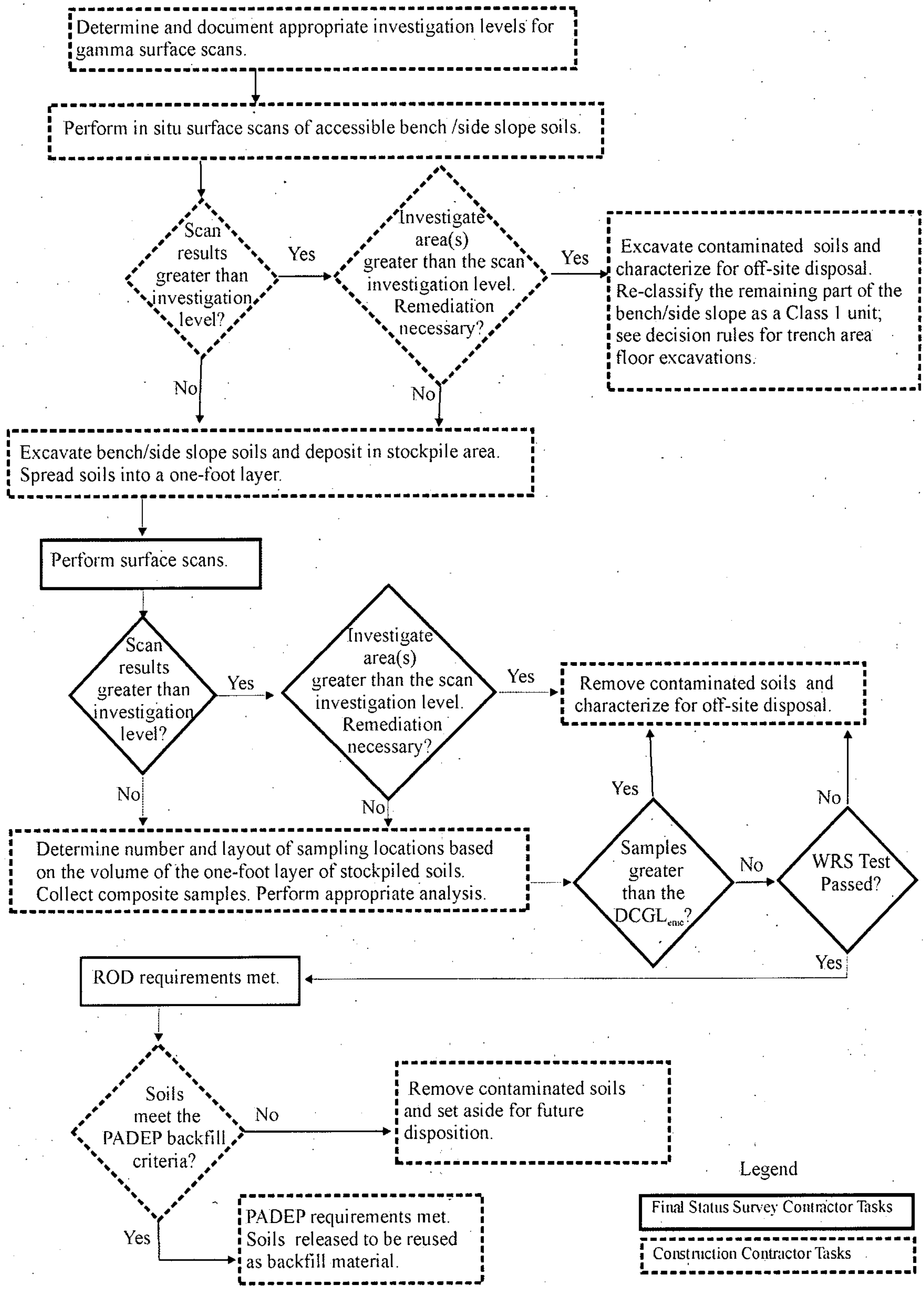
fails the WRS test, the soil unit will be removed from the area and characterized for off-site disposal. If a result is less than DCGL standards but indicates contamination at levels inconsistent with the original Class 2 area designation, the archived increments will be analyzed to determine if the area should have been classified as a Class 1 area and/or whether contamination that would pose DCGL concerns is present.

6. If a survey unit satisfies all DCGL requirements, soil samples from the stockpile layer survey unit will be analyzed for chemicals required to meet the PADEP backfill requirements (PADEP 2004). If the samples meet the PADEP backfill criteria, the soils will be released to be reused as backfill soils at the site. If the soils fail to meet the PADEP backfill criteria, the soils will be removed and placed in a separate stockpile for future deposition.

Figure 4-5 provides a flow diagram of the decision logic for FSS data collection and decision-making applied to the bench/side slope soils. Each activity listed in the flow diagram is identified as a task that is expected to be performed by either the FSS contractor or the construction contractor. For planning purposes, it is assumed that bench/side slope soil excavated from the trench areas for slope stability will be sampled as outlined in Figure 4-5 and in the following text.

1. A technically defensible gross activity investigation level will be developed for surface scans by using a FIDLER or equivalent detector. This investigation level will be derived to indicate a contamination level that is not equivalent or consistent to background. (Since some of the ROCs are not detectable at their DCGL standards via field scanning, a FIDLER or equivalent detector investigation level will be defined as readings that are inconsistent with background conditions.)
2. Before excavation of the bench/side slope soils, surface scans will be performed over accessible bench/side slope soil by the construction contractor using a FIDLER or equivalent detector. In situ gamma scan data from the side slopes will be obtained by walking or scanning by hand the bench/side slope soil and collecting measurements

Figure 4-5 Decision Flow Diagram for Class 2 Units – Bench/Side Slope Soils



at an appropriate density. These data will be used to identify potential areas of soil contamination or to justify removing these soils to the stockpile area for ex-situ FSS sampling. Surface gamma scan results will be compared to the investigation level discussed above, and locations where the data indicate an anomaly (defined as scan measurements not equivalent or consistent with background) will be flagged. Composite biased sampling will be conducted at these locations, and/or the soils will be excavated and further characterized for off-site disposal. In the case of composite sampling, a sufficient soil mass will be collected to support the formation of the composite sample and to allow archiving of each individual increment for future analysis, if required. (An additional discussion on composite sampling is provided in Section 5.1.2.) If contaminated soil or material is removed from cutback walls/bench areas, this part of the excavation will be addressed as a Class 1 unit in conjunction with the excavation floors.

3. The bench/side slope soil will be removed and transported to the stockpile area. The soil will be spread into 1-ft (0.3-m) layers for scanning and sampling. The 100% surface scans will be conducted for the 1-ft (0.3-m) layer of overburden soil by using a FIDLER or equivalent detector. Gamma scan data will be obtained by walking the designated layer of soil in parallel paths at a traverse spacing of 1 m, and traverses will also be performed orthogonal to the original traverses. The goal is to have a data density of approximately one measurement per square meter. Surface gamma scan results will be compared to the investigation level(s) discussed above, and locations where the data indicate an anomaly (defined as scan measurements not equivalent or consistent to background) will be flagged. Composite biased sampling will be conducted at these locations to confirm $\mathrm{DCGL}_{\mathrm{emc}}$ compliance, and/or the soils in the area will be excavated and further characterized for off-site disposal. In the case of composite sampling, a sufficient soil mass will be collected to support the formation of the composite sample and to allow archiving of each individual increment for future analysis, if required. (An additional discussion on composite sampling is provided in Section 5.1.2.) These gamma walkover surveys will be used (in addition to the soil sample results) to demonstrate DCGL compliance.
4. The number of systematic samples will be determined on the basis of the volume of the stockpiled material. Each Class 2 layer will have a maximum volume of 2,000 yd^3 of soil,

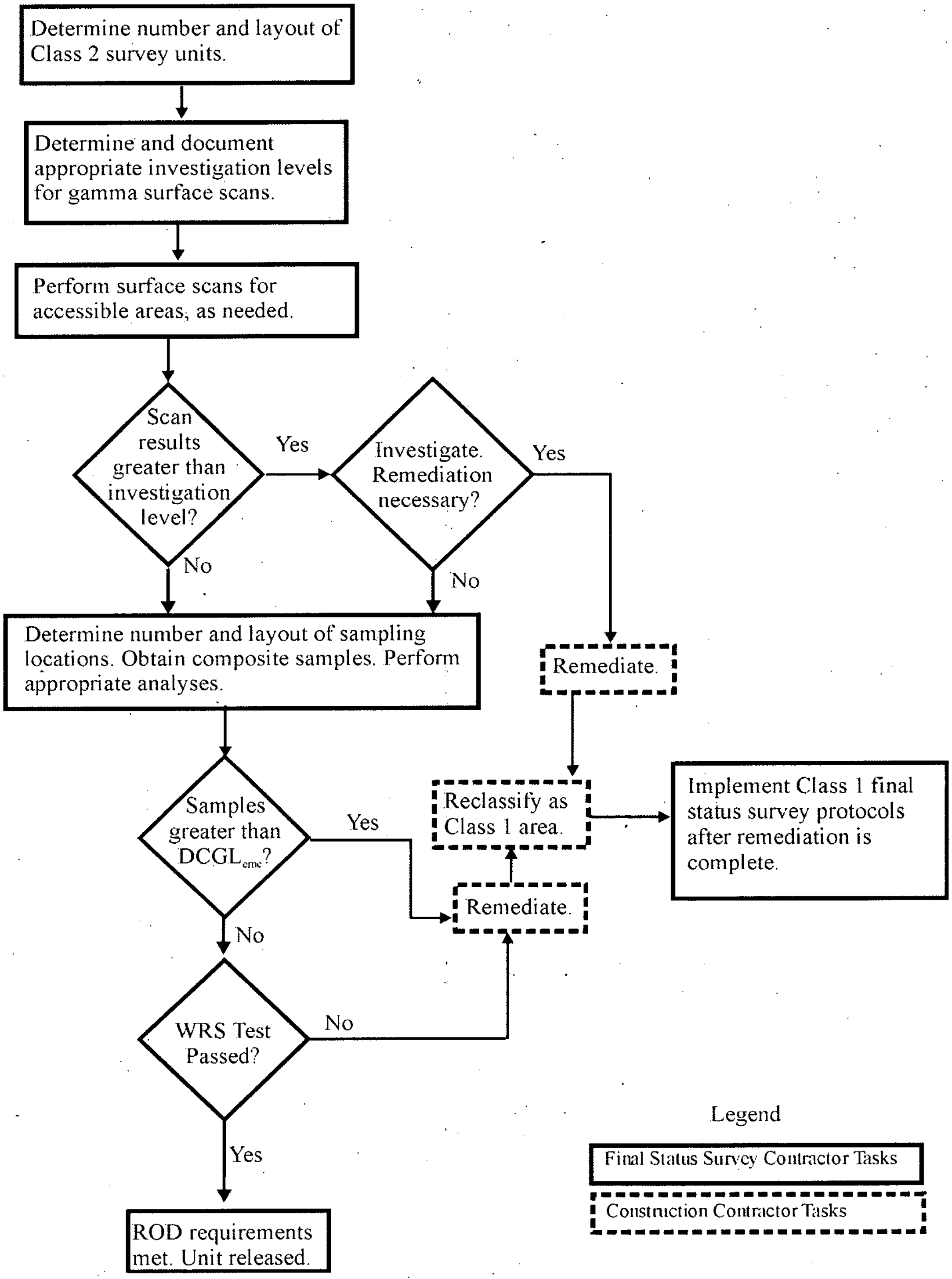
equivalent to the volume of soil analyzed by collecting surface samples to a 6-in. (15-cm) depth from a 10,000-m^2 area conventional Class 2 survey unit. On the basis of the RI Th-232 data and Type I (alpha) error tolerance of 0.025 (or 2.5%) and an initial Type II (beta) error tolerance rate of 0.10 (or 10%), the expected number of samples per survey unit is nine. Nine samples will be collected from each overburden Class 2 unit up to 2,000 yd^3 in volume, resulting in a sample density of at least one sample per 220 yd^3 Sampling locations will be laid out on triangular grids, where possible.

5. Composite samples representative of the top 6 in. (15 cm) of soil will be collected from a 1-ft (0.3-m) soil layer unit up to 2,000 yd^3 in volume. In the case of composite sampling, a sufficient soil mass will be collected to support the formation of the composite sample and to allow archiving of each individual increment for future analysis, if required. (An additional discussion on composite sampling is provided in Section 5.1.2.) These samples will be analyzed for Am-241, Pu-239, Th-232, U-234, U-235, and U-238 by either gamma or alpha spectrometry. Liquid scintillation is the analytical method that will be used to analyze for Pu-241. The resulting SOR scores will first be compared to 100-m^2 $DCGL_{emc}$ requirements. If a result is greater than a $DCGL_{emc}$, the contaminated soil will be removed and characterized for off-site disposal. If all of the SOR values are less than the 100-m^2 $DCGL_{emc}$, the results will then be used to calculate $DCGL_w$ SOR values, and the WRS test, as described in Appendix C, will be applied to sample results. If the unit fails the WRS test, the soil unit will be removed from the area and characterized for off-site disposal. If a result is less than DCGL standards but indicates contamination at levels inconsistent with the original Class 2 area designation, the archived increments will be analyzed to determine if the area should have been classified as a Class 1 area and/or whether contamination that would pose DCGL concerns is present.
6. If a survey unit satisfies all DCGL requirements, soil samples from the stockpile layer (survey unit) will be analyzed for chemicals required to meet the PADEP backfill requirements (PADEP 2004). If the samples meet the PADEP backfill criteria, the soils will be released to be reused as backfill soils at the site. If the soils fail to meet the PADEP backfill criteria, the soils will be removed and placed in a separate stockpile for future deposition.

Figure 4-6 provides a flow diagram for the in situ Class 2 units (i.e., soils surrounding the Class 1 areas and sediments within Dry Run). Each activity listed in the flow diagram is identified as a task that is expected to be performed by either the FSS contractor or the construction contractor. The following text describes the decision logic in Figure 4-6. Note that surface walkover surveys have already been performed and these data will be used to support the FSS closure process (see Section 2.0 and Figure 2-1.), as appropriate. In addition, before the start of remediation, the remediation/construction contractor will be performing a comprehensive walkover survey of the entire site prior to the start of excavation. These data may also be included as part of the in situ Class 2 FSS data set. Additional final status gamma walkover surveys in Class 2 areas will be performed only on an as-needed basis.

1. After remediation, the number of Class 2 FSSs and the layouts will be determined on the basis of the final excavation footprints and civil surveys of the Class 1 areas. Class 2 units should encompass all areas in the study area not included in Class 1 or Class 3 units.
2. The number of systematic composite surface sample locations will be determined for each unit. The number of locations will be determined by $DCGL_w$ (WRS test) requirements. On the basis of the Th-232 RI data and Type I (alpha) error tolerance of 0.025 (or 2.5%) and an initial Type II (beta) error tolerance of 0.05 (or 5%), the expected number of in situ samples per survey unit is 11. Sampling locations will be laid out on triangular grids, where possible. For Dry Run, sampling locations will be located on a linear grid, centered on the middle of the streambed, where possible.
3. Composite samples representative of the top 6 in. (15 cm) of soil will be collected. In the case of composite sampling, a sufficient soil mass will be collected to support the formation of the composite sample and to allow archiving of each individual increment for future analysis, if required. (An additional discussion on composite sampling is provided in Section 5.1.2.) These samples will be analyzed for Am-241, Pu-239, Th-232, U-234, U-235, and U-238 by either gamma or alpha spectrometry. Liquid scintillation is

Figure 4-6 Decision Flow Diagram for In Situ Class 2 Units



the analytical method that will be used to analyze for Pu-241. The resulting SOR scores will be compared to $DCGL_{emc}$ requirements. The individual $DCGL_w$ SOR values for the surface samples will be computed, and the WRS test, as described in Appendix C, will be applied to the sample results. If a result is less than DCGL standards but indicates contamination at levels inconsistent with the original Class 2 area designation, the archived increments will be analyzed to determine if the area should have been classified as a Class 1 area and/or whether contamination that would pose DCGL concerns is present.

4. If a survey unit satisfies all DCGL requirements, the unit will be considered to be in compliance with ROD requirements and ready for release. If a survey unit fails one or more of the DCGL requirements and requires additional remediation, the affected areas of the FSS unit will be reclassified as a Class 1 unit and subjected to additional FSS data collection with Class 1 closure protocols to verify compliance with DCGL requirements.

4.4 DECISION RULES FOR CLASS 3 UNITS

The following text describes the decision logic for the Class 3 units.

