Department of Energy
West Valley Demonstration Project
10282 Rock Springs Road
West Valley, NY 14171-9799

December 17, 2009

Dr. Keith I. McConnell, Deputy Director
Decommissioning and Uranium Recovery Licensing Directorate
Division of Waste Management and Environmental Protection
Office of Federal and State Materials and Environmental Management Programs
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: Submission of the Phase 1 Final Status Survey Plan (FSSP) for the West Valley Demonstration Project (WVDP) for U.S. Nuclear Regulatory Commission (NRC) Review

Dear Dr. McConnell:

The purpose of this letter is to submit the Phase 1 FSSP for the WVDP for NRC review and comment.

Twenty paper copies of the plan are provided to this end, along with 20 compact disks, each of which contains an electronic copy of the plan.

The Phase 1 FSSP provides the protocols for demonstrating that specific portions of the WVDP project premises meet the Derived Concentration Guideline Levels (DCGL) developed by the Phase 1 DP, consistent with the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM).

Plan Content

The Phase 1 FSSP has been developed consistent with NUREG-1757, Volume 1. The plan includes:

- Applicable DCGL requirements as developed by the Phase 1 DP for surface soils, sediments, and deep subsurface soils that will be exposed by the Waste Management Area (WMA) 1 and 2 excavations;
- Key assumptions pertinent to the proposed Phase 1 final status survey activities;
- The basis for final status survey unit classification for areas affected by Phase 1 activities;
- The roles of gross activity scans, biased sampling, and systematic sampling for demonstrating compliance with DCGL requirements;

- The planned area-specific final status survey field activities;
- Laboratory analytical requirements;
- The decision-logic to be used (including appropriate statistical tests) to evaluate data sets obtained by final status survey data collection;
- Quality assurance/quality control requirements; and
- Reporting and documentation requirements.

The spatial scope of the FSSP includes the deep excavated soil surfaces that will be associated with the WMA 1 and 2 excavations and surface soils outside those excavations where contamination deeper than one meter is absent and DOE believes surface soil conditions meet Phase 1 DCGL requirements. The FSSP does not include protocols for final status survey data collection for stream sediments since it is not DOE's expectation at this time that Erdman Brook and Franks Creek sediments will be addressed as part of Phase 1 DP activities; the plan may be amended at a later date to provide for sediment protocols if necessary.

It is DOE's expectation that the work accomplished under this FSSP will result in data that demonstrate, consistent with MARSSIM, that Phase 1 DCGL standards have been achieved for specific areas of the site, and that it can potentially be used by NYSERDA in support of license termination for those portions of the Center where Phase 1 final status survey data collection took place.

Given the complexity of the Phase 1 DP, the FSSP, and the WVDP site, a briefing on the FSSP contents may be appropriate before NRC begins its review. DOE can provide such a briefing to NRC staff upon NRC's request.

For Further Information

Please let us know if NRC needs any additional references or other information for review of the plan. Please refer any questions about this submittal to either Mark Bellis or Moira Maloney of my staff at (716) 942-4814 or (716) 942-4255, respectively.

Sincerely,

Bryan C. Bower, Director
West Valley Demonstration Project

Enclosures: 1. Attachment 1: Matters of Interest Related to Dose Modeling (15 copies)
2. Phase 1 of the WVDP DP (15 copies with CDs)

cc: See Page 3

MNM:101800 - 450.4

cc: M. A. Gilbertson, DOE-HQ, EM-50, w/o enc.
M. J. Letourneau, DOE-HQ, EM-11, CLOV, w/enc.
J. M. Moon, DOE-HQ, EM-51, FORS, w/o enc.
M. S. Bellis, DOE-EMCBC, WV-DOE, w/enc.
M. N. Maloney, DOE-WVDP, AC-DOE, w/enc.
L. Camper, NRC, w/o enc.
C. Glen, NRC, w/o enc.
R. Tadesse, NRC, w/o enc.
P. J. Bembia, NYSERDA, AC-NYS (6 copies)

Reading Rooms: (w/enc.)
Ashford Office Complex Public Reading Room (West Valley, NY)
Hulbert Library, Springville, NY
U.S. Department of Energy, FOIA Reading Room (DOE-HQ, Room 1E-190)

MNM:101800 - 450.4

Phase 1 Final Status Survey Plan
West Valley Demonstration Project

Prepared for the
U.S. Department of Energy
West Valley Demonstration Project
West Valley, New York

By

Argonne National Laboratory
Environmental Science Division
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Argonne, IL 60439

December 16, 2009

This plan is based on the Phase 1 Decommissioning Plan for the West Valley Demonstration Project, Revision 2, which is based on the preferred alternative in the Revised Draft Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center. If changes to that document occur during the course of the National Environmental Policy Act process that affect the Phase 1 Decommissioning Plan, such as changes to the preferred alternative, or if a different approach is selected in the Record of Decision, this plan will be revised as necessary to reflect the changes.