1. The Class 3 area will encompass all areas in the study area not included in Class 1 or Class 2 units.
2. Because the Class 3 area is not expected to contain any residual radioactivity or is expected to contain levels of residual radioactivity at a small fraction of the $DCGL_w$ requirements, the FSS data collection activities will not be as intense as those associated with Class 1 or Class 2 units. The number of sample locations will be determined by $DCGL_w$ (WRS test) requirements. On the basis of the Th-232 RI data and Type I (alpha) error tolerance of 0.025 (or 2.5%) and an initial Type II (beta) error tolerance of 0.05 (or 5%), the expected number of in situ samples per survey unit is 11. The composite surface samples will be laid out on a random start triangular grid, consistent with the Class 1 and Class 2 survey units. In the case of composite sampling, sufficient soil mass will be collected to support the formation of the composite sample and to allow archiving of each

individual increment for future analysis, if required. (Although MARSSIM recommends random location placement for systematic samples from Class 3 units, experience has shown that this can result in an undesirable clustering of samples within the unit. A random start triangular grid is recommended here to avoid this situation.)

3. Composite samples representative of the top 6 in. (15 cm) of soil will be collected. In the case of composite sampling, sufficient soil mass will be collected to support the formation of the composite sample and to allow archiving of each individual increment for future analysis, if required. (An additional discussion on composite sampling is provided in Section 5.1.2.) These samples will be analyzed for Am-241, Pu-239, Th-232, U-234, U-235, and U-238 by either gamma or alpha spectrometry. Liquid scintillation is the analytical method that will be used to analyze for Pu-241. The results will be compared to the appropriate DCGL standards. The resulting SOR scores will be compared to DCGL_{emc} requirements. The individual DCGL_{w} SOR values for the surface samples will be computed, and the WRS test, as described in Appendix C, will be applied to the sample results. If a result is less than DCGL standards but indicates contamination at levels inconsistent with the original Class 2 area designation, the archived increments will be analyzed to determine if the area should have been classified as a Class 1 area and/or whether contamination that would pose DCGL concerns is present.

4. If any individual sample yields a result above DCGL_{emc} requirements, remediation and reclassification of that area as a Class 1 unit will be necessary, and the area will be reclassified as a Class 1 unit.

5. If the Class 3 survey unit satisfies all DCGL requirements, the unit will be considered to be in compliance with ROD requirements and ready for release. If the survey unit fails one or more of the DCGL requirements and requires additional remediation, the affected areas of the FSS unit will be reclassified as a Class 1 unit and subjected to additional FSS data collection with Class 1 closure protocols to verify compliance with DCGL requirements.

5 FIELD ACTIVITIES

The principal field activities that will be conducted as part of the SLDA site FSS include the following: surficial gamma scans of the overburden and bench/side slope soils and of the floors and walls of excavated areas, nonintrusive geophysical surveys where required, collection of soil samples and their analysis by alpha and gamma spectroscopy. The remainder of this section briefly describes each of these activities. More details on the field activities will be provided in a sampling plan to be prepared before the FSS is implemented.

5.1 GAMMA SCANNING MEASUREMENTS AND SOIL SAMPLING

5.1.1 Gamma Scanning Surveys

When excavation is complete, systematic gamma scan surveys of the excavation floors and along the face of the side walls or benches will be conducted by using a FIDLER or equivalent detector. In the trench areas, surficial gamma scans will be performed in situ for every 1-ft (0.3-m) lift of the trench overburden soils (to a depth of 3 ft [1 m]). Procedures are provided in the MARSSIM 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* (NRC 1998).

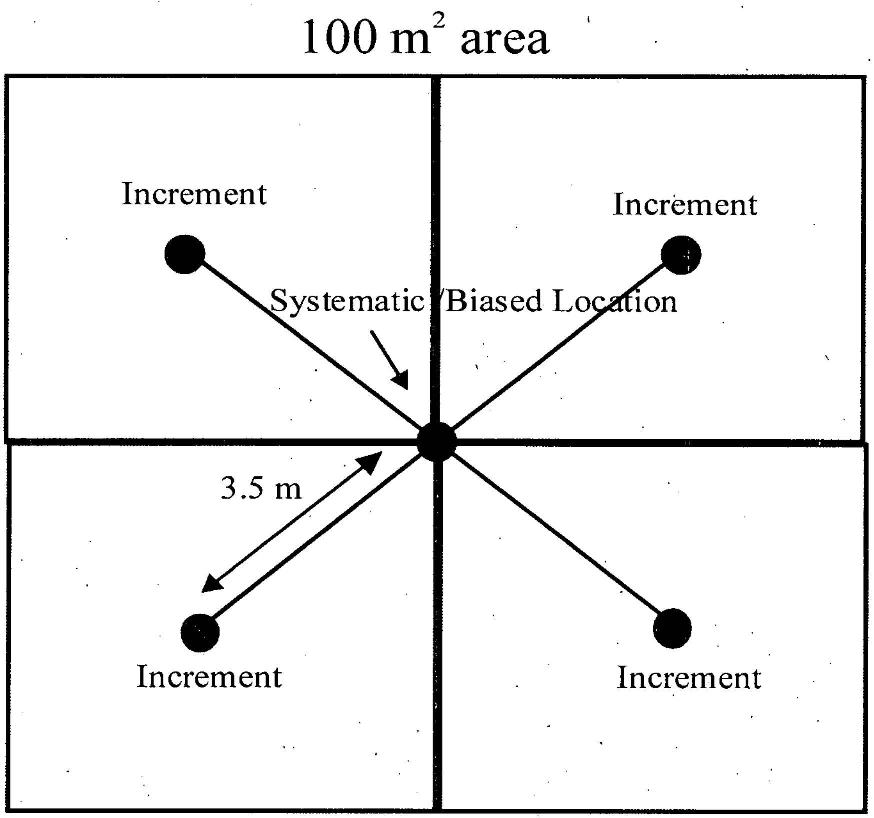
Following the removal of the overburden and side slope soils to the stockpile area, the soils will be shaped into 1-ft (0.3-m) layers, and systematic surveys will be performed. Gamma scan surveys will be conducted for the surrounding Class 2 and Class 3 areas on an as-needed basis. Gamma scan surveys measurements will be logged by using instrumentation with integrated GPS capability or its equivalent. The ROCs, Am-241, Th-232, U-235, and U-238 are readily detectable in soils at levels below the DCGLs by gamma scanning instruments, such as a FIDLER or equivalent detector. (Th-232 is detectable based on the presence of Ra-228 and subsequent radioactive decay products.) While Pu-239 and Pu-241 are not readily identifiable by using a FIDLER or equivalent detector, the likely presence of collocated Am-241 enhances the ability of the scans to identify plutonium concerns. In addition, the DCGLs for Pu-241 are much higher than those for Am-241. Similarly, while U-234 is generally not readily identifiable by using a FIDLER or equivalent detector, the presence of other collocated uranium isotopes (principally U-235) enhances the ability of the scans to identify U-234 concerns. The use of a FIDLER or equivalent detector may not be definitive in all cases, but it should be adequate for identifying areas where ROCs are present at activity concentrations inconsistent with background conditions and possibly at or above the $\mathrm{DCGL_{emc}}$ values. The FSS contractor will calculate scan MDCs for the selected detector and for those ROCs that can be detected. These calculations and results should be included in its work plans. It is recommended that the selected gross gamma detector(s) be used for all FSSs (i.e., excavation floors, cutback walls, and overburden soils). In addition, it is recommended that the same detector(s) that were selected to help guide the excavation be used for final status walkover surveys.

5.1.2 Soil Sampling in Class 1, Class 2, and Class 3 Units

Scanning surveys with a FIDLER or equivalent detector, combined with a GPS and data logging capabilities, will be deployed as conditions allow. The scanning surveys from the floors of the Class 1 units and from the overburden and bench/side slope soils of the Class 2 units will be evaluated for anomalies and spatial patterns or trends in gross activity that might be indicative of residual contamination of concern. If suspicious anomalies or patterns that are not consistent with background are identified, biased surface samples may be collected, and/or the concerns may be addressed via additional excavation.

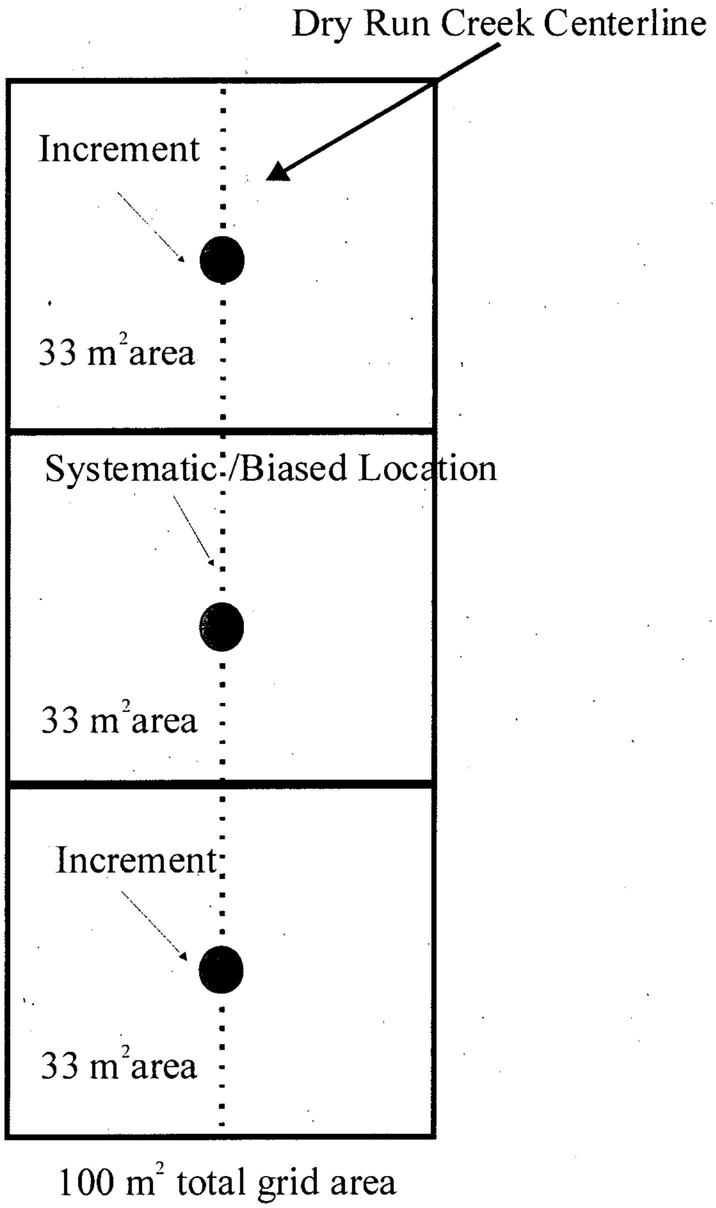
For biased and gridded in situ soil sampling (except for Dry Run, a separate Class 2 unit), a composite sample will be created from soils using a five-point sampling scheme. The five-increment sample will be centered on the systematic grid node or biased location, and it will consist of soils representative of a 100-m^2 area, with one sample located on the systematic grid node/biased location, and the other four located in four quadrants 3.5 m from the systematic/biased location in a star pattern (see Figure 5-1). The spacing was selected so that each of the incremental samples represented an equivalent area. If the increment locations based on this method fail to fall within the excavation footprint or survey unit being sampled, the sample(s) may be manually oriented to ensure that the four sampling locations (extending from the grid node) are located within the excavated area or unit.

Figure 5-1 Five-Increment Sample Diagram for In Situ Composite Sampling



For Dry Run, a composite sample will be created from soils by using a three-point sampling design. The three-point increments will be centered on the systematic grid node along the center of the streambed; one sample increment will be collected from the grid node, another will be collected upstream of the grid node, and the other will be collected downstream (see Figure 5-2). Each upstream and downstream sample increment will represent one-third (or 33 m^2) of the total 100-m^2 area. The distance of the samples from the center grid node will depend on the width of the creek in the sampling area.

Figure 5-2 Three-Increment Sample Diagram for Composite Sampling at Dry Run



In both cases, sufficient soil mass will be collected to support the formation of the required composite sample and to allow archiving of each individual increment for future analysis, if required.

One sample will be formed from these five or three equal-volume increments and submitted for analysis. The purpose of the five- and three-point composite sample is to obtain as representative a result of the 100-m^2 area as cost-effectively as possible, while minimizing the possibility of either missing contamination that should be removed or excavating soil that actually meets the DCGL requirements.

Soil samples will be collected by using a stainless steel scoop or spoon and will be homogenized in a stainless steel bowl or container prior to containerization. In general, samples will be analyzed by gamma and/or alpha spectrometry. Table 5-1 summarizes sampling and analytical requirements. Matrix spike/matrix spike duplicate (MS/MSD), field duplicate, and USACE-Buffalo District QA split samples will be collected from the same locations to enhance the comparability of results.

For the in situ Class 1, Class 2 (except for Dry Run), and Class 3 areas, a triangular grid will be used to determine the layout of the systematic composite sample locations for the floors and walls of the survey units. The start point for the systematic grid will be randomly selected. The systematic composite samples will be collected by using a five-point increment sampling technique. For Dry Run, a liner grid will be used to determine the layout of the systematic sampling locations. The linear grid for Dry Run will be centered down the middle of the streambed. The systematic composite samples will be collected by using a three-point increment sampling technique.

5.1.3 Field Measurements

Field measurements to be conducted as part of the SLDA site investigation may include organic vapor monitoring and field radiological screening. These measurements will be performed as specified in the health and safety and emergency response plan.

Radiological screening will be conducted to meet several requirements during this investigation. Field scans will be conducted by using radiological field screening instruments (e.g., Geiger-Mueller detectors and swipe counters) for the release of equipment and materials during and after the investigation and including samples and sample coolers. In addition, scans will be conducted to satisfy the requirements of the site safety and health plan (SS&HP) for radiological monitoring of personnel involved in on-site activities. Stationary scans using a FIDLER or an equivalent gross gamma detector will also be used to identify potentially elevated radionuclide levels in surface soils at sampling locations before samples are collected. These data will be logged and used to determine if the potential for contamination above $DCGL_w$ and $DCGL_{emc}$ requirements exists at individual locations. An investigation level will be derived to indicate a contamination level that is not equivalent to or consistent with the background level. Since some of the ROCs are not detectable at their DCGL standards via field scanning, a FIDLER or equivalent detector investigation level will be defined as readings that are inconsistent with background conditions.

All radiological screening will be conducted in accordance with the contractor's radiological protection plan or applicable procedures.

5.2 GEOPHYSCAL SURVEYS

When excavation is complete, scanning surveys with a nonintrusive geophysical detector combined with a GPS (or equivalent) and data logging capabilities will be deployed in trench area excavations where the excavation floor is soil rather than weathered bedrock. The geophysical survey will be conducted to determine if there are anomalies that potentially indicate that buried metallic debris remains in the subsurface (only if the excavation does not reach weathered bedrock). A focused, high-sensitivity metal detector survey, similar to the EM61-K2 pre-excavation geophysical survey that was conducted at the SLDA site, will be used to identify buried metallic material in the subsurface and also to help define the disposal pits as a series of linear trenches (SAIC 2006). The geophysical survey will be logged by using GPS instrumentation (integrated with the geophysical survey) or civil survey methods in order to map the geophysical survey data.

Table 5-1 Analytical Requirements for the Final Status Survey Soil Samples at the SLDA Site

Samples	Analytical Parameter[a]	Analytical Method	Field Samples[b]	Field Duplicate Samples (10%)	MS/MSD Samples (5%)	Total Samples[c]	USACE QA Split Samples (5%)
All	Am-241 and Th-232	Gamma spectrometry (DOE HASL 300, 4.5.2.3)	490	49	25	589	25
All	Pu-239	Alpha spectrometry (Pu-11-RC-Mod)	490	49	25	589	25
All	Pu-241	Liquid scintillation (Pu-11-RC-Mod)	490	49	25	589	25
All	Isotopic uranium (U-234, U-235, and U-238)	Alpha spectrometry (U-02-RC-Mod)	490	49	25	589	25

[a] The analytical methods listed are the same as those used for analyzing the soil samples collected during the RI.

[b] Sample numbers are based on estimates provided in Tables 4-1 and 4-2 of this FSSP.

[c] Estimates may be adjusted as additional data become available.

If suspicious anomalies or patterns are identified, these areas will be investigated before the FSS gamma scans and soil sampling are implemented to determine if these concerns need to be addressed via additional excavation.

5.3 QUALITY ASSURANCE PROCEDURES

5.3.1 Contractor Quality Assurance Program

The contractor chemical/radiological quality control (CCQC) program to be utilized during this investigation consists of three primary phases: preparatory, initial, and follow-up. All CCQC functions and reviews will be directed by the chemical/radiological quality control (CQC) representative. Detailed procedures relating to the CCQC will be provided in the project quality assurance project plan (QAPP) developed to support the field sampling.

- *Preparatory Phase:* The preparatory phase of the CCQC program is documented by the CQC representative and includes meetings to be held with contractor and subcontractor personnel to address issues, including the review of procedures, field decontamination, investigation-derived waste (IDW) management, and sample management.
- *Initial Phase:* The initial phase of the CCQC program is conducted by the CQC representative and includes monitoring and audits associated with the initial work performed as part of each definable feature of work. Initial phase topics include field sampling oversight, sample management documentation, and inspection of field logbooks and other field records.
- *Follow-up Phase:* The follow-up phase of the CCQC program is conducted by the CQC representative and includes the daily performance of the activities noted in the initial phase until completion of the specific definable feature of work.

5.3.2 Daily Quality Control Reports

The contractor will prepare daily quality control reports (DQCRs) that will be signed and dated by the CQC representative. Daily reports then will be submitted to the USACE Project Manager and USACE Contracting Representative on a weekly basis. Each DQCR will address topics, including a summary of work performed, weather conditions, and departures from the approved sampling and analysis plan (SAP). Any deviation that may affect the project DQOs will be immediately forwarded to the USACE Project Manager and USACE Contracting Representative.

5.3.3 Corrective Actions

Corrective actions will be initiated if problems relating to analytical/equipment errors or noncompliance with approved criteria are identified. Corrective actions will be documented through a formal corrective action program at the time the problem is identified.

Any nonconformance with the established procedures presented in the plan or in the project QAPP will be identified and corrected in accordance with the QAPP. The contractor Project Manager will issue a nonconformance report (NCR) for each nonconforming condition. In addition, corrective actions will be implemented and documented in the appropriate field logbook.

Detailed procedures for corrective actions relating to sample collection/field measurements and laboratory analyses will be explained in the QAPP developed to support the field sampling.

5.4 SAMPLE CHAIN-OF-CUSTODY/DOCUMENTATION

5.4.1 Field Logbooks

All information pertinent to field activities, including field instrument calibration data, will be recorded in field logbooks. The logbooks will be bound, and the pages will be consecutively numbered. Entries in the logbooks will be made in black waterproof ink and will include, at a minimum, a description of all activities, individuals involved in field activities, dates and times of drilling and sampling, weather conditions, any problems encountered, and all field measurements. Lot numbers, manufacturer names, and expiration dates of standards used for field instrument calibration will be recorded in the field logbooks. A summary of each day's activities also will be recorded in the logbooks.

Sufficient information will be recorded in the logbooks to permit reconstruction of all site characterization activities conducted. Information recorded on other project documents will not be repeated in the logbooks except in summary form where determined necessary. When not being utilized during field work, all field logbooks will be kept in the possession of the appropriate field personnel or in a secure place. Upon completion of the field activities, all logbooks will become part of the final project evidence file.

Entries recorded in logbooks will include, but not be limited to, the following information:

- Author, date, and times of arrival at and departure from the work site;
- Purpose of the field activity and summary of daily tasks;
- Names and responsibilities of field crew members;
- Sample collection method;
- Number and volume of samples collected;
- Information regarding sampling changes, scheduling modifications, and change orders;
- Details of the sampling location, including a sketch map illustrating the sampling location;
- Field observations;
- Types of field instruments used and purpose of use, including calibration methods and results;
- Any field measurements made (e.g., radiological activity and landfill gas);
- Sample identification number(s); and
- Sample documentation information.

5.4.2 Photographs

Photographs taken during the project will be noted in the field logbook in accordance with the requirements of the field procedure. If photographs are taken to document sampling points, two or more permanent reference points should be included within the photograph in order to facilitate relocating the point at a later date. In addition to the information recorded in the field logbook, one or more site photograph reference maps will be prepared as required.

5.4.3 Sample Numbering System

A unique sample numbering scheme will be used to identify each sample designated for laboratory analysis. The purpose of this numbering scheme is to provide a tracking system for the retrieval of analytical and field data on each sample. Sample identification numbers will be used on all sample labels or tags, field data sheets and/or logbooks, chain-of-custody records, and all other applicable documentation used during the project.

The sample numbering scheme used for field samples will also be used for duplicate samples so that these types of samples will not be discernible by the laboratory. Other field QC samples will be numbered, however, so that they can be readily identified. A summary of the sample numbering scheme to be used for the project is presented in Table 5-2.

5.5 SAMPLE DOCUMENTATION

The activities and procedures described in this section will be performed in accordance with the requirements of the project QAPP and field procedures presented in the QAPP.

5.5.1 Sample Labels

Labels will be affixed to all sample containers during sampling activities. Information will be recorded on each sample container label at the time of sample collection. The information to be recorded on the labels will be as follows:

Table 5-2 Sample Identification (ID) Numbering Scheme

Site/Sample Type	USACE Sample ID[a]
SLDA site	
Surface sample	SLDACU-SSXXX-MM/DD/YY-Z.Z – Z.Z
Wall sample	SLDACU-WSXXX-MM/DD/YY-Z.Z-Z.Z
Quality control	
Trip blank sample	SLDACU-TBXXX-MM/DD/YY
Duplicate sample	
Surface sample	SLDACU-SS9XX-MM/DD/YY-Z.Z-Z.Z
Wall sample	SLDACU-WS9XX-MM/DD/YY-Z.Z-Z.Z
Rinsate blank sample	SLDAWW-RBXXX-MM/DD/YY
Quality assurance	
Split sample	
Surface sample	SLDACU-SS8XX-MM/DD/YY-Z.Z-Z.Z
Wall sample	SLDACU-WS8XX-MM/DD/YY-Z.Z-Z.Z

[a] SLDACU = SLDA identifier; C represents the class number, and U represents the unit number.
XXX = unique sample ID numbering, starting sequentially with 001 for each area.
8XX = unique sample ID numbering, starting sequentially with 801 for the project for QA samples.
9XX = unique sample ID numbering, starting sequentially with 901 for the project for QC samples.
MM/DD/YY = date of sample collection (e.g., 04/22/94). Z.Z-Z.Z = depth of sample collection in feet (e.g., 0.0–0.5).
Note: If a biased surface sample is collected, the unique sample ID will use 030 as a starting value and then increase incrementally for each survey unit.

- Sample identification number,
- Sample type,
- Sampled interval (e.g., 0–6 in. or 0–15 cm),
- Site name and sampling station number,
- Analysis to be performed,
- Type of chemical preservative present in container,
- Date and time of sample collection, and
- Sampler's name and initials.

5.5.2 Cooler Receipt Checklist

The condition of shipping coolers and enclosed sample containers will be documented upon receipt at the analytical laboratory. This documentation will be accomplished by using the cooler receipt checklist as described in the QAPP prepared by the FSS contractor. A copy of the checklist will either be placed into each shipping cooler along with the completed chain-of-custody form or provided to the laboratory at the start of the project. Another copy of the checklist will be faxed to the contractor's field manager immediately after it has been completed at the laboratory. The original completed checklist will be transmitted with the final analytical results from the laboratory.

5.5.3 Chain-of-Custody Records

Chain-of-custody procedures implemented for the project will provide documentation of the handling of each sample from the time of collection until completion of laboratory analysis. The chain-of-custody form serves as a legal record of possession of the sample. A sample is considered to be under custody if one or more of the following criteria are met:

- The sample is in the sampler's possession.
- The sample is in the sampler's view after being in the sampler's possession.
- The sample was in the sampler's possession and then was placed into a locked area to prevent tampering.
- The sample is in a designated secure area.

Custody will be documented throughout the project field sampling activities by a chain-of-custody form initiated on each day that samples are collected. The chain-of-custody will accompany the samples from the site to the laboratory and will be returned to the laboratory coordinator with the final analytical report. All personnel with sample custody responsibilities will be required to sign, date, and note the time on a chain-of-custody form when relinquishing samples from their immediate custody (except in a case in which samples are placed into designated secure areas for temporary storage prior to shipment). Bills of lading or airbills will be used as custody documentation during times when the samples are being shipped from the site to the laboratory, and they will be retained as part of the permanent sample custody documentation.

Chain-of-custody forms will be used to document the integrity of all samples collected. To maintain a record of sample collection, transfer between personnel, shipment, and receipt by the laboratory, chain-of-custody forms will be filled out for sample sets as deemed appropriate during the course of fieldwork. An example of the chain-of-custody form to be used for the project will be provided in the project QAPP.

The individual responsible for shipping the samples from the field to the laboratory will be responsible for completing the chain-of-custody form and noting the date and time of shipment. This individual will also inspect the form for completeness and accuracy. After the form has been inspected and determined to be satisfactorily completed, the responsible individual will sign, date, and note the time of transfer on the form. The chain-of-custody form will be put in a sealable plastic bag and placed inside the cooler used for sample transport after the field copy of the form has been detached. The field copy of the form will be appropriately filed and kept at the site for the duration of the site activities.

In addition to the chain-of-custody form, chain-of-custody seals will also be placed on each cooler used for sample transport. These seals will consist of a tamper-proof adhesive material placed across the lid and body of the coolers. The chain-of-custody seals will be used to ensure that no samples are tampered with between the time the samples are placed into the coolers and the time the coolers are opened for analysis at the laboratory. Cooler custody seals will be signed and dated by the individual responsible for completing the chain-of-custody form contained within the cooler.

5.5.4 Receipt of Sample Forms

The contracted laboratory will document the receipt of environmental samples by accepting custody of the samples from the approved shipping company. In addition, the contracted laboratory will document the condition of the environmental samples upon receipt.

5.6 DOCUMENTATION PROCEDURES

The tracking procedure to be utilized for documenting all samples collected during the project will involve the following series of steps.

- Collect and place samples into laboratory sample containers.
- Complete sample container label information, as defined in Section 5.4.
- Complete sample documentation information in the field logbook, as defined in Section 5.3.
- Complete project and sampling information sections of the chain-of-custody form(s), as defined in Section 5.4
- Complete the airbill for the cooler to be shipped.
- Perform a completeness and accuracy check of the chain-of-custody form(s).
- Complete the sample relinquishment section of the chain-of-custody form(s), as defined in Section 5.4, and place the form(s) into cooler.
- Place chain-of-custody seals on the exterior of the cooler, as defined in Section 5.4.3.
- Package and ship the cooler to the laboratory, as defined in Section 5.7.
- Receive cooler at the laboratory, inspect contents, and fax contained chain-of-custody form(s) and cooler receipt form(s), as defined in the project QAPP.
- Transmit original chain-of-custody form(s) with the final analytical results from the laboratory.

5.7 CORRECTIONS TO DOCUMENTATION

All original information and data in field logbooks, on sample labels, on chain-of-custody forms, and on any other project-related documentation will be recorded in black waterproof ink and in a completely 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 all corrections will be initialed and dated by the individual responsible for the entry.

5.8 SAMPLE PACKAGING AND SHIPPING

5.8.1 Sample Packaging

Sample containers will be packaged in thermally insulated rigid-body coolers. Sample packaging and shipping will be conducted in accordance with procedures that will be described in the project QAPP and applicable U.S. Department of Transportation (DOT) specifications.

A checklist to be provided in the project QAPP 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. This documentation will be accomplished by using the cooler receipt checklist to be provided in the project QAPP.

5.8.2 Additional Requirements for Samples Classified as Radioactive Materials

The transportation of radioactive materials is regulated by DOT under 49 CFR 173.401. Samples generated during project activities will be transported in accordance with procedures that ensure compliance with regulatory requirements. For radioactive materials, the following activities will be performed in addition to those carried out to meet the packaging and shipping requirements cited in Section 5.7:

- The shipper and receiver addresses must be affixed to the cooler in case the Federal Express airbill is lost during shipping. In addition, to meet IATA regulations, a label that says "Radioactive Material, Excepted Package" must be attached to the outside of the shipping container if the package will be shipped by air, as are Federal Express and United Parcel Service shipments.
- Samples will be screened before being packed to determine if they meet the definition of a DOT Class 7 (radioactive) material.
- For samples that meet DOT requirements for radioactive materials:
  - The cooler will be surveyed for radiation and to ensure the package meets the requirements for limited quantity as found in 49 CFR.
  - The outside of the inner packaging, or, if there is no inner packaging, the outside of the package itself, must be labeled "Radioactive."
  - The outside of the package must be labeled "UN2910".
- The following labels will be placed on the cooler:
  - Appropriate hazard class label and
  - "Cargo Aircraft Only," if applicable.
- The airbill for the shipment will be completed and attached to the top of the shipping systematic gamma scan box/cooler, which will then be transferred to the courier for delivery to the laboratory.

5.8.3 Sample Shipping

All environmental samples collected during the project will be shipped no later than 48 to 72 hours after the time of collection. The latter time of 72 hours may be necessary if the samples are collected on a Friday and have to be shipped on a Monday via commercial courier. During the time period between collection and shipment, all samples will be stored in a secure area. All coolers containing environmental samples will be shipped overnight to the laboratory by Federal Express, a similar courier, or a laboratory courier.

5.9 INVESTIGATION-DERIVED WASTE

USACE-Buffalo District is conducting field activities that generate environmental media in support of the Formerly Utilized Sites Remedial Action Program (FUSRAP) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The media generally consist of soil, sludge, water, and spent personal protective equipment (PPE) resulting from drilling operations, sampling activities, remedial actions, and associated site activities. When accumulated, the media must be managed appropriately to minimize the exposure and risks to human health and the environment while ensuring they adhere to applicable regulatory requirements. The objective of this section is to establish specific management practices for the handling and subsequent disposition of these media.

The IDW includes all materials generated during project performance that cannot be effectively reused, recycled, or decontaminated in the field. It consists of both materials that could potentially pose a risk to human health and the environment (e.g., sampling and decontamination wastes) and materials that have little potential to pose risk to human health and the environment (e.g., sanitary solid wastes). Two types of IDW will be generated during the implementation of field activities: indigenous and nonindigenous IDW. Indigenous IDW that is expected to be generated during site characterization activities at the SLDA site consists primarily of soils and debris in the trench areas. Nonindigenous IDW that is expected to be generated includes decontamination fluid/water and miscellaneous trash, including PPE. When accumulated, the media must be managed appropriately to minimize exposure and risks to human health and the environment while ensuring they adhere to applicable regulatory requirements.

5.10 FIELD DECONTAMINATION

Field sampling equipment used during soil sampling will be decontaminated according to the standard operating procedure (SOP) of the field sampling plan (FSP). Equipment to be decontaminated includes stainless steel scoops, bowls, spoons, core barrels, and hand auger barrels. Other equipment used during sampling activities that does not directly contact sample materials (down-hole rods, shovels, etc.) will be cleaned by a pressurized steam cleaner to remove visible soil contamination.

Field decontamination will be conducted in an area near the field equipment staging area or in an area approved by the USACE-Buffalo District. Decontamination activities will be conducted so that all solid and liquid wastes generated can be containerized and disposed of as described in Section 5.9.

6 LABORATORY ANALYSIS

Samples will be transferred to a USACE-approved radio-analytical laboratory for analyses in accordance with documented laboratory-specific standard methods and the sampling and analysis plan for the SLDA site. Specific analyses for each sample will generally include alpha and gamma spectrometry. In accordance with MARSSIM, analytical techniques will provide a minimum detection level of 25% of the individual radionuclide cleanup goals for all primary contaminants, with a preferred target minimum detection level of 10% of these individual radionuclide cleanup goals.

Soil samples weighing approximately 1 kilogram (kg) will be obtained. Samples will be packaged and uniquely identified in accordance with chain-of-custody and site-specific procedures. High-resolution gamma spectrometry, alpha spectrometry, and liquid scintillation will be used to quantify ROCs (see Section 5.1.3, Table 5.1). Activity concentrations in soil will be reported in units of picocuries per gram. Other QC activities are incorporated into specific field survey procedures.

7 REPORT OF SURVEY FINDINGS

Survey procedures and sampling results will be documented in a FSS report, following the general guidance for FSS reports in NUREG-1757, Vol. 2, Rev. 1 (NRC 2006) and MARSSIM (EPA 2000). This FSS report will become an integral part of the site radiological assessment report. This FSS report will contain, at a minimum, the following information:

- A facility map that shows scan data, locations of elevated direct radiation levels, and sampling locations from each survey unit;
- Tables of radionuclide concentrations in each sample from each survey unit, including,, but not limited to, the results in picocuries per gram, measurement errors, detection limits, and sample depths;
- Summary statistics for analytical data, surface scan data, and gamma logging data from each survey unit;
- A graphical display of individual sample concentrations in the form of posting plots and/or histograms for each survey unit and visual identification of trends; and
- Results of the WRS test.

The interpretation of survey results will follow the DQA process as outlined in both Chapter 8 and Section 2.3 of Appendix E of MARSSIM. There are five steps in the DQA process:

1. Review the DQOs and survey design.
2. Conduct a preliminary data review.
3. Select a statistical test.
4. Verify the assumptions of the statistical test.
5. Draw conclusions about the data.

The primary purpose of the DQO and survey design review is to ascertain, after data collection, that the original assumptions built into the DQO process that generated the data collection strategy are still valid. Examples where deviations might have taken place include these: (a) the spatial scope of the data collection should change (e.g., fieldwork indicates contamination extends beyond spatial boundaries originally defined by the DQO process) or (b) there is the unexpected presence of other contaminants of concern. These types of deviations would require revisiting the DQO process, adjusting for realities uncovered by field work, and determining whether the data collected still meet the original objectives of the data collection, and, if not, what corrective steps are required.

The preliminary data review should include a review of QA reports to ensure that the data produced are of the quality assumed by the DQO process and a review of the data sets themselves to identify trends and properties that may be pertinent to the decisions that must be made on the basis of the data. This effort would include basic data analysis techniques, such as creating posting maps and histograms, determining means and standard deviations, etc.