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ACRONYMS, ABBREVIATIONS, AND SYMBOLS

Am	Americium
C	Carbon
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CG	Cleanup Goals
cm	Centimeter
Cm	Curium
Cs	Cesium
CSAP	characterization sampling and analysis plan
CSM	Conceptual Site Model
DCGL	Radionuclide-specific Derived Concentration Guideline Levels
DOE	Department of Energy
DOT	Department of Transportation
DQCR	Daily Quality Control Reports
DQI	Data Quality Indicators
DQO	Data Quality Objectives
emc	radionuclide-specific activity concentrations that must be met over areas smaller than individual survey units
EPA	Environmental Protection Agency
FIDLER	Field Instrument for Detection of Low Energy Radiation
FSS	Final Status Survey
FSSP	Final Status Survey Plan
FSSR	Final Status Survey Report
ft	foot
g	Gram
GWS	Gamma Walkover Survey(s)
I	Iodine
IDW	investigation-derived waste
LBGR	Lower Bound of the Gray Region
m	meter
m^2	square meter
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	Minimum Detectable Concentration
mrem	Millirem

NaI	Sodium Iodide
NCR	nonconformance report
NFS	Nuclear Fuel Services
NIST	National Institute of Standards and Technology
Np	Neptunium
NRC	Nuclear Regulatory Commission
pCi	picocurie
Phase 1 DP	Phase 1 Decommissioning Plan for the West Valley Demonstration Project
PPE	personal protective equipment
Pu	Plutonium
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
Ra	Radium
RCRA	Resource Conservation and Recovery Act
ROI	Radionuclides of Interest
RQC	Radiological Quality Control
SOR	Sum of Ratios
Sr	Strontium
Tc	Technetium
Th	Thorium
U	Uranium
w	radionuclide-specific activity concentrations that must be met, on average, for each individual survey unit
WMA	Waste Management Area
WRS	Wilcoxon Rank Sum
WVDP	West Valley Demonstration Project
yd^3	cubic yard
yr	year

RECORD OF REVISIONS

Date	Section	Revision	Reason

EXECUTIVE SUMMARY

This plan provides the technical basis and associated protocols to support Phase 1 Final Status Survey (FSS) data collection and interpretation as part of the West Valley Demonstration Project Phase 1 Decommissioning Plan process. This plan is consistent with the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM). The Phase 1 Decommissioning Plan provides the relevant Derived Concentration Guideline Levels (DCGLs) for the Phase 1 radionuclides of interest. This plan includes protocols that will be applied to the deep excavations planned for Waste Management Area (WMA) 1 and WMA 2, for surface soils outside the WMA 1 and WMA 2 excavations that do not have contamination impacts at depths greater than one meter, and for areas that are used for Phase 1 contaminated soil lay down purposes. All excavated and lay down areas will be classified as MARSSIM Class 1 areas. Surface soils that have not been excavated, are not expected to exceed DCGLs, and do not have contamination impacts at depths greater than one meter will be divided into either Class 1, Class 2, or Class 3 areas depending on the expected potential for surface soil contamination in those areas. The plan uses gamma scans combined with biased soil samples to address $DCGL_{emc}$ concerns. The plan uses systematic soil sampling combined with area factors to address $DCGL_w$ and $DCGL_{emc}$ concerns. For both biased and systematic sampling, incremental compositing techniques are used to improve soil sample representativeness and the ability to reliably identify the existence of elevated areas. The Sign test will be used to statistically evaluate $DCGL_w$ compliance. If the results from the Characterization Sampling and Analysis Plan (CSAP) data collection indicate that background may be a significant issue for Sign test implementation, the Wilcoxon Rank Sum (WRS) test will be used instead to demonstrate $DCGL_w$ compliance. A reference area will be selected based on CSAP data results if the WRS test becomes a necessity. The WMA 1 excavation footprint includes approximately 476 foundation pilings that will be trimmed and left in place. Because of concerns that these pilings may have served as preferential flow pathways into the underlying Lavery till, piling-specific systematic and biased sampling will be conducted to address those concerns. FSS data collection results will be summarized, presented, and interpreted within one or more FSS reports.