For the purposes of this FSS, the statistical test has already been chosen. The principal requirement of the DQA process is to check, on the basis of the data review, that the data are valid and capable of supporting the selected statistical test. As a nonparametric test, the WRS test imposes very few assumptions on the character of the data set for use, other than the assumptions that non-detect results do not form a significant fraction of the overall results and that detection limits are below the DCGL requirements.

The last step of the DQA process involves performing the statistical tests and data analyses specified by the FSS, drawing conclusions, and documenting results.

8 REFERENCES

ARCO/B&W (Atlantic Richfield Corporation/Babcock & Wilcox), 1995, *Parks Shallow Land Disposal Facility Site Characterization Report*, Vandergrift, Pennsylvania, May.

ARCO/B&W, 1996, *1995 Field Work Report.*

Cabrera Services, Inc., 2009a, *Final Site Operations Plan, Shallow Land Disposal Area, Formerly Utilized Sites Remedial Action Program (FUSRAP) Site Remediation, Parks Township, Armstrong County, Pennsylvania*, September.

Cabrera Services, Inc., 2009b, *Final Sampling and Analysis Plan Part 1 – Field Sampling Plan, Shallow Land Disposal Area, FUSRAP Site Remediation, Parks Township, Armstrong County, Pennsylvania*, May.

EPA (U.S. Environmental Protection Agency), 2000, *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*, EPA 402-R-97-016, Rev. 1, August.

EPA, 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.

EPA, 2009, *Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual (MARSAME)*, EPA 402-R-09-001, January.

NRC, 1998, *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions*, NUREG-1507, June.

NRC, 2001, *Inspections 07000364/2000002 and 07003085/2001001,* prepared by BWXT Services, Inc., Parks Township Facility, and Shallow Land Disposal Area, Vandergrift Pennsylvania.

NRC, 2006, *Consolidated Decommissioning Guidance*, NUREG-1757, Vols. 1 and 2, September.

ORAU (Oak Ridge Associated Universities), 1982, *Radiological Assessment of the Parks Township Burial Site (Babcock & Wilcox), Leechburg, Pennsylvania.*

ORAU, 1987, *Survey of Remediated Areas – Parks Township Burial Site (Babcock and Wilcox), Leechburg, Pennsylvania.*

ORAU, 1990, *Survey of Remediated Areas – Parks Township Burial Site, (Babcock and Wilcox), Leechburg, Pennsylvania.*

PADEP (Pennsylvania Department of Environmental Protection), 2004, *Management of Fill Policy*, Bureau of Land Recycling and Waste Management, Document No. 258-2182-773, April.

SAIC (Science Applications International Corporation), 2006, *Shallow Land Disposal Area Geophysical Investigation, Geophysical Survey Report,* Rev. 0, December.

TEC (U.S. Army Topographic Engineering Center), 2003, *Shallow Land Disposal Area Historic Photographic Analysis*, June.

USACE (U.S. Army Corps of Engineers), 1998, *Technical Project Planning (TPP) Process*, Engineer Manual (EM) 200-1-2, Department of the Army, Washington, D.C., August.

USACE, 2003a, *Final Gamma Walkover Survey Report, Shallow Land Disposal Area (SLDA) Site, Parks Township, Armstrong County, Pennsylvania*, prepared by URS Corporation, Buffalo, New York, August.

USACE, 2003b, *Final Remedial Investigation Sampling and Analysis Plan, Part II – Quality Assurance Project Plan, Project Work Plans, Acquisition of Field Data and Technical Support for Shallow Land Disposal Area (SLDA), Parks Township, Armstrong County, Pennsylvania*, prepared by URS Group, Inc., Buffalo, New York, August.

USACE, 2005, *Remedial Investigation Report, Shallow Land Disposal Area (SLDA) Site, Parks Township, Armstrong County, Pennsylvania*, prepared by URS Group, Inc., Buffalo, New York, July.

USACE, 2006a, *Feasibility Study for the Shallow Land Disposal Area Site, Parks Township, Armstrong County, Pennsylvania*, prepared by URS Group, Inc., Buffalo, New York, September.

USACE, 2006b, *Proposed Plan for the Shallow Land Disposal Area Site, Parks Township, Armstrong County, Pennsylvania*, prepared by URS Group, Inc., Buffalo, New York, September.

USACE, 2007, *Record of Decision for the Shallow Land Disposal Area (SLDA) Site, Parks Township, Armstrong County, Pennsylvania*, August.

APPENDIX A: DEVELOPMENT OF DERIVED CONCENTRATION GUIDELINES

APPENDIX A

DEVELOPMENT OF DERIVED CONCENTRATION GUIDELINES

Preliminary remediation goals (PRGs) were previously developed for the eight primary radionuclides of concern at the site based on an annual dose of 25 millirem per year (mrem/yr) above background to a subsistence farmer residing at the site using the RESRAD computer code (Argonne 2001). The annual radiation dose of 25 mrem/yr for future unrestricted use of the site is specified as the standard that must be met in 10 CFR 20.1402, *Radiological Criteria for Unrestricted Use*, which was determined to be relevant and appropriate for the SLDA site. A subsistence farmer scenario was used in developing the PRGs as this scenario involves very intensive uses of the site, and the PRGs developed for this scenario will be conservative. That is, other less intensive future uses would result in lower doses than for the subsistence farmer. This land use is consistent with current and likely future land uses in this area as discussed in Section 6.3.1.6 of the *Remedial Investigation Report, Shallow Land Disposal Area (SLDA) Site* (RIR) (USACE 2005).

The PRGs were calculated from the mean dose-to-source ratios of the peak doses over a 1,000-year time period for the eight radionuclides of concern at the site using the probabilistic version of the RESRAD computer code. Use of the RESRAD computer code for this calculation is consistent with current decommissioning guidance of the U.S. Nuclear Regulatory Commission (NRC 1999, 2000, 2002). The approach used to calculate these PRGs and the input parameters for the RESRAD computer code are described in Appendix A of the *Final Remedial Investigation Sampling and Analysis Plan* (USACE 2003) and were developed with the input and concurrence of the Pennsylvania Department of Environmental Protection (PADEP). These PRGs were based on an area of 3,350 square meters (m^2), the approximate area covered by the nine trenches in the upper portion of the site.

The PRGs were adopted as the wide area derived concentration guideline levels ($DCGL_W$s) for the selected remedy in the *Record of Decision for Remedial Action at the Shallow Land Disposal Area Site* (ROD) (USACE 2007). This was done as the PRGs were previously developed in a manner consistent with their eventual use for this purpose. That is, although the PRGs were specifically developed to guide field data collections activities for completion of the RIR, consideration was given to their eventual use as $DCGL_W$s in the site-specific input parameters that were selected for their development. No additional information was obtained during the remedial investigation (RI) fieldwork that indicated a need to modify any of the RESRAD input parameters used to develop these cleanup criteria.

The ROD noted that a sum of ratios (SOR) approach would be used to confirm compliance with the dose standard of 25 millirems per year (mrem/yr) if more than one radionuclide was present at a given location. Two of the eight radionuclides of concern, radium-228 (Ra-228) and americium-241 (Am-241), are decay products of two other radionuclides at the site, thorium-232 (Th-232) and plutonium-241 (Pu-241), respectively. Residual Ra-228 and Th-232 would be expected to be in a state of secular equilibrium in soil following excavation, given that Ra-228 has a half-life of 5.8 years and close to 40 years has elapsed since disposal activities at the site ceased. It is therefore only necessary to use the Th-232 DCGL to ensure that the cleanup goals for both radionuclides have been met. The Th-232 DCGL accounts for the ingrowth of Ra-228 in the future, so using the Th-232 DCGL to address both Th-232 and Ra-228 is a valid approach.

In contrast, since Am-241 has a much longer half-life than Pu-241, these two radionuclides will never attain an equilibrium condition. Given the high concentrations of these two radionuclides in localized areas of surface soil near trench 10, it will be necessary to use DCGLs for both radionuclides to ensure compliance with the dose standard of 25 mrem/yr through the SOR calculation.

Based on these considerations, DCGLs are developed for seven radionuclides in this Final Status Survey Plan (FSSP). The $DCGL_{W}$s were developed based on an site-specific area of 3,350 m^2, rather than the RESRAD default parameter of 10,000 m^2. A comprehensive list of the RESRAD parameters given in Appendix A of the *Final Remedial Investigation Sampling and Analysis Plan* (USACE 2003), is included in Appendix B of this FSSP. Note that an area of 3,350 square meters (m^2), used to develop the $DCGL_{W}$s, produce essentially the same estimated annual dose as an area of 10,000 m^2. For comparison, a RESRAD calculation was performed using a 10,000 m^2 contaminated area; the resulting residual radionuclide values were within 8% of the DCGLs for all of the radionuclides calculated for the 3,350 m^2 area.

Soil guideline values were calculated for smaller areas for use in developing the elevated measurement comparison (emc) or hot spot criteria, i.e., the $DCGL_{emc}$s. The input parameters are the same as used to develop the $DCGL_{W}$s (see Appendix B), except for the size of the contaminated area and four additional parameters that are directly related to the size of the contaminated area. These parameters and the values used in the RESRAD evaluations for the 100 m^2 and 1 m^2 areas are given in Table A-1, and the resulting residual radioactive soil $DCGL_{emc}$ guidelines for these two areas are provided in Table A-2. The $DCGL_{emc}$s that will be used at the SLDA site are those for 100 m^2 area. Residual soil guidelines are given in Table A-2 for a 1 m^2 area to indicate the sensitivity of area to residual soil concentration levels to aid in site-specific cleanup decisions as remedial actions progress at the site. The DCGLs provided in Table A-2 are incremental to background activity concentrations.

TABLE A-1 RESRAD Parameters That Were Adjusted to Calculate $\mathrm{DCGL_{emc}}$ Values[a]

Parameter Name	Definition	Value Used for Various Contaminated Areas		
		$3{,}350\ \mathrm{m}^{2}$[b]	$100\ \mathrm{m}^{2}$[c]	$1\ \mathrm{m}^{2}$[c]
Length parallel to aquifer flow	Distance (m) between two parallel line perpendicular to the direction of aquifer flow, one at the upgradient edge and the other at the downgradient edge of the contaminated zone	220	16	1
Plant food contaminated fraction	Fractional amount of plant food obtained from contaminated area; remainder is from offsite sources	1	0.05	0.0005
Meat contaminated fraction	Fractional amount of meat obtained from contaminated area; remainder is from offsite sources	1	0.03	0.0003
Milk contaminated fraction	Fractional amount of milk obtained from contaminated area; remainder is from offsite sources	1	0.03	0.0003

[a] The RESRAD input values for these four parameters used for development of the PRGs (which were subsequently adopted as the $\mathrm{DCGL_w}$ values in the ROD) are those given for an area of 3,350 m^2. Conservative values were generally used in the RESRAD calculations for the other contaminated areas. For a contaminated area of 1,000 m^2, the plant food ingestion fraction of 0.5 was selected as this is the RESRAD default (deterministic) value for this size of a contaminated area. This value was subsequently scaled linearly for areas smaller than 1,000 m^2 down to a value of 0.0005 for an area of 1 m^2. For the meat and milk ingestion pathways, the contaminated fraction was scaled linearly from 3,350 m^2 for all smaller contaminated area sizes. Hence, a value of 0.3 was used as the contaminated fraction for these two ingestion pathways for an area of 1,000 m^2. As for the contaminated food fraction, this value was subsequently scaled linearly for areas smaller than 1,000 m^2 down to a value of 0.0003 for an area of 1 m^2. This is conservative, as the RESRAD default (deterministic) values for these two parameters for an area of 1,000 m^2 is 0.05, which is much lower than the value of 0.3 used in this calculation for this area. These values were determined to be reasonable but conservative for determination of the $\mathrm{DCGL_{emc}}$ values.

[b] Original RESRAD parameters used in $\mathrm{DCGL_w}$ calculations (USACE 2003).

[c] Modified RESRAD parameters based on the size of the contaminated area.

TABLE A-2 Radionuclide DCGLs for Areas of 1 to 10,000 m^2 for the Seven Radionuclides at the SLDA Site

Radionuclide	DCGLs for the Various Contaminated Areas (pCi/g) [(a)]		
	3,350 m^{2} [(b)]	100 m^{2}[(c)]	1 m^2
Americium-241	28	420	6,300
Plutonium-239	33	570	13,000
Plutonium-241	890	13,000	220,000
Thorium-232	1.4	5.3	49
Uranium-234	96	240	13,000
Uranium-235	35	110	890
Uranium-238	120	520	4,500

[a] The DCGLs are incremental to background activity concentrations.

[b] The DCGLs for the 3,350 m^2 area will be implemented as the DCGL$_w$ values.

[c] The DCCLs for the 100 m^2 area will be implemented as the DCGL$_{emc}$ values.

APPENDIX A

REFERENCES

Argonne National Laboratory, 2001, *User's Manual for RESRAD Version 6.0*, ANL/EAD-4, Environmental Assessment Division, Argonne, IL, prepared for the U.S. Department of Energy, Washington, DC, July

USACE (U.S. Army Corps of Engineers), 2003, *Final Remedial Investigation Sampling and Analysis Plan, Part I – Field Sampling Plan, Project Work Plans, Acquisition of Field Data and Technical Support for Shallow Land Disposal Area (SLDA) Parks Township, Armstrong County, Pennsylvania,* prepared by URS Group, Buffalo, New York, August

USACE, 2005, *Remedial Investigation Report, Shallow Land Disposal Area (SLDA) Site, Parks Township, Armstrong County, Pennsylvania*, prepared by URS Group, Buffalo, New York, October

USACE, 2007, *Record of Decision for Remedial Action at the Shallow Land Disposal Area Site, Parks Township, Armstrong County, Pennsylvania*, prepared by U.S. Army Corps of Engineers, Buffalo District, Buffalo, New York, October

NRC (U.S. Nuclear Regulatory Commission), 1999, *Residual Radioactive Contamination from Decommissioning, Parameter Analysis,* NUREG/CR-5512, Volume 3, Office of Nuclear Regulatory Research, Division of Risk Analysis and Applications, Washington, DC, October

NRC, 2000, *NMSS Decommissioning Standard Review Plan,* NUREG-1727, Office of Nuclear Material Safety and Safeguards, Division of Waste Management, Washington, DC, September

NRC, 2002, *Consolidated NMSS Decommissioning Guidance, Decommissioning Process for Materials Licensees, Final Report,* NUREG/CR-1757, Volume 1, Office of Nuclear Material Safety and Safeguards, Division of Waste Management, Washington, DC, September

APPENDIX B: RESRAD MODEL INPUT PARAMETERS

APPENDIX B

RESRAD MODEL INPUT PARAMETERS

Table B-1 lists the input parameters used to derive the preliminary remediation goals (PRGs) which were adopted as the wide area derived concentration guideline levels ($DCGL_w$s). The input parameters were based on site-specific information where appropriate and NUREG recommended values elsewhere. This information was provided in Appendix A of the *Final Remedial Investigation Sampling and Analysis Plan* (USACE 2003).