1.0 INTRODUCTION AND PURPOSE

The *Phase 1 Decommissioning Plan for the West Valley Demonstration Project* (Revision 2, December 2009) (Phase 1 DP) describes the Phase 1 decommissioning activities proposed for the West Valley Demonstration Project (WVDP) premises. These activities will at least partially address residual radionuclide contamination concerns in environmental media (soils, sediments, and groundwater). The Phase 1 DP includes unrestricted release Derived Concentration Guideline Levels (DCGLs) for the identified radionuclides of interest (ROI) pertinent to the environmental media to be addressed by Phase 1 activities.

The objective of the Phase 1 decommissioning activities is to remove certain facilities and remediate specific portions of the WVDP premises to criteria for unrestricted release consistent with the License Termination Rule in 10 CFR 20.1402 in a manner that will not limit future Phase 2 decommissioning options. The Phase 1 DP activities are intended to reduce short- and long-term health and safety risks in a manner that will ultimately support the Phase 2 decommissioning activities required to complete decontamination and decommissioning of the project premises.

As part of Phase 1 decommissioning activities, data will be collected to demonstrate that upon completion of the waste management area (WMA) 1 and 2 excavations the excavation floors meet the appropriate DCGL requirements. In addition, the Department of Energy (DOE) may also choose to collect data to demonstrate that surface soils for other portions of the WVDP project premises also meet the Phase 1 DCGL requirements (DP Revision 2, Table 5-14) for those areas where contamination is not present at depths greater than one meter (m). Examples of these areas include the following: (1) soils exposed by hardstand, pad, or foundation removal that are believed to be below DCGL requirements; (2) soils with surface contamination above DCGL goals that DOE chooses to remediate; or (3) other soils where there is no evidence of contamination above DCGL requirements.

The Phase 1 DP includes DCGL requirements for stream sediments. Stream sediments are not expected to be included in Phase 1 Final Status Survey (FSS) activities. If addressing stream sediments becomes advantageous, this plan will be revised as appropriate.

This Final Status Survey Plan (FSSP) describes the decision-making process and data requirements necessary for Phase 1 FSS purposes. The contents of this plan supplement and expand upon contents of the Phase 1 DP Section 9 and Appendix G. The information contained in this plan is consistent with

MARSSIM (NUREG 1575 and DOE/EH-412/0020/0403) and NUREG 1757. All field activities conducted as part of FSSP activities will be conducted consistent with the Health and Safety Plan described by the Phase 1 DP.

2.0 FINAL STATUS SURVEY DESIGN BASIS

As required by the Phase 1 DP, the Phase 1 FSSP is consistent with the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), Revision 1 (NUREG-1575, Revision 1, August 2000). There are aspects of the WVDP premises (e.g., buried subsurface soil contamination) that are beyond MARSSIM's scope. In those instances, the proposed closure protocols will be consistent with the intent of MARSSIM.

2.1 WVDP Premises and Proposed Phase I Activities

The WVDP premises consist of approximately 167 acres. The major features of the premises include existing facilities and associated above ground and buried infrastructure, disposal areas, active and inactive waste lagoons, roads, hardstands and paved parking lots, a railway spur, streams that drain the area, and open land. The project premises were used for commercial spent-fuel reprocessing in the 1960s and early 1970s. Reprocessing activities resulted in environmental releases of radionuclides to surrounding soils, surface water, and groundwater.