TABLE B-1 Input Parameters Used at Parks SLDA Site for Probabilistic and Deterministic RESRAD Analysis

Input Parameter	Units	Type[a]	Priority[a]	Deterministic	Probabilistic analysis					Basis/Reference
					value/ distribution	Distribution's statistical parameters[b]				
						1	2	3	4	
Sample specifications for probabilistic analysis										
Random seed	none	NA	NA	NA	1000	NR[c]	NR	NR	NR	RESRAD default
Number of observations	none	NA	NA	NA	1000	NR	NR	NR	NR	The value is increased from RESRAD default value of 100 to 1000 to reduce the uncertainty in the results
Number of repetitions	none	NA	NA	NA	3	NR	NR	NR	NR	RESRAD default
Sampling technique	none	NA	NA	NA	Latin Hypercube	NR	NR	NR	NR	RESRAD default
Grouping of observations	none	NA	NA	NA	correlated or uncorrelated	NR	NR	NR	NR	RESRAD default
Initial Nuclide Concentration in Soil	pCi/g	P	2	1 for each radionuclide	1 for each radionuclide	NR	NR	NR	NR	DCGLs independent of initial concentration
Distribution coefficients in contaminated, unsaturated, and saturated zones[d]	cm^3/g	P	1		truncated lognormal-n					For deterministic analysis recommended site values from SLDA are used. If the value was not provided median values from distribution are used. For all except uranium truncated lognormal-n distribution from NUREG/CR-6697 is used in the probabilistic analysis
Ac-227				10,000, 10,000, 20	-	6.72	3.22	.001	.999	For deterministic site-specific value and for probabilistic distribution from NUREG/CR-6697
Am-241				1445, 1445, 1445	-	7.28	3.15	.001	.999	For deterministic median value from distribution and for probabilistic distribution from NUREG/CR-6697

TABLE B-1 Input Parameters Used at Parks SLDA Site for Probabilistic and Deterministic RESRAD Analysis (continued)

Np-237				17, 17, 17	-	2.84	2.25	.001	.999	For deterministic median value from distribution and for probabilistic distribution from NUREG/CR-6697
Pa-231				10,000, 10,000, 50	-	5.94	3.22	.001	.999	For deterministic site-specific value and for probabilistic distribution from NUREG/CR-6697
Pb-210+D				10,000, 10,000, 200	-	7.78	2.76	.001	.999	For deterministic site-specific value and for probabilistic distribution from NUREG/CR-6697
Pu-238				953, 953, 953	-	6.86	1.89	.001	.999	For deterministic median value from distribution and for probabilistic distribution from NUREG/CR-6697
Pu-239				953, 953, 953	-	6.86	1.89	.001	.999	For deterministic median value from distribution and for probabilistic distribution from NUREG/CR-6697
Pu-240				953, 953, 953	-	6.86	1.89	.001	.999	For deterministic median value from distribution and for probabilistic distribution from NUREG/CR-6697
Pu-241+D				953, 953, 953	-	6.86	1.89	.001	.999	For deterministic median value from distribution and for probabilistic distribution from NUREG/CR-6697
Pu-242				953, 953, 953	-	6.86	1.89	.001	.999	For deterministic median value from distribution and for probabilistic distribution from NUREG/CR-6697
Ra-226+D				10,000, 10,000, 60	-	8.17	1.70	.001	.999	For deterministic site-specific value and for probabilistic distribution from NUREG/CR-6697
Ra-228+D				10,000, 10,000, 70	-	8.17	1.70	.001	.999	For deterministic site-specific value and for probabilistic distribution from NUREG/CR-6697
Th-228+D				20,000, 20,000, 20,000	-	8.68	3.62	.001	.999	For deterministic site-specific value and for probabilistic distribution from NUREG/CR-6697
Th-229+D				20,000, 20,000, 20,000	-	8.68	3.62	.001	.999	For deterministic site-specific value and for probabilistic distribution from NUREG/CR-6697
Th-230				20,000, 20,000, 20,000	-	8.68	3.62	.001	.999	For deterministic site-specific value and for probabilistic distribution from NUREG/CR-6697

TABLE B-1 Input Parameters Used at Parks SLDA Site for Probabilistic and Deterministic RESRAD Analysis (continued)

Th-232				20,000, 20,000, 20,000	-	8.68	3.62	.001	.999	For deterministic site-specific value and for probabilistic distribution from NUREG/CR-6697
U-233				425.6, 750, 750	Bounded lognormal-n	4.84, 4.84, 4.84	3.13, 3.13, 3.13	50, 3, 3	10,000, 1,000, 1,000	For deterministic site-specific value for the unsaturated and saturated zone and median value from the distribution for the contaminated zone. For probabilistic analysis distribution modified from NUREG/CR-6697 based on site-specific bounds
U-234				425.6, 750, 750	Bounded lognormal-n	4.84, 4.84, 4.84	3.13, 3.13, 3.13	50, 3, 3	10,000, 1,000, 1,000	For deterministic site-specific value for the unsaturated and saturated zone and median value from the distribution for the contaminated zone. For probabilistic analysis distribution modified from NUREG/CR-6697 based on site-specific bounds
U-235+D				425.6, 750, 750	Bounded lognormal-n	4.84, 4.84, 4.84	3.13, 3.13, 3.13	50, 3, 3	10,000, 1,000, 1,000	For deterministic site-specific value for the unsaturated and saturated zone and median value from the distribution for the contaminated zone. For probabilistic analysis distribution modified from NUREG/CR-6697 based on site-specific bounds
U-236				425.6, 750, 750	Bounded lognormal-n	4.84, 4.84, 4.84	3.13, 3.13, 3.13	50, 3, 3	10,000, 1,000, 1,000	For deterministic site-specific value for the unsaturated and saturated zone and median value from the distribution for the contaminated zone. For probabilistic analysis distribution modified from NUREG/CR-6697 based on site-specific bounds

TABLE B-1 Input Parameters Used at Parks SLDA Site for Probabilistic and Deterministic RESRAD Analysis (continued)

U-238+D				425.6, 750, 750	Bounded lognormal-n	4.84, 4.84, 4.84	3.13, 3.13, 3.13	50, 3, 3	10,000, 1,000, 1,000	For deterministic site-specific value for the unsaturated and saturated zone and median value from the distribution for the contaminated zone. For probabilistic analysis distribution modified from NUREG/CR-6697 based on site-specific bounds
Plant transfer factors	pCi/g plant per pCi/g soil	P	1		for all truncated lognormal-n					For deterministic median value from distribution and for probabilistic distribution from NUREG/CR-6697
Ac-227				1E-3		-6.91	1.1	.001	.999	-
Am-241				1E-3		-6.91	0.9	.001	.999	-
Np-237				2E-2		-3.91	0.9	.001	.999	-
Pa-231				1E-2		-4.61	1.1	.001	.999	-
Pb-210+D				4E-3		-5.52	0.9	.001	.999	-
Pu-238				1E-3		-6.91	0.9	.001	.999	-
Pu-239				1E-3		-6.91	0.9	.001	.999	-
Pu-240				1E-3		-6.91	0.9	.001	.999	-
Pu-241+D				1E-3		-6.91	0.9	.001	.999	-
Pu-242				1E-3		-6.91	0.9	.001	.999	-
Ra-226+D				4E-2		-3.22	0.9	.001	.999	-
Ra-228+D				4E-2		-3.22	0.9	.001	.999	-
Th-228+D				1E-3		-6.91	0.9	.001	.999	-
Th-229+D				1E-3		-6.91	0.9	.001	.999	-
Th-230				1E-3		-6.91	0.9	.001	.999	-
Th-232				1E-3		-6.91	0.9	.001	.999	-
U-233				2E-3		-6.21	0.9	.001	.999	-
U-234				2E-3		-6.21	0.9	.001	.999	-
U-235+D				2E-3		-6.21	0.9	.001	.999	-
U-236				2E-3		-6.21	0.9	.001	.999	-
U-238				2E-3		-6.21	0.9	.001	.999	-

TABLE B-1 Input Parameters Used at Parks SLDA Site for Probabilistic and Deterministic RESRAD Analysis (continued)

Meat transfer factor	pCi/kg per pCi/d	P	2		for all truncated lognormal-n					For deterministic median value from distribution and for probabilistic distribution from NUREG/CR-6697
Ac-227				2E-5		-10.82	1.0	.001	.999	-
Am-241				5E-5		-9.9	0.2	.001	.999	-
Np-237				1E-3		-6.91	0.7	.001	.999	-
Pa-231				5E-6		-12.21	1.0	.001	.999	-
Pb-210+D				8E-4		-7.13	0.7	.001	.999	-
Pu-238				1E-4		-9.21	0.2	.001	.999	-
Pu-239				1E-4		-9.21	0.2	.001	.999	-
Pu-240				1E-4		-9.21	0.2	.001	.999	-
Pu-241+D				1E-4		-9.21	0.2	.001	.999	-
Pu-242				1E-4		-9.21	0.2	.001	.999	-
Ra-226+D				1E-3		-6.91	0.7	.001	.999	-
Ra-228+D				1E-3		-6.91	0.7	.001	.999	-
Th-228+D				1E-4		-9.21	1.0	.001	.999	-
Th-229+D				1E-4		-9.21	1.0	.001	.999	-
Th-230				1E-4		-9.21	1.0	.001	.999	-
Th-232				1E-4		-9.21	1.0	.001	.999	-
U-233				8E-4		-7.13	0.7	.001	.999	-
U-234				8E-4		-7.13	0.7	.001	.999	-
U-235+D				8E-4		-7.13	0.7	.001	.999	-
U-236				8E-4		-7.13	0.7	.001	.999	-
U-238+D				8E-4		-7.13	0.7	.001	.999	-
Milk transfer factor	pCi/L per pCi/d	P	2		for all truncated lognormal-n					For deterministic median value from distribution and for probabilistic distribution from NUREG/CR-6697
Ac-227				2E-6		-13.12	0.9	.001	.999	-
Am-241				2E-6		-13.12	0.7	.001	.999	-
Np-237				1E-5		-11.51	0.7	.001	.999	-
Pa-231				5E-6		-12.21	0.9	.001	.999	-
Pb-210+D				3E-4		-8.11	0.9	.001	.999	-
Pu-238				1E-6		-13.82	0.5	.001	.999	-
Pu-239				1E-6		-13.82	0.5	.001	.999	-
Pu-240				1E-6		-13.82	0.5	.001	.999	-
Pu-241+D				1E-6		-13.82	0.5	.001	.999	-
Pu-242				1E-6		-13.82	0.5	.001	.999	-
Ra-226+D				1E-3		-6.91	0.5	.001	.999	-
Ra-228+D				1E-3		-6.91	0.5	.001	.999	-

TABLE B-1 Input Parameters Used at Parks SLDA Site for Probabilistic and Deterministic RESRAD Analysis (continued)

Th-228+D				5E-6		-12.21	0.9	.001	.999	-
Th-229+D				5E-6		-12.21	0.9	.001	.999	-
Th-230				5E-6		-12.21	0.9	.001	.999	-
Th-232				5E-6		-12.21	0.9	.001	.999	-
U-233				4E-4		-7.82	0.6	.001	.999	-
U-234				4E-4		-7.82	0.6	.001	.999	-
U-235+D				4E-4		-7.82	0.6	.001	.999	-
U-236				4E-4		-7.82	0.6	.001	.999	-
U-238+D				4E-4		-7.82	0.6	.001	.999	-
Fish bioaccumulation factor	pCi/kg per pCi/L	P	2		for all lognormal					For deterministic median value from distribution and for probabilistic distribution from NUREG/CR-6697
Ac-227				15		2.7	1.1			-
Am-241				30		3.4	1.1			-
Np-237				30		3.4	1.1			-
Pa-231				10		2.3	1.1			-
Pb-210+D				300		5.7	1.1			-
Pu-238				30		3.4	1.1			-
Pu-239				30		3.4	1.1			-
Pu-240				30		3.4	1.1			-
Pu-241+D				30		3.4	1.1			-
Pu-242				30		3.4	1.1			-
Ra-226+D				50		3.9	1.1			-
Ra-228+D				50		3.9	1.1			-
Th-228+D				100		4.6	1.1			-
Th-229+D				100		4.6	1.1			-
Th-230				100		4.6	1.1			-
Th-232				100		4.6	1.1			-
U-233				10		2.3	1.1			-
U-234				10		2.3	1.1			-
U-235+D				10		2.3	1.1			-
U-236				10		2.3	1.1			-
U-238+D				10		2.3	1.1			-

TABLE B-1 Input Parameters Used at Parks SLDA Site for Probabilistic and Deterministic RESRAD Analysis (continued)

Crustacea bioaccumulation factor	pCi/kg per pCi/L	P	3							RESRAD default
Ac-227				1,000	1,000	NR	NR	NR	NR	RESRAD default
Am-241				1,000	1,000	NR	NR	NR	NR	RESRAD default
Np-237				400	400	NR	NR	NR	NR	RESRAD default
Pa-231				110	110	NR	NR	NR	NR	RESRAD default
Pb-210+D				100	100	NR	NR	NR	NR	RESRAD default
Pu-238				100	100	NR	NR	NR	NR	RESRAD default
Pu-239				100	100	NR	NR	NR	NR	RESRAD default
Pu-240				100	100	NR	NR	NR	NR	RESRAD default
Pu-241+D				100	100	NR	NR	NR	NR	RESRAD default
Pu-242				100	100	NR	NR	NR	NR	RESRAD default
Ra-226+D				250	250	NR	NR	NR	NR	RESRAD default
Ra-228+D				250	250	NR	NR	NR	NR	RESRAD default
Th-228+D				500	500	NR	NR	NR	NR	RESRAD default
Th-229+D				500	500	NR	NR	NR	NR	RESRAD default
Th-230				500	500	NR	NR	NR	NR	RESRAD default
Th-232				500	500	NR	NR	NR	NR	RESRAD default
U-233				60	60	NR	NR	NR	NR	RESRAD default
U-234				60	60	NR	NR	NR	NR	RESRAD default
U-235+D				60	60	NR	NR	NR	NR	RESRAD default
U-236				60	60	NR	NR	NR	NR	RESRAD default
U-238+D				60	60	NR	NR	NR	NR	RESRAD default
Number of unsaturated zones	none	P	3	1	1	NR	NR	NR	NR	RESRAD default
Time since material placement	years	P	3	0	0	NR	NR	NR	NR	RESRAD default
Groundwater concentration	pCi/L	P	3	0	0	NR	NR	NR	NR	RESRAD default
Solubility limit	mol/L	P	3	0	0	NR	NR	NR	NR	RESRAD default
Leach rate	/year	P	3	0	0	NR	NR	NR	NR	RESRAD default
Use plant soil ratio	check box	NA	3	No	No	NR	NR	NR	NR	RESRAD default
Basic radiation dose limit	mrem/yr	NA	3	25	25	NR	NR	NR	NR	NRC free release dose limit
Calculation times	years	P	3	1,3,10,30,100,300,1000	1,3,10,30,100,300,1000	NR	NR	NR	NR	RESRAD default
Thickness of contaminated zone	m	P	2	4	4	NR	NR	NR	NR	Scenario assumption
Area of contaminated zone	m^2	P	2	3350	3350	NR	NR	NR	NR	Scenario assumption based on site-specific data[j]

TABLE B-1 Input Parameters Used at Parks SLDA Site for Probabilistic and Deterministic RESRAD Analysis (continued)

Length parallel to aquifer flow	m	P	2	220	220	NR	NR	NR	NR	Scenario assumption based on site specific data[i, j]
Cover depth	m	P	2	0	0	NR	NR	NR	NR	Contamination begins at the surface
Density of cover material	g/cm^3	P	1	Not used	Not used	NR	NR	NR	NR	NA
Cover erosion rate	m/yr	P, B	2	Not used	Not used	NR	NR	NR	NR	NA
Density of contaminated zone	g/cm^3	P	1	1.6	Truncated normal	1.5105	0.1855	.001	.999	For deterministic site-specific value[c, j] For probabilistic distribution from NUREG/CR-6697 for the silty clay loam soil type[g, j]. The density of contaminated zone is correlated with contaminated zone total porosity with a rank correlation coefficient value of -0.96 in the probabilistic run.
Contaminated zone erosion rate	m/yr	P, B	2	1E-3	Continuous logarithmic	See NUREG/CR-6697 for distribution's statistical parameters				For deterministic site-specific value[j] For probabilistic distribution from NUREG/CR-6697
Contaminated zone total porosity	none	P	2	0.4	Truncated normal	0.43	0.0699	.001	.999	For deterministic site-specific value[c] For probabilistic distribution from NUREG/CR-6697 for the silty clay loam soil type[c] The total porosity of contaminated zone is correlated with contaminated zone density with a rank correlation coefficient value of -0.96 in the probabilistic run.
Contaminated zone field capacity	none	P	3	0.2	0.2	NR	NR	NR	NR	RESRAD default
Contaminated zone hydraulic conductivity	m/yr	P	2	10	Bounded lognormal-n	2.00	2.11	0.0196	13403	For deterministic site specific value. For probabilistic distribution from the site specific values[c, g]
Contaminated zone b parameter	none	P	2	4.8	Bounded lognormal-n	1.96	0.265	3.02	15.5	For deterministic site specific value. For probabilistic distribution from NUREG/CR-6697 for the silty clay loam soil type[g, l]
Humidity in air	g/m^3	P	2	NR	NR	NR	NR	NR	NR	Parameter not required because tritium is not a contaminant of concern
Evapotranspiration coefficient	none	P	2	0.67	0.67	NR	NR	NR	NR	High confidence site specific value[c]
Wind speed	m/s	P	2	4.24	Bounded lognormal-n	1.445	0.2419	1.4	13	Distribution from NUREG/CR-6697

TABLE B-1 Input Parameters Used at Parks SLDA Site for Probabilistic and Deterministic RESRAD Analysis (continued)

Precipitation rate	m/yr	P	2	1.02	1.02	NR	NR	NR	NR	Site specific value[j]
Irrigation rate	m/yr	B	3	0.1125	0.1125	NR	NR	NR	NR	Value from NUREG/CR-6697
Irrigation mode	none	B	3	Overhead	Overhead	NR	NR	NR	NR	RESRAD default
Runoff coefficient	none	P	2	0.23	0.23	NR	NR	NR	NR	High confidence site specific value[c-f]
Watershed area for nearby stream or pond	m^2	P	3	32900	32,900	NR	NR	NR	NR	High confidence site specific value[j]
Accuracy for water soil computation	none	NA	3	0.001	0.001	NR	NR	NR	NR	RESRAD default
Density of saturated zone	g/cm^3	P	1	1.78	Bounded normal	1.78	0.11	1.63	1.93	For deterministic site specific value. For probabilistic distribution from the site specific values[c, j]. The density of saturated zone is correlated with saturated zone total porosity and effective porosity with a rank correlation coefficient values of -0.96 in the probabilistic run.
Saturated zone total porosity	none	P	1	0.3377	Bounded normal	0.3377	0.0394	0.2759	0.3561	For deterministic site specific value. For probabilistic distribution from the site specific values[c, j]. The total porosity of saturated zone is correlated with saturated zone density and effective porosity with a rank correlation coefficient values of -0.96 and 0.96, respectively, in the probabilistic run.