To address known historical releases and other areas of interest, the Phase 1 DP activities include the following planned environmental remediation activities: (1) a deep (30 – 45 feet [ft]), extensive (3 acre) excavation of contaminated soils adjacent to and beneath the Main Plant Process Building (i.e., WMA 1); (2) a deep (up to 14 ft), extensive (4 acre) excavation of contaminated soils adjacent to and beneath facilities and lagoons associated with the Low-Level Waste Treatment Facility (i.e., WMA 2); and (3) excavation of contaminated and uncontaminated near-surface soils (approximately 2 ft below grade) associated with selective building and infrastructure removal in WMA 1, WMA 2, WMA 3, WMA 5, WMA 6, WMA 7, WMA 9, and WMA 10. In addition to these planned excavations, DOE may also choose to remove additional surface contaminated soils and/or sediments as part of Phase 1 decommissioning work. Upon completion of the Phase 1 DP activities, any residual contamination within the WVDP premises that results in a dose exceedance concern will be addressed by Phase 2 decommissioning activities.

Figure 1 provides a map of the project premises identifying the footprints of the WMAs. Figure 2 is an oblique aerial photograph of the project premises from the west to the east showing the existing buildings and the layout of the proposed WMA 1 and WMA 2 excavations.

2.2 DCGL Requirements

The Phase 1 DP identified 18 ROI for the project premises and developed DCGL values for each ROI based on a 25 millirem (mrem)/year (yr) dose requirement (incremental to background) assuming a goal of unrestricted release. The DCGL requirements included a $DCGL_w$ value to be applied as an area-averaged goal to FSS units and a $DCGL_{emc}$ value applicable to one square meter (m^2) areas. The Phase 1 DP also provides area factors that can be used to calculate additional $DCGL_{emc}$ requirements for areas smaller than FSS units. In addition, the Phase 1 DP distinguishes between DCGL values for surface soils (defined as soils to a depth of one m) and subsurface soils (defined as soils at significant depth that would be temporarily exposed by proposed Phase 1 excavation activities in WMA 1 and WMA 2), and stream.