TABLE B-1 Input Parameters Used at Parks SLDA Site for Probabilistic and Deterministic RESRAD Analysis (continued)

Saturated zone effective porosity	none	P	1	0.2702	Bounded normal	0.2702	0.0315	0.2207	0.2849	For deterministic site specific value derived from total porosity. For probabilistic distribution from the site specific total porosity values[c, j]. The effective porosity of saturated zone is correlated with saturated zone density and total porosity with a rank correlation coefficient values of -0.96 and 0.96, respectively, in the probabilistic run.
Saturated zone field capacity	none	P	3	0.2	0.2	NR	NR	NR	NR	RESRAD default
Saturated zone hydraulic conductivity	m/yr	P	1	7.5	Bounded lognormal-n	2.00	2.11	0.0196	13403	For deterministic site specific value. For probabilistic distribution from the site specific values[c, g]
Saturated zone hydraulic gradient	none	P	2	0.15	Loguniform	0.01	0.4			Distribution from the site specific values[c, j]
Saturated zone b parameter	none	P	2	NR	NR	NR	NR	NR	NR	Parameter is not used because water table drop rate is zero
Water table drop rate	m/yr	P	3	0	0	NR	NR	NR	NR	Medium confidence site specific value[c]
Well pump intake depth (below water table)	m	P	2	3	Triangular	3	10	30		For deterministic site specific value. For probabilistic distribution from NUREG/CR-6697 is modified to capture site specific low well pump intake depth of 3 m[c, j]
Model: nondispersion (ND) or mass balance (MB)	none	P	3	ND	ND	NR	NR	NR	NR	RESRAD default
Well pumping rate	m^3 /yr	B, P	2	884	Uniform	250	1519			Minimum is RESRAD default and maximum from NUREG/CR-6697
Number of unsaturated zones	none	P	3	1	1	NR	NR	NR	NR	Default value used
Unsaturated zone thickness	m	P	1	3	3	NR	NR	NR	NR	Site specific value[i, j]

TABLE B-1 Input Parameters Used at Parks SLDA Site for Probabilistic and Deterministic RESRAD Analysis (continued)

Unsaturated zone soil density	g/cm^3	P	2	1.78	Bounded normal	1.78	0.11	1.63	1.93	For deterministic site specific value. For probabilistic distribution from the site specific values[c, j]. The density of unsaturated zone is correlated with unsaturated zone total porosity and effective porosity with a rank correlation coefficient values of -0.96 in the probabilistic run.
Unsaturated zone soil total porosity	none	P	2	0.3377	Bounded normal	0.3377	0.0394	0.2759	0.3561	For deterministic site specific value. For probabilistic distribution from the site specific values[c, j]. The total porosity of unsaturated zone is correlated with unsaturated zone density and effective porosity with a rank correlation coefficient values of -0.96 and 0.96, respectively, in the probabilistic run.
Unsaturated zone soil effective porosity	none	P	2	0.2702	Bounded normal	0.2702	0.0315	0.2207	0.2849	For deterministic site specific value derived from total porosity. For probabilistic distribution from the site specific total porosity values[c, j]. The effective porosity of unsaturated zone is correlated with unsaturated zone density and total porosity with a rank correlation coefficient values of -0.96 and 0.96, respectively, in the probabilistic run.
Unsaturated zone field capacity	none	P	3	0.2	0.2	NR	NR	NR	NR	RESRAD default
Unsaturated zone hydraulic conductivity	m/yr	P	2	7.4	7.4	NR	NR	NR	NR	Site specific value [c, i, j]
Unsaturated zone b parameter	none	P	2	4.8	Bounded lognormal-n	1.96	0.265	3.02	15.5	For deterministic site specific value. For probabilistic distribution from NUREG/CR-6697 for the silty clay loam soil type[c, g, ji]
Inhalation rate	m^3 /yr	M, B	3	8,578	8578	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3

TABLE B-1 Input Parameters Used at Parks SLDA Site for Probabilistic and Deterministic RESRAD Analysis (continued)

Mass loading for inhalation	g/m^3	P, B	2	2.35E-5	Continuous linear	See NUREG/CR-6697 for distribution's statistical parameters				Distribution from NUREG/CR-6697
Exposure duration	yr	B	3	30	30	NR	NR	NR	NR	RESRAD default
Indoor dust filtration factor	none	P, B	2	0.55	Uniform	0.15	0.95			Distribution from NUREG/CR-6697
External gamma shielding factor	none	P	2	0.27	Bounded lognormal-n	-1.3	0.59	0.044	1	Distribution from NUREG/CR-6697
Indoor time fraction	none	B	3	0.6571	0.6571	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Outdoor time fraction	none	B	3	0.1181	0.1181	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Shape of the contaminated zone	none	P	3	Circular	circular	NR	NR	NR	NR	RESRAD default
Fruit vegetable and grain consumption	kg/yr	M, B	2	112	112	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Leafy vegetable consumption	kg/yr	M, B	3	21.4	21.4	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Milk consumption	L/yr	M, B	2	233	233	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Meat and poultry consumption	kg/yr	M, B	3	65.1	65.1	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Fish consumption	kg/yr	M, B	3	20.6	20.6	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Other seafood consumption	kg/yr	M, B	3	0.9	0.9	NR	NR	NR	NR	RESRAD default
Soil ingestion rate	g/yr	M, B	2	18.26	18.26	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Drinking water intake	L/yr	M, B	2	478.8	478.8	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Drinking water contaminated fraction	none	B, P	3	1	1	NR	NR	NR	NR	RESRAD default
Household water contaminated fraction	none	B, P	3	1	1	NR	NR	NR	NR	RESRAD default
Livestock water contaminated fraction	none	B, P	3	1	1	NR	NR	NR	NR	RESRAD default
Irrigation water contaminated fraction	none	B, P	3	1	1	NR	NR	NR	NR	RESRAD default
Aquatic food contaminated fraction	none	B, P	2	1	1	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Plant food contaminated fraction	none	B, P	3	1	1	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Meat contaminated fraction	none	B, P	3	1	1	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Milk contaminated fraction	none	B, P	3	1	1	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Livestock fodder intake for meat	kg/d	M	3	27.1	27.1	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Livestock fodder intake for milk	kg/d	M	3	63.2	63.2	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Livestock water intake for meat	L/d	M	3	50	50	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Livestock water intake for milk	L/d	M	3	60	60	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Livestock soil intake	kg/d	M	3	0.5	0.5	NR	NR	NR	NR	RESRAD default
Mass loading for foliar deposition	g/m^3	P	3	0.0004	0.0004	NR	NR	NR	NR	NUREG/CR-5512, gardening

TABLE B-1 Input Parameters Used at Parks SLDA Site for Probabilistic and Deterministic RESRAD Analysis (continued)

Depth of soil mixing layer	m	P	2	0.233	Triangular	0	0.15	0.6		Distribution from NUREG/CR-6697
Depth of roots	m	P	1	2.15	Uniform	0.3	4			Distribution from NUREG/CR-6697
Groundwater fractional usage for drinking water	none	B, P	3	1	1	NR	NR	NR	NR	RESRAD default
Groundwater fractional usage for household water	none	B, P	3	1	1	NR	NR	NR	NR	RESRAD default
Groundwater fractional usage for livestock water	none	B, P	3	1	1	NR	NR	NR	NR	RESRAD default
Groundwater fractional usage for irrigation water	none	B, P	3	1	1	NR	NR	NR	NR	RESRAD default
Wet weight crop yield for non-leafy vegetables	kg/m^2	P	2	1.75	Truncated lognormal-n	0.56	0.48	.001	.999	Distribution from NUREG/CR-6697
Wet weight crop yield for leafy vegetables	kg/m^2	P	3	2.88921	2.88921	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Wet weight crop yield for fodder	kg/m^2	P	3	1.8868	1.8868	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Length of growing season for non-leafy vegetables	yr	P	3	0.246	0.246	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Length of growing season for leafy vegetables	yr	P	3	0.123	0.123	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Length of growing season for fodder	yr	P	3	0.082	0.082	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Translocation factor for non-leafy	none	P	3	0.1	0.1	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Translocation factor for leafy	none	P	3	1	1	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Translocation factor for fodder	none	P	3	1	1	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Weathering removal constant	1/yr	P	2	32.9	Triangular	5.1	18	84		Distribution from NUREG/CR-6697
Wet foliar interception fraction for non-leafy	none	P	3	0.35	0.35	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Wet foliar interception fraction for leafy	none	P	2	0.581	Triangular	0.06	0.67	0.95		Distribution from NUREG/CR-6697
Wet foliar interception fraction for fodder	none	P	3	0.35	0.35	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Dry-foliar interception fraction for non-leafy	none	P	3	0.35	0.35	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Dry-foliar interception fraction for leafy	none	P	3	0.35	0.35	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3
Dry-foliar interception fraction for fodder	none	P	3	0.35	0.35	NR	NR	NR	NR	NUREG/CR-5512, Vol. 3

TABLE B-1 Input Parameters Used at Parks SLDA Site for Probabilistic and Deterministic RESRAD Analysis (continued)

Radon pathway parameters										For all radon pathway parameters RESRAD default values used
Cover total porosity	none	P	3	0.4	0.4	NR	NR	NR	NR	RESRAD default
Cover volumetric water content	none	P	3	0.05	0.05	NR	NR	NR	NR	RESRAD default
Cover radon diffusion coefficient	m^2/s	P	3	2E-6	2E-6	NR	NR	NR	NR	RESRAD default
Building foundation thickness	m	P	3	0.15	0.15	NR	NR	NR	NR	RESRAD default
Building foundation density	g/cm^3	P	3	2.4	2.4	NR	NR	NR	NR	RESRAD default
Building foundation total porosity	none	P	3	0.1	0.1	NR	NR	NR	NR	RESRAD default
Building foundation volumetric water content	none	P	3	0.03	0.03	NR	NR	NR	NR	RESRAD default
Building foundation radon diffusion coefficient	m^2/s	P	3	3E-7	3E-7	NR	NR	NR	NR	RESRAD default
Contaminated zone radon diffusion coefficient	m^2/s	P	3	2E-6	2E-6	NR	NR	NR	NR	RESRAD default
Radon vertical dimension of mixing	m	P	3	2	2	NR	NR	NR	NR	RESRAD default
Building air exchange rate	/hr	P, B	3	0.5	0.5	NR	NR	NR	NR	RESRAD default
Building room height	m	P	3	2.5	2.5	NR	NR	NR	NR	RESRAD default
Building indoor area factor	none	P	3	0	0	NR	NR	NR	NR	RESRAD default
Foundation depth below ground surface	m	P	3	-1	-1	NR	NR	NR	NR	RESRAD default
Radon 222 emanation coefficient	none	P	3	0.25	0.25	NR	NR	NR	NR	RESRAD default
Radon 220 emanation coefficient	none	P	3	0.15	0.15	NR	NR	NR	NR	RESRAD default
Storage times of contaminated food stuff										Behavioral priority 3 parameters, default values used
Fruits, non leafy vegetables, and grain	days	B	3	14	14	NR	NR	NR	NR	RESRAD default
Leafy vegetables	days	B	3	1	1	NR	NR	NR	NR	RESRAD default
Milk	days	B	3	1	1	NR	NR	NR	NR	RESRAD default
Meat	days	B	3	20	20	NR	NR	NR	NR	RESRAD default
Fish	days	B	3	7	7	NR	NR	NR	NR	RESRAD default
Crustacea and mollusk	days	B	3	7	7	NR	NR	NR	NR	RESRAD default
Well water	days	B	3	1	1	NR	NR	NR	NR	RESRAD default
Surface water	days	B	3	1	1	NR	NR	NR	NR	RESRAD default
Livestock fodder	days	B	3	45	45	NR	NR	NR	NR	RESRAD default

[a] P = physical, B = behavioral, and M = metabolic; when more than one parameter type is listed, the more conservative parameter type is used in the analysis. Priority values are from NUREG/CR-6697.

[b] For truncated normal and lognormal distributions, distribution parameter 1 is the mean, 2 is the standard deviation, 3 is the lower quantile value, and 4 is the upper quantile. For bounded lognormal distribution, parameter 3 and 4 are the actual lower and upper bounds. Parameters for continuous linear and continuous logarithmic distributions are not provided in this table (values are from NUREG/CR-6697 Appendix C). For uniform distribution, parameter 1 is the minimum and parameter 2 is the maximum value. For triangular distribution, parameter 1 is the minimum value, parameter 2 is the most likely value, and parameter 3 is the maximum value of the distribution.

[C] NR = not required (RESRAD parameters for which distributions are not developed and for which statistical parameters are not required).

[d] The site-specific values for distribution coefficients are from: Parks SLDA Site Characterization Report, 1993; Parks SLDA 1999 Field Work and Fate and Transport Analysis, 2000; Understanding Variation in Partition Coefficient, Kd, Values: Vol. II, Review of Geochemisty and Available Kd Values for Cadmium, Cesium, Chromium, Lead, Plutonium, Radon, Strontium, Tritium, and Uranium. EPA 402-R-99-004A, 1999; and USACE analysis using site-specific data.

[e] Parks SLDA Site Characterization Report, 1993.

[f] Parks SLDA 1999 Field Work and Fate and Transport Analysis, 2000.

[g] Information on Hydrologic Conceptual Models, Parameters, Uncertainty Analysis, and Data Sources for Dose Assessments at Decommissioning Sites, NUREG/CR-6656, 1999.

[h] Understanding Variation in Partition Coefficient, Kd, Values: Vol. II, Review of Geochemisty and Available Kd Values for Cadmium, Cesium, Chromium, Lead, Plutonium, Radon, Strontium, Tritium, and Uranium. EPA 402-R-99-004A, 1999.

[i] Second Quarter 1999 Groundwater Assessment Parks Township SLDA, 1999.

[J] USACE analysis using site-specific data.

APPENDIX B

REFERENCES

U.S. Army Corps of Engineers (USACE), 2003, *Final Remedial Investigation Sampling and Analysis Plan, Part I – Field Sampling Plan, Project Work Plans, Acquisition of Field Data and Technical Support for Shallow Land Disposal Area (SLDA) Parks Township, Armstrong County, Pennsylvania,* prepared by URS Group, Buffalo, New York, August.

APPENDIX C: IMPLEMENTING THE WILCOXON RANK SUM (WRS) TEST TO DEMONSTRATE $DCGL_W$ COMPLIANCE

APPENDIX C

IMPLEMENTING THE WILCOXON RANK SUM (WRS) TEST TO DEMONSTRATE DCGL$_W$ COMPLIANCE

The *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)* (EPA 2000) provides two alternative statistical tests for establishing that a final status survey (FSS) unit is in compliance with relevant derived concentration guideline level (DCGL$_w$) standards. These two tests are the Sign test and the Wilcoxon Rank Sum (WRS) test. The Sign test is intended to be used at sites where the contaminants of concern (COC) are either not present in background media, or are at concentrations significantly less than their DCGL$_w$ values. The WRS test is used at sites where one or more of the COCs are present in background media and their background concentrations are close to relevant DCGL$_w$ values.

In the case of SLDA, thorium-232 (Th-232) is a COC that is naturally occurring. Background concentrations of Th-232 have been observed at values greater than its DCGL$_w$; consequently, the WRS test will be used at SLDA to demonstrate that FSS units have met their relevant DCGL$_w$ standards. Because there are multiple COCs for SLDA, the primary parameter of interest from a FSS perspective is the Sum of Ratios (SOR), a value calculated using sample results. The SOR is the sum of each COC divided by its DCGL$_w$ standard. If all the COCs are not present in background, a SOR value greater than one indicates an overall DCGL$_w$ exceedance. However, when one or more of the COCs are present in background, it is possible that even background samples could result in an SOR value greater than one; hence the need to use the WRS test.

The null hypothesis for the WRS test is that the FSS unit under consideration is contaminated above DCGL$_w$ criteria, where DCGL$_w$ standards are values that are incremental to background concentrations. The WRS test determines whether the sample results from the FSS unit are consistent with the null hypothesis, i.e., that activity concentrations within the unit exceed background by more than the DCGL$_w$ standard. If not, the WRS test rejects the null hypothesis and concludes that the FSS is in compliance with the $DCGL_w$ standards. At SLDA, the value used for the $DCGL_w$ evaluation by the WRS test is the SOR.

The WRS test requires a background or reference area that has been sampled with protocols similar to what are being used for FSS purposes. At SLDA, surface and subsurface background samples were collected as part of the remedial investigation (RI) (USACE 2005). These RI samples form the background data set that will be used for the FSS as part of a WRS test that will be conducted for each final status survey unit. Since the RI sampling identified a systematic difference between surface and subsurface soils in background Th-232 activity concentrations, FSS units will be separated into surface and subsurface FSS units. In the case of surface FSS units (i.e., Class 2 and 3 units), the surface background data set will be used to conduct the WRS test. In the case of subsurface FSS units (i.e., excavated Class 1 units), the subsurface background data set will be used to conduct the WRS test.

Table C.1 provides the surface background sample data to be used for the WRS test. Table C.2 provides the subsurface background sample data to be used for the WRS test. In each case, the sample value of interest is its SOR value. (The spatial coordinates for the 18 background sample locations are listed in Table C-3.)

The process for conducting the WRS test for individual FSS units is as follows:

1. The FSS unit under consideration is classified as either surface (i.e., Class 2 and 3 unexcavated units) or subsurface (i.e., Class 1 units), and the relevant background data set identified.

2. An SOR score is calculated for each sample result from the FSS unit.

3. The average SOR score for the FSS unit is compared to the average SOR score for the relevant background data set. If the average FSS SOR score is more than

one greater than the average background SOR value, then the conclusion is that the unit is contaminated above the allowed $DCGL_w$ standard. If the difference is less than one, continue to step #4.

4. The maximum individual sample SOR value in the FSS unit is compared with the smallest relevant individual background sample SOR value. If the difference between these two values is less than one, then the conclusion is the unit meets the $DCGL_w$ standard. If not, continue to step #5.

5. The SOR values for the relevant background data set are each increased by adding one to their values (as described in Section 8.4.2 of MARSSIM [EPA 2000]).

6. The FSS sampling results are combined with the relevant background data set, and the pooled data set ranked by SOR score from smallest to largest.

7. Each data point is assigned its rank value, which will range between one and n + m, where n is the number of relevant background samples and m is the number of samples from the survey unit. In the case of a group of identical sample results, the identical results will each be assigned the average of the group's rank.

8. Sum the ranks of the samples from the background data set. The sum is called W_r. Compare the value of W_r with the critical value contained in MARSSIM's Table I.4 for the appropriate values of n (number of FSS unit samples), m (number of background samples), and alpha (desired error rate). If W_r is greater than the critical value, reject the null hypothesis and conclude that the FSS unit meets the $DCGL_w$ standard. Otherwise, accept the null hypothesis that the FSS unit is contaminated above the $DCGL_w$ standard.

Table C-1 Surface Background Sample Results

SAMPLE ID	Am-241 (pCi/g)	Pu-239 (pCi/g)	Pu-241 (pCi/g)	Th-232 (pCi/g)	U-234 (pCi/g)	U-235 Alpha (pCi/g)	U-238 (pCi/g)	SOR DCGLw
SO-BK-001-0-0.5	*0.03*	*0.00*	*0.00*	0.99	0.91	*0.08*	0.98	0.73
SO-BK-002-0-0.5	*-0.05*	*0.00*	*5.93*	1.31	0.91	*0.14*	0.96	0.96
SO-BK-003-0-0.5	*-0.05*	*-0.01*	*2.25*	0.77	0.72	*0.03*	1.11	0.57
SO-BK-004-0-0.5	*0.00*	*-0.01*	*3.34*	1.11	1.09	*0.10*	1.04	0.82
SO-BK-005-0-0.5	*0.02*	*0.00*	*1.03*	0.99	0.78	*0.07*	0.84	0.73
SO-BK-006-0-0.5	*0.00*	*0.04*	*1.58*	1.22	0.81	*0.13*	0.74	0.89
SO-BK-007-0-0.5	*-0.02*	*0.02*	*1.71*	0.80	1.03	*0.10*	0.99	0.59
SO-BK-008-0-0.5	*R*	*R*	*2.97*	1.16	0.92	0.19	0.98	0.86
SO-BK-009-0-0.5	*0.02*	*0.00*	*5.04*	0.74	0.73	0.18	0.91	0.56
SO-BK-010-0-0.5	*0.00*	*-0.01*	*0.36*	0.98	0.61	*0.05*	0.93	0.71
SO-BK-011-0-0.5	*0.04*	*0.04*	*-2.51*	1.17	0.90	0.17	1.00	0.86
SO-BK-012-0-0.5	*0.04*	*0.01*	*4.05*	1.23	1.26	*0.06*	0.82	0.91
SO-BK-013-0-0.5	*-0.01*	*0.01*	*-1.64*	1.10	0.79	*0.04*	0.88	0.80
SO-BK-014-0-0.5	*-0.02*	*0.00*	*-1.21*	0.94	0.80	*0.07*	1.01	0.69
SO-BK-015-0-0.5	*-0.01*	*0.03*	*-1.10*	1.16	0.97	*0.19*	0.79	0.85
SO-BK-016-0-0.5	*0.11*	*0.02*	*-0.43*	1.14	1.22	*0.04*	1.25	0.84
SO-BK-017-0-0.5	*-0.02*	*0.01*	*-4.04*	1.08	1.07	*0.06*	1.13	0.79
SO-BK-018-0-0.5	*0.04*	*R*	*-0.12*	1.17	1.32	*0.16*	1.20	0.87
Mean Value	0.007	**0.0098**	0.957	**1.058**	**0.935**	**0.102**	**0.975**	**0.778**

Italicized numbers are the reported values less than the Minimum Detectable Limits (MDL).

R entries were rejected results that were not used in the SOR equation.

Mean values that are not bold were not statistically different from zero.

Table C-2 Subsurface Background Sample Results

SAMPLE ID	Am-241 (pCi/g)	Pu-239 (pCi/g)	Pu-241 (pCi/g)	Th-232 (pCi/g)	U-234 (pCi/g)	U-235 Alpha (pCi/g)	U-238 (pCi/g)	SOR DCGLw
SB-BK-001-2-4	*-0.04*	*0.00*	*4.27*	1.59	1.04	*0.03*	1.01	1.16
SB-BK-002-2-4	*-0.06*	*-0.01*	*-2.10*	1.77	0.95	0.17	1.06	1.28
SB-BK-003-2-4	*R*	*0.00*	*5.44*	1.28	0.72	*0.04*	0.83	0.94
SB-BK-004-2-4	*-0.04*	*0.03*	*-0.35*	1.47	1.22	*0.11*	1.03	1.07
SB-BK-005-2-4	*-0.01*	*0.00*	*-1.32*	1.54	1.24	*0.13*	1.30	1.13
SB-BK-006-2-4	*-0.02*	*0.00*	*3.43*	1.61	1.11	0.21	1.21	1.18
SB-BK-007-2-4	*-0.01*	*-0.02*	*2.16*	1.43	1.16	*0.05*	1.19	1.05
SB-BK-008-2-4	*0.02*	*0.00*	*6.00*	*1.45*	1.04	0.27	1.41	1.07
SB-BK-009-2-4	*-0.03*	*0.00*	*4.78*	1.57	1.11	*0.07*	0.87	1.15
SB-BK-010-2-4	*-0.04*	*0.00*	*2.07*	1.11	0.94	*0.12*	0.94	0.81
SB-BK-011-2-4	*-0.02*	*-0.01*	*6.61*	1.57	1.22	*0.11*	0.96	1.15
SB-BK-012-2-4	*0.01*	*R*	*0.90*	1.62	1.11	*0.13*	1.03	1.18
SB-BK-013-2-4	*0.01*	*-0.01*	*-3.02*	1.52	1.07	*0.12*	0.93	1.10
SB-BK-014-2-4	*0.04*	*-0.01*	*3.36*	1.59	0.94	*0.03*	0.89	1.16
SB-BK-015-2-4	*-0.01*	*0.03*	*-1.62*	1.1	1.11	0.24	0.71	0.81
SB-BK-016-2-4	*0.00*	*-0.02*	*-5.39*	1.63	1.17	*0.13*	1.10	1.18
SB-BK-017-2-4	*0.11*	*0.00*	*1.92*	1.51	1.28	*0.14*	1.20	1.11
SB-BK-018-2-4	*-0.01*	*0.00*	*-0.10*	1.57	1.15	*0.05*	0.99	1.14
Mean Value	-0.005	-0.002	1.502	**1.496**	**1.088**	**0.118**	**1.036**	**1.093**

Italicized numbers are the reported values less than the MDL.

R entries were rejected results that were not used in the SOR equation.

Mean values that are not bold were not statistically different from zero.

Table C-3 Spatial Coordinates for the RI Background Samples

Sample ID	Northing (ft)	Easting (ft)
BK-001	484510.94	1450264.91
BK-002	484469.01	1450174.76
BK-003	484425.15	1450084.53
BK-004	484448.67	1450017.83
BK-005	484491.88	1450107.43
BK-006	484535.61	1450197.69
BK-007	484422.82	1450309.3
BK-008	484445	1450244.51
BK-009	484402.67	1450154.81
BK-010	484357.59	1450056.52
BK-011	484336.07	1450127.97
BK-012	484379.81	1450218.69
BK-013	484355.33	1450287.26
BK-014	484314.85	1450196.94
BK-015	484269.86	1450105.7
BK-016	484246.96	1450174.92
BK-017	484291.81	1450263.67
BK-018	484333.15	1450353.73

I.4 Critical Values for the WRS Test

Table I.4 Critical Values for the WRS test

m is the number of reference area samples and n is the number of survey unit samples.

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 2	α=0.001	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43
	α=0.005	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	40	42
	α=0.01	7	9	11	13	15	17	19	21	23	25	27	28	30	32	34	36	38	39	41
	α=0.025	7	9	11	13	15	17	18	20	22	23	25	27	29	31	33	34	36	38	40
	α=0.05	7	9	11	12	14	16	17	19	21	23	24	26	27	29	31	33	34	36	38
	α=0.1	7	8	10	11	13	15	16	18	19	21	22	24	26	27	29	30	32	33	35
	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 3	α=0.001	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	56	59	62	65
	α=0.005	12	15	18	21	24	27	30	32	35	38	40	43	46	48	51	54	57	59	62
	α=0.01	12	15	18	21	24	26	29	31	34	37	39	42	45	47	50	52	55	58	60
	α=0.025	12	15	18	20	22	25	27	30	32	35	37	40	43	45	47	50	52	55	57
	α=0.05	12	14	17	19	21	24	26	28	31	33	36	38	40	43	45	47	50	52	54
	α=0.1	11	13	16	18	20	22	24	27	29	31	33	35	37	40	42	44	46	48	50
	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 4	α=0.001	18	22	26	30	34	38	42	46	49	53	57	60	64	68	71	75	78	82	86
	α=0.005	18	22	26	30	33	37	40	44	47	51	54	58	61	64	68	71	75	78	81
	α=0.01	18	22	26	29	32	36	39	42	46	49	52	56	59	62	66	69	72	76	79
	α=0.025	18	22	25	28	31	34	37	41	44	47	50	53	56	59	62	66	69	72	75
	α=0.05	18	21	24	27	30	33	36	39	42	45	48	51	54	57	59	62	65	68	71
	α=0.1	17	20	22	25	28	31	34	36	39	42	45	48	50	53	56	59	61	64	67
	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 5	α=0.001	25	30	35	40	45	50	54	58	63	67	72	76	81	85	89	94	98	102	107
	α=0.005	25	30	35	39	43	48	52	56	60	64	68	72	77	81	85	89	93	97	101
	α=0.01	25	30	34	38	42	46	50	54	58	62	66	70	74	78	82	86	90	94	98
	α=0.025	25	29	33	37	41	44	48	52	56	60	63	67	71	75	79	82	86	90	94
	α=0.05	24	28	32	35	39	43	46	50	53	57	61	64	68	71	75	79	82	86	89
	α=0.1	23	27	30	34	37	41	44	47	51	54	57	61	64	67	71	74	77	81	84
	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 6	α=0.001	33	39	45	51	57	63	67	72	77	82	88	93	98	103	108	113	118	123	128
	α=0.005	33	39	44	49	54	59	64	69	74	79	83	88	93	98	103	107	112	117	122
	α=0.01	33	39	43	48	53	58	62	67	72	77	81	86	91	95	100	104	109	114	118
	α=0.025	33	37	42	47	51	56	60	64	69	73	78	82	87	91	95	100	104	109	113
	α=0.05	32	36	41	45	49	54	58	62	66	70	75	79	83	87	91	96	100	104	108
	α=0.1	31	35	39	43	47	51	55	59	63	67	71	75	79	83	87	91	94	98	102

Table I.4 Critical Values for the WRS Test (continued)

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 7	α=0.001	42	49	56	63	69	75	81	87	93	98	104	110	116	122	128	133	139	145	151
	α=0.005	42	49	55	61	66	72	77	83	88	94	99	105	110	116	121	127	132	138	143
	α=0.01	42	48	54	59	65	70	76	81	86	92	97	102	108	113	118	123	129	134	139
	α=0.025	42	47	52	57	63	68	73	78	83	88	93	98	103	108	113	118	123	128	133
	α=0.05	41	46	51	56	61	65	70	75	80	85	90	94	99	104	109	113	118	123	128
	α=0.1	40	44	49	54	58	63	67	72	76	81	85	90	94	99	103	108	112	117	121

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 8	α=0.001	52	60	68	75	83	89	95	102	109	115	122	128	135	141	148	154	161	167	174
	α=0.005	52	60	66	73	79	85	92	98	104	110	116	122	129	135	141	147	153	159	165
	α=0.01	52	59	65	71	77	84	90	96	102	108	114	120	125	131	137	143	149	155	161
	α=0.025	51	57	63	69	75	81	86	92	98	104	109	115	121	126	132	137	143	149	154
	α=0.05	50	56	62	67	73	78	84	89	95	100	105	111	116	122	127	132	138	143	148
	α=0.1	49	54	60	65	70	75	80	85	91	96	101	106	111	116	121	126	131	136	141

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 9	α=0.001	63	72	81	88	96	104	111	118	126	133	140	147	155	162	169	176	183	190	198
	α=0.005	63	71	79	86	93	100	107	114	121	127	134	141	148	155	161	168	175	182	188
	α=0.01	63	70	77	84	91	98	105	111	118	125	131	138	144	151	157	164	170	177	184
	α=0.025	62	69	76	82	88	95	101	108	114	120	126	133	139	145	151	158	164	170	176
	α=0.05	61	67	74	80	86	92	98	104	110	116	122	128	134	140	146	152	158	164	170
	α=0.1	60	66	71	77	83	89	94	100	105	111	117	123	129	134	140	145	151	157	162

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 10	α=0.001	75	85	94	103	111	119	128	136	144	152	160	167	175	183	191	199	207	215	222
	α=0.005	75	84	92	100	108	115	123	131	138	146	153	160	168	175	183	190	197	205	212
	α=0.01	75	83	91	98	106	113	121	128	135	142	150	157	164	171	178	186	193	200	207
	α=0.025	74	81	89	96	103	110	117	124	131	138	145	151	158	165	172	179	186	193	199
	α=0.05	73	80	87	93	100	107	114	120	127	133	140	147	153	160	166	173	179	186	192
	α=0.1	71	78	84	91	97	103	110	116	122	128	135	141	147	153	160	166	172	178	184

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 11	α=0.001	88	99	109	118	127	136	145	154	163	171	180	188	197	206	214	223	231	240	248
	α=0.005	88	98	107	115	124	132	140	148	157	165	173	181	189	197	205	213	221	229	237
	α=0.01	88	97	105	113	122	130	138	146	153	161	169	177	185	193	200	208	216	224	232
	α=0.025	87	95	103	111	118	126	134	141	149	156	164	171	179	186	194	201	208	216	223
	α=0.05	86	93	101	108	115	123	130	137	144	152	159	166	173	180	187	195	202	209	216
	α=0.1	84	91	98	105	112	119	126	133	139	146	153	160	167	173	180	187	194	201	207

Table I.4 Critical Values for the WRS Test (continued)

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 12	α=0.001	102	114	125	135	145	154	164	173	183	192	202	210	220	230	238	247	256	266	275
	α=0.005	102	112	122	131	140	149	158	167	176	185	194	202	211	220	228	237	245	254	263
	α=0.01	102	111	120	129	138	147	156	164	173	181	190	198	207	215	223	232	240	249	257
	α=0.025	100	109	118	126	135	143	151	159	168	176	184	192	200	208	216	224	232	240	248
	α=0.05	99	108	116	124	132	140	147	155	163	171	179	186	194	202	209	217	225	233	240
	α=0.1	97	105	113	120	128	135	143	150	158	165	172	180	187	194	202	209	216	224	231

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 13	α=0.001	117	130	141	152	163	173	183	193	203	213	223	233	243	253	263	273	282	292	302
	α=0.005	117	128	139	148	158	168	177	187	196	206	215	225	234	243	253	262	271	280	290
	α=0.01	116	127	137	146	156	165	174	184	193	202	211	220	229	238	247	256	265	274	283
	α=0.025	115	125	134	143	152	161	170	179	187	196	205	214	222	231	239	248	257	265	274
	α=0.05	114	123	132	140	149	157	166	174	183	191	199	208	216	224	233	241	249	257	266
	α=0.1	112	120	129	137	145	153	161	169	177	185	193	201	209	217	224	232	240	248	256