Figure 1 WVDP Waste Management Areas

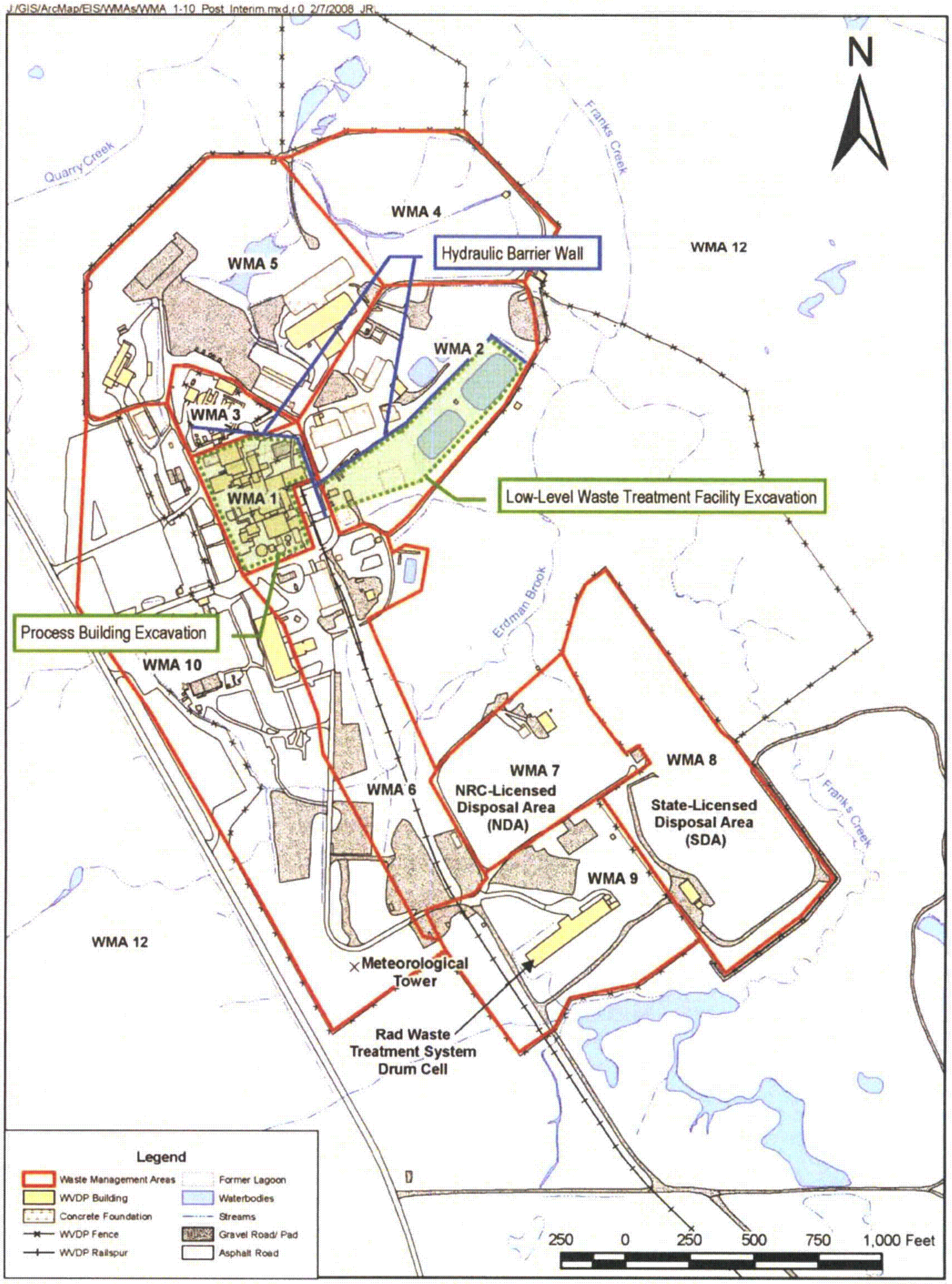
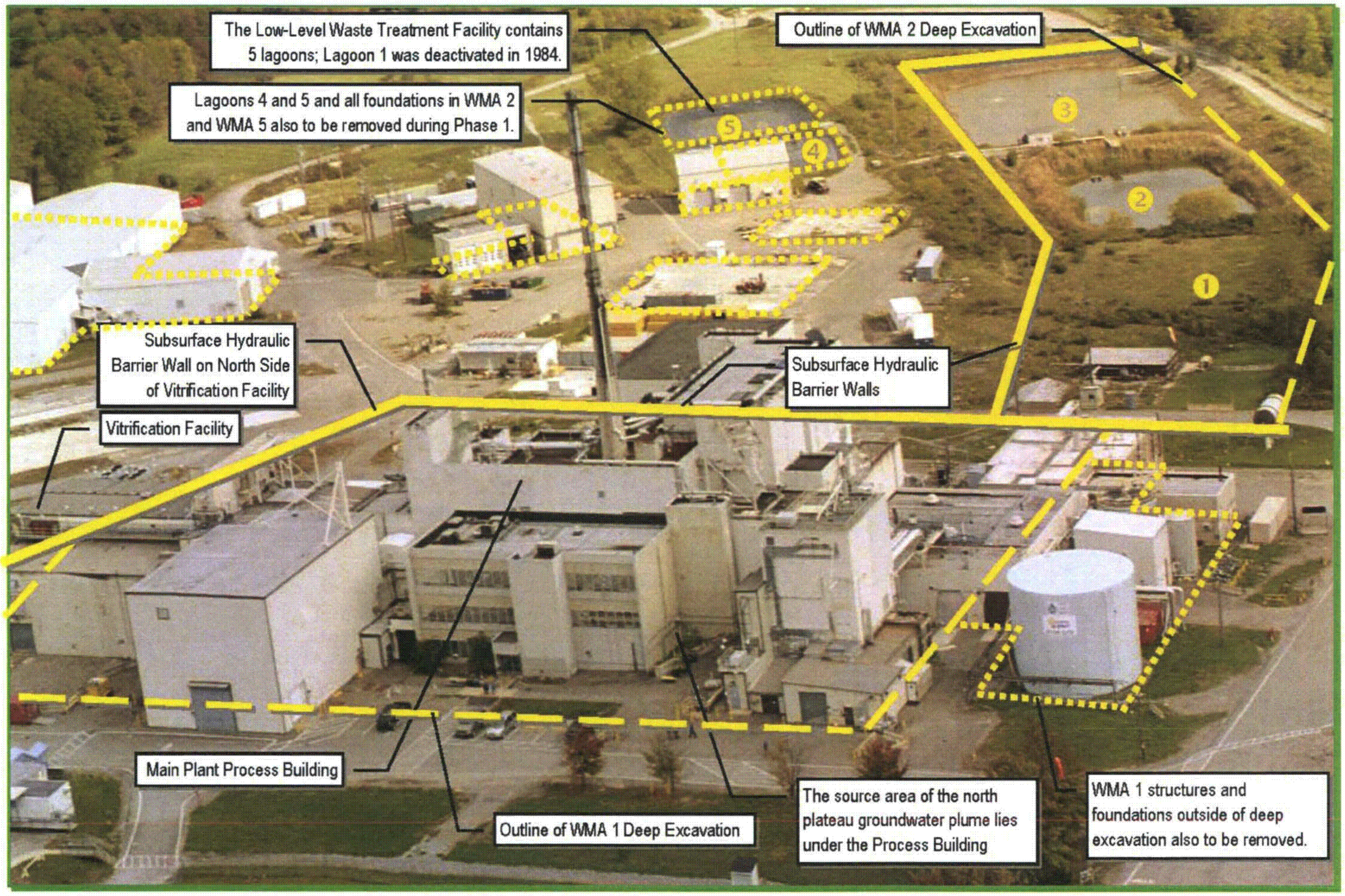


Figure 2 Oblique Aerial Photograph of WMA 1 and WMA 2



sediments. These DCGL values were further refined to reflect cumulative dose concerns, resulting in a final set of DCGL values listed in Table 5-14 of the Phase 1 DP. Table 5-14 of the Phase 1 DP refers to these as cleanup goals. The cleanup goals are more conservative than the DCGL requirements since they account for the possibility of cumulative dose. To be consistent with the Phase 1 DP terminology, from this point forward, the term "cleanup goals" (CG) will be used to refer to the requirements that must be met; specifically, the term CG_w refers to radionuclide-specific activity concentrations that must be met, on average, for each individual survey unit, and the term CG_{emc} refers to radionuclide-specific activity concentrations that must be met over areas smaller than individual survey units. Table 5-14 of the Phase 1 DP is reproduced as Table 1 in the FSSP.

2.3 Key Assumptions

The FSSP includes several key assumptions discussed below.

- *Consultation with NRC on the Phase 1 Decommissioning Plan.* DOE consulted with NRC on the Phase 1 DP and made changes in Revision 2 of the plan to address NRC's related requests for information. This FSSP is based on the DCGLs and CGs as defined in Revision 2 to the Phase 1 DP. Any changes in these DCGL/GC values or definitions may require revisions to this FSSP.
- *CG Definitions.* The Phase 1 DP provides CG definitions for the 18 ROI. In the case of surface soil CGs, the assumed vertical interval is one m in depth. The planned Phase 1 soil and stream sediment characterization work within the project premises described in the Characterization Sample and Analysis Plan (CSAP) may identify project premise characteristics that are inconsistent with the conceptual site model (CSM) used for CG derivation (e.g., surface contamination restricted to the top few centimeters (cm) of the soil surface, subsurface contamination covered by several cm of clean overburden soil, or contaminated soils extending to a depth greater than one m in depth). To address this potential issue: (1) surface soil CG standards and the FSS process will only be applied outside the WMA 1 and WMA 2 excavations when contamination impacts are less than one m in depth; (2) surface soil CG standards will be applied to the top 15 cm of soil and to the top 1-m soil interval as part of the FSS process; and (3) the presence of thin, highly elevated zones overlain by clean surface soils will be evaluated by the CSAP data collection. In the last instance, if near surface contaminated layers are encountered by CSAP data collection that result in potential dose concerns, but that would not have been identified by the proposed FSS data collection, then the FSS process will be modified to meet the specific needs of those areas.

Table 1 Phase 1 Cleanup Goals (picoCurie/gram [pCi/g]) (source: WVDP Phase 1 Decommissioning Plan, Revision 2, Table 5-14)

Nuclide	Surface Soil		Subsurface Soil		Streambed Sediment	
	CG^1_w	CG^2_{EMC}	CG_w	CG_{EMC}	CG_w	CG_{EMC}
Am-241	2.6E+01	3.9E+03	2.8E+03	1.2E+04	1.0E+03	3.3E+04
C-14	1.5E+01	1.6E+06	4.5E+02	8.0E+04	1.8E+02	1.1E+06
Cm-243	3.1E+01	7.5E+02	5.0E+02	4.0E+03	3.1E+02	3.2E+03
Cm-244	5.8E+01	1.2E+04	9.9E+03	4.5E+04	3.8E+03	4.5E+05
Cs-137	1.4E+01	3.0E+02	1.4E+02	1.7E+03	1.0E+02	1.2E+03
I-129	2.9E-01	6.0E+02	3.4E+00	3.4E+02	7.9E+01	9.3E+04
Np-237	2.3E-01	7.5E+01	4.5E-01	4.3E+01	3.2E+01	1.7E+03
Pu-238	3.6E+01	7.6E+03	5.9E+03	2.8E+04	1.2E+03	2.7E+05
Pu-239	2.3E+01	6.9E+03	1.4E+03	2.6E+04	1.2E+03	2.5E+05
Pu-240	2.4E+01	6.9E+03	1.5E+03	2.6E+04	1.2E+03	2.5E+05
Pu-241	1.0E+03	1.3E+05	1.1E+05	6.8E+05	3.4E+04	1.1E+06
Sr-90	3.7E+00	7.9E+03	1.3E+02	7.3E+03	4.7E+02	1.4E+05
Tc-99	1.9E+01	2.6E+04	2.7E+02	1.5E+04	6.6E+04	1.4E+07
U-232	1.4E+00	5.9E+01	3.3E+01	4.2E+02	2.2E+01	2.5E+02
U-233	7.5E+00	8.0E+03	8.6E+01	9.4E+03	2.2E+03	1.2E+05
U-234	7.6E+00	1.6E+04	9.0E+01	9.4E+03	2.2E+03	5.9E+05
U-235	3.1E+00	6.1E+02	9.5E+01	3.3E+03	2.3E+02	2.5E+03
U-238	8.9E+00	2.9E+03	9.5E+01	9.9E+03	8.2E+02	1.3E+04

Notes:
[1]CG_w refers to activity concentrations that must be achieved, on average, over areas the size of final status survey units.
[2]CG_{EMC} refers to activity concentrations that must be achieved, on average, over 1 m^2 areas.

- *LBGR*. MARSSIM's Lower Bound on the Grey Region (LBGR) is defined as the bottom of a range of values where the consequences of making a decision error are relatively minor. In practice it corresponds to the average residual activity concentration that will be present when FSS data collection activities begin. For areas that do not require remediation, the LBGR is the existing average level of contamination present. For areas requiring remediation, the LBGR is the cleanup level targeted by the remediation program. By definition, the LBGR represents activity concentrations that are below the required CG standards. In combination with the Type II error rate and expected sample variability, the LBGR is an important determinant of the number of systematic samples required to demonstrate compliance with the CG_w.

- *Data Gaps*. There are key data gaps that will be addressed as part of the pre-design characterization work called for by the Phase 1 DP and described in the CSAP. One example of these is the presence and spatial prevalence of the 18 ROI identified in the Phase 1 DP. A second example is the presence and importance of radionuclides other than the 18 identified by the Phase 1 DP. While unlikely, this FSSP may need to be revised if conditions encountered during CSAP characterization work are determined to be significantly different from the Phase 1 DP assumptions and CSM.
- *Chemical Contamination*. Chemical contamination may exist for portions of the project premises. Chemical contamination concerns will be addressed in compliance with the Resource Conservation and Recovery Act (RCRA), and are not directly within the scope of the Phase 1 FSSP. Samples collected as part of the FSSP process may also be analyzed for chemical constituents as necessary for waste stream characterization, and/or to fulfill RCRA requirements.
- *Scope of Phase 1 FSSP Data Collection*. As part of Phase 1 decommissioning activities, data will be collected to demonstrate that the floors and walls of the WMA 1 and 2 excavations meet the appropriate CG requirements. In addition, the DOE may also choose to collect data to demonstrate that surface soils for other portions of the WVDP premises also meet the Phase 1 CG requirements for those situations where contamination is not present at depths greater than one m in depth. Examples of these areas include: (1) soils exposed by hardstand, pad, or foundation removal that are believed to be below CG requirements; (2) soils with surface contamination above CG goals that DOE chooses to remediate; and/or (3) other soils where there is no evidence of contamination above CG requirements.
- *Sign Test Applicability*. Because all 18 ROI identified in the Phase 1 DP are either not naturally occurring or have CG_w requirements an order of magnitude or more above background levels, the Sign test is considered appropriate for demonstrating compliance with wide-area CG (CG_w) requirements. In the event that CG values are lowered it may be necessary to establish a background reference area and use the Wilcoxon Rank Sum (WRS) instead of the Sign test to demonstrate compliance with the CG_w requirements. To address that possibility, this plan includes a reference area that can be used for background sampling, as necessary.
- *CG_{emc} Applicability*. The CG_{emc}, as derived by the Phase 1 DP, is radionuclide-specific and applies to one m^2 areas. Gross gamma surveys will be used for demonstrating compliance with the CG_{emc} criteria where appropriate. In addition, appropriate CG_{emc} values will be calculated that correspond to the area represented by systematic samples collected to demonstrate CG_w compliance using area factors provided by the Phase 1 DP (see Tables 9.1 and 9.2 in the Phase 1 DP). The latter is intended to address the ROIs that are not detectable by gamma scans and that

may exist in isolation for specific portions of the project premises (e.g., the floor of the WMA 1 excavation where Strontium-90 [Sr-90] may be the principal radionuclide of interest).

- *ROI List.* The Phase I DP identified 18 ROI for the project premises. Because historical processes and contaminant release scenarios vary from location to location across the project premises, not all 18 ROI may be pertinent to specific areas. The assumption is that CSAP data collection may be used to determine which of the 18 ROI are pertinent to specific areas within the project premises. If the CSAP data results indicate only a subset of the ROI are pertinent for specific areas, then the FSS sample analyses for those individual areas may be limited to the smaller set of relevant ROI.
- *Use of SOR Calculations.* Because of the multiple ROI, all FSS determinations will be based on sample sum of ratio (SOR) calculations. The SOR calculation for any particular sample will be based on the subset of radionuclides pertinent to the FSS unit that was the source of the sample.
- *Subsurface Soil Contamination.* The Phase 1 FSS process is not applicable to areas outside the WMA 1 and 2 excavations where subsurface soil contamination exists greater than one m in depth.
- *Null Hypothesis and Acceptable Error Rates.* For the Sign test, the null hypothesis will be that FSS units are contaminated above CG_w levels based on sample SOR values. In this context, the acceptable Type I error rate (i.e., rejecting the null hypothesis when it should have been accepted) will be 0.05. The Type II error rate (i.e., accepting the null hypothesis when it should have been rejected) will be set based on an engineering cost analysis that weighs the potential for false contaminated conclusions with the costs of FSS data collection. The Type I error rate establishes the minimum number of systematic samples required for Sign test implementation. In the case of an error rate of 0.05, the minimum number is five samples per survey unit; FSS units, however, will likely require more systematic samples than this minimum number to meet Type II error rate needs.
- *Role of Composite Sampling.* While not discussed in MARSSIM, the use of composite samples is one means for attaining desired Type II error rates while controlling analytical costs when performing CG_w (or $DCGL_w$) evaluations and increasing the likelihood that CG_{emc} exceedances are identified for radionuclides that are not detectable by gross activity scans. Composite sampling combines soil increments (e.g., individual soil samples) systematically distributed across a portion of a FSS unit into a homogenized composite sample before analysis. Sufficient composite samples are collected from each survey unit to satisfy Sign or WRS test requirements. The type of compositing proposed, and its advantages are well documented, have been used effectively within the RCRA and Comprehensive Environmental Response, Compensation,

and Liability Act (CERCLA) cleanup programs, and have regulatory support (see EPA 1995, EPA 2002a and EPA 2002b). Section 4.3 describes the soil sample compositing process in greater detail. Appendix A provides a technical justification.

- The minimum number of composite samples per survey unit is determined by the desired Type I error rate and the statistical test to be used and makes use of standard MARSSIM concepts, equations, and tables. The minimum number of soil increments contributing to each composite sample is a function of the desired Type II error rate, the degree of heterogeneity expected within survey units, the confidence desired to identify elevated areas, and the expected average residual activity concentration. Composite sampling will be used during the FSS process when appropriate to improve overall decision-making performance.
- *Analytical Methods*. The Phase 1 DP ROI list includes 18 radionuclides with, in some cases, relatively low CG_w requirements. The 18 radionuclides span a range of required analytical techniques, including gamma spectroscopy, alpha spectroscopy, liquid scintillation, and gas proportional counting. Later sections in this plan specify the analytical performance requirements for each radionuclide. In some cases (e.g., gamma spectroscopy and liquid scintillation), a field-based laboratory may prove advantageous