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 14	α=0.001	133	147	159	171	182	193	204	215	225	236	247	257	268	278	289	299	310	320	330
	α=0.005	133	145	156	167	177	187	198	208	218	228	238	248	258	268	278	288	298	307	317
	α=0.01	132	144	154	164	175	185	194	204	214	224	234	243	253	263	272	282	291	301	311
	α=0.025	131	141	151	161	171	180	190	199	208	218	227	236	245	255	264	273	282	292	301
	α=0.05	129	139	149	158	167	176	185	194	203	212	221	230	239	248	257	265	274	283	292
	α=0.1	128	136	145	154	163	171	180	189	197	206	214	223	231	240	248	257	265	273	282

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 15	α=0.001	150	165	178	190	202	212	225	237	248	260	271	282	293	304	316	327	338	349	360
	α=0.005	150	162	174	186	197	208	219	230	240	251	262	272	283	293	304	314	325	335	346
	α=0.01	149	161	172	183	194	205	215	226	236	247	257	267	278	288	298	308	319	329	339
	α=0.025	148	159	169	180	190	200	210	220	230	240	250	260	270	280	289	299	309	319	329
	α=0.05	146	157	167	176	186	196	206	215	225	234	244	253	263	272	282	291	301	310	319
	α=0.1	144	154	163	173	182	191	200	209	218	227	236	246	255	264	273	282	291	300	309

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 16	α=0.001	168	184	197	210	223	236	248	260	272	284	296	308	320	332	343	355	367	379	390
	α=0.005	168	181	194	206	218	229	241	252	264	275	286	298	309	320	331	342	353	365	376
	α=0.01	167	180	192	203	215	226	237	248	259	270	281	292	303	314	325	336	347	357	368
	α=0.025	166	177	188	200	210	221	232	242	253	264	274	284	295	305	316	326	337	347	357
	α=0.05	164	175	185	196	206	217	227	237	247	257	267	278	288	298	308	318	328	338	348
	α=0.1	162	172	182	192	202	211	221	231	241	250	260	269	279	289	298	308	317	327	336

Table I.4 Critical Values for the WRS Test (continued)

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 17	α=0.001	187	203	218	232	245	258	271	284	297	310	322	335	347	360	372	384	397	409	422
	α=0.005	187	201	214	227	239	252	264	276	288	300	312	324	336	347	359	371	383	394	406
	α=0.01	186	199	212	224	236	248	260	272	284	295	307	318	330	341	353	364	376	387	399
	α=0.025	184	197	209	220	232	243	254	266	277	288	299	310	321	332	343	354	365	376	387
	α=0.05	183	194	205	217	228	238	249	260	271	282	292	303	313	324	335	345	356	366	377
	α=0.1	180	191	202	212	223	233	243	253	264	274	284	294	305	315	325	335	345	355	365

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 18	α=0.001	207	224	239	254	268	282	296	309	323	336	349	362	376	389	402	415	428	441	454
	α=0.005	207	222	236	249	262	275	288	301	313	326	339	351	364	376	388	401	413	425	438
	α=0.01	206	220	233	246	259	272	284	296	309	321	333	345	357	370	382	394	406	418	430
	α=0.025	204	217	230	242	254	265	278	290	302	313	325	337	348	360	372	383	395	406	418
	α=0.05	202	215	226	238	250	261	273	284	295	307	318	329	340	352	363	374	385	396	407
	α=0.1	200	211	222	233	244	255	266	277	288	299	309	320	331	342	352	363	374	384	395

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 19	α=0.001	228	246	262	277	292	307	321	335	350	364	377	391	405	419	433	446	460	473	487
	α=0.005	227	243	258	272	286	300	313	327	340	353	365	379	392	405	419	431	444	457	470
	α=0.01	226	242	256	269	283	296	309	322	335	348	361	373	386	399	411	424	437	449	462
	α=0.025	225	239	252	265	278	290	303	315	327	340	352	364	377	389	401	413	425	437	450
	α=0.05	223	236	248	261	273	285	297	309	321	333	345	356	368	380	392	403	415	427	439
	α=0.1	220	232	244	256	267	279	290	302	313	325	336	347	358	370	381	392	403	415	426

	n =	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
m = 20	α=0.001	250	269	286	302	317	333	348	363	377	392	407	421	435	450	464	479	493	507	521
	α=0.005	249	266	281	296	311	325	339	353	367	381	395	409	422	436	450	463	477	490	504
	α=0.01	248	264	279	293	307	321	335	349	362	376	389	402	416	429	442	456	469	482	495
	α=0.025	247	261	275	289	302	315	329	341	354	367	380	393	406	419	431	444	457	470	482
	α=0.05	245	258	271	284	297	310	322	335	347	360	372	385	397	409	422	434	446	459	471
	α=0.1	242	254	267	279	291	303	315	327	339	351	363	375	387	399	410	422	434	446	458

Reject the null hypothesis if the test statistic (W_r) is greater than the table (critical) value. For n or m greater than 20, the table (critical) value can be calculated from:

$$m(n+m+1)/2 + z\sqrt{nm(n+m+1)/12} \tag{I.1}$$

if there are few or no ties, and from

$$m(n+m+1)/2 + z\sqrt{\frac{nm}{12}\left[(n+m+1) - \sum_{j=1}^{g}\frac{t_j(t_j^2-1)}{(n+m)(n+m-1)}\right]} \tag{I.2}$$

if there are many ties, where g is the number of groups of tied measurements and t_j is the number of tied measurements in the jth group. z is the (1-α) percentile of a standard normal distribution, which can be found in the following table:

α	z
0.001	3.09
0.005	2.575
0.01	2.326
0.025	1.960
0.05	1.645
0.1	1.282

Other values can be found in Table I-1.

APPENDIX C

REFERENCES

EPA (U.S. Environmental Protection Agency), 2000, *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*, EPA 402-R-97-016, Rev. 1, August.

USACE (U.S. Army Corps of Engineers), 2005, *Remedial Investigation Report, Shallow Land Disposal Area (SLDA) Site, Parks Township, Armstrong County, Pennsylvania*, prepared by URS Group, Inc., Buffalo, New York, July.

APPENDIX D: TRENCH SOILS AT THE MATERIAL PROCESSING BUILDING BELOW THE DERIVED CONCENTRATION GUIDELINES

PROCEDURE FOR DEMONSTRATING COMPLIANCE

APPENDIX D

TRENCH SOILS AT THE MATERIAL PROCESSING BUILDING BELOW THE DERIVED CONCENTRATION GUIDELINES

PROCEDURE FOR DEMONSTRATING COMPLIANCE

INTRODUCTION

The objective of the Shallow Land Disposal Area (SLDA) remediation is to excavate waste and contaminated soil from the existing burial trenches, process the waste/soil for disposal, and prepare processed waste/soil for shipment to an offsite disposal facility. Waste/soils removed from the trenches shall be sampled, sorted, and segregated by waste type, contamination level, and potential source of contamination (i.e., materials that are low level and/or mixed radioactive wastes and soils that are contaminated below the site cleanup levels). The sampling, segregating, treating, and packaging of excavated soil and debris will be performed inside an on-site material processing building (MPB).

Based on examination of historical records and previous investigations and discussions with individuals familiar with disposal operations at SLDA, the waste materials were reportedly placed into a series of pits that were constructed adjacent to one another. The Atomic Energy Commission regulation (i.e., 10 CFR 20.304), in effect at the time these disposals took place, required that individual burials be separated by a minimum of 6 feet (ft) (1.8 meters [m]). Following placement in the pits, the waste materials were covered with about 4 ft (1.2 m) of clean soil. The disposals at the SLDA site were reportedly conducted in accordance with this regulation that also limited disposal quantity and frequency. These individual burials are referred to as "pits" in historical reports and also by former workers (USACE 2005 and 2006). The depths of placement of disposed materials within the "pits" are reported to have ranged from 4 ft (1.2 m) to 14 ft (4.3 m) below ground surface (bgs) (ARCO/B&W 1995). These pits were generally constructed in a linear manner, as confirmed by historical and current geophysical surveys of the site, and they are shown on site drawings and maps as a series of linear trenches. On the basis of these historical records and previous investigations of how the disposals were conducted, there is the potential that soils excavated from the trenches could be below the derived concentration guideline levels (DCGLs). The objective of this write-up is to provide a process to demonstrate DCGL compliance for soils from the MPB that could potentially remain on the SLDA site.

TESTING FOR DCGL COMPLIANCE

The MPB soils without any visual evidence of contamination and with sample results indicating activity concentrations below DCGLs may be transported to the stockpile area for final status survey (FSS) sampling to demonstrate compliance with $DCGL_w$ and $DCGL_{emc}$ requirements. The soils will be sampled at a density equivalent to a Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) Class 1 unit. For a conventional Class 1 unit, samples are typically collected from the surface to a depth of 6 inches [in.] (15 centimeters [cm]) in a 2,000 square meter (m^2) area, thus the volume of soil sampled is 400 cubic yards (yd^3). To be consistent with the volume of soil that is sampled from a representative Class 1 unit, the soils from the MPB will be divided into survey units up to 400 yd^3 for scanning and sampling. It is not expected that 400 yd^3 of "post processed" below DCGL soil will be present in the MPB at any time. "Post-processed" soil below the DCGL's will be removed from the MPB and transported to the FSS pad as space is needed within the MPB to accommodate additional excavated material.

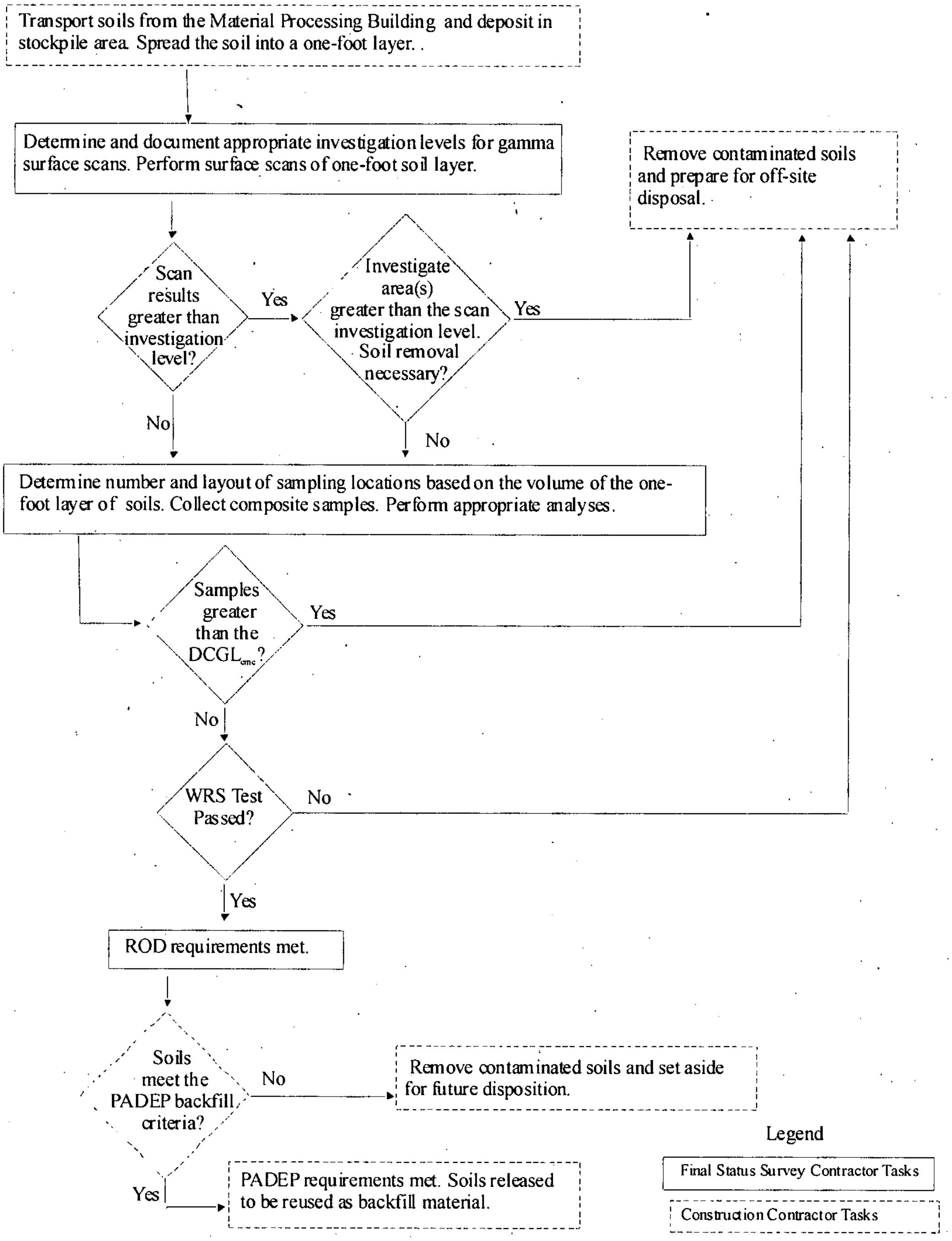
Figure D-1 provides a flow diagram of the decision logic for final status survey data collection and decision making applied to ex situ soils to be addressed as Class 1 units. After the soil is transported from the MPB to the stockpile area, up to 400 yd^3 of soil will be spread into a 1-ft (0.3-m) layer for scanning and composite sampling (consistent with the overburden and benching soil). The 100% surface scans will be conducted for the 1-ft (0.3-m) layer of soil using a FIDLER or equivalent detector.

Gamma scan data will be obtained by walking the designated layer of soil in parallel paths using a traverse spacing of 1 m and traverses will also be performed orthogonal to the original traverses. The goal is to have a data density of approximately one measurement per square meter. Surface gamma scan results will be compared to the investigation level and locations will be flagged where the data indicate an anomaly, defined as a contamination level that is not equivalent or consistent to background. A composite biased sample or samples will be collected at these locations to determine either $DCGL_{emc}$ compliance or exceedance. If the $DCGL_{emc}$ is exceeded, soils in the elevated area will be flagged for off-site disposal. The gamma walkover surveys will be used (in addition to the soil sample results) to demonstrate DCGL compliance.

As discussed in Section 4.1.5 of the final status survey plan (FSSP), Table 5.3 in MARSSIM was used to determine the range of FSS composite samples per survey unit. A relative shift of four (described in Section 4.1.4 of the FSSP) and Type I error rate of 0.025 or 2.5% resulted in acceptable composite sample numbers that range between 6 and 15 per survey unit, depending on the Type II error rate. An initial Type II error rate of 0.05 or 5% was selected for the survey units which equates to 11 composite samples per survey unit. Sampling locations will be laid out on triangular grids, where possible. Composite samples will be collected from a depth interval of 0 to 1-ft (0.3-m), the entire vertical layer, to obtain representative samples from a soil layer unit up to 400 yd^3 in volume. Additional discussion regarding composite sampling is provided in Section 5.1.2. The composite samples will be analyzed for americium-241 (Am-241), pluntoium-239 (Pu-239), thorium-232 (Th-232), uranium-234 (U-234), uranium-235 (U-235), and uranum-238 (U-238) by either gamma or alpha spectrometry. Liquid scintillation is the analytical method that will be used to analyze for pluntoium-241 (Pu-241). The resulting sum of ratios (SOR) scores will be first compared to 100-square meter (m^2) $DCGL_{emc}$ requirement. If a sample result is greater than a $DCGL_{emc}$, the contaminated soil within the elevated area will be segregated and removed for off-site disposal. If all of the SOR values are less than the 100-m^2 $DCGL_{emc,}$ the results will then be used to calculate $DCGL_w$ SOR values. $DCGL_w$ compliance will be demonstrated using the Wilicoxon Rank Sum (WRS) test, as described in Appendix C. If the unit fails the WRS test, the soil layer will be removed and prepared for off-site disposal.

If a survey unit satisfies all DCGL requirements, soil samples from the stockpile layer survey unit will be analyzed for chemicals required to meet the PADEP backfill requirements (PADEP 2004). If the samples meet the PADEP backfill criteria, the soils will be released to be reused as backfill soils at the site. If the soils fail to meet the PADEP backfill criteria, the soils will be removed and placed in a separate stockpile for future deposition.

Figure D-1 Decision Flow Diagram for Class 1 Units – Ex-Situ Soils from the Material Processing Building



APPENDIX D

REFERENCES

ARCO/B&W (Atlantic Richfield Corporation/Babcock & Wilcox), 1995, *Parks Shallow Land Disposal Facility Site Characterization Report*, Vandergrift, Pennsylvania, May.

EPA (U.S. Environmental Protection Agency), 2000, *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*, EPA 402-R-97-016, Rev. 1, August.

PADEP (Pennsylvania Department of Environmental Protection), 2004, *Management of Fill Policy*, Bureau of Land Recycling and Waste Management, Document.

USACE (U.S. Army Corps of Engineers), 2005, *Remedial Investigation Report, Shallow Land Disposal Area (SLDA) Site. Parks Township, Armstrong County, Pennsylvania*, prepared by URS Group, Inc., Buffalo, New York, July.

USACE 2006, *Feasibility Study for the Shallow Land Disposal Area Site, Parks Township, Armstrong County, Pennsylvania*, prepared by URS Group, Inc., Buffalo, New York, September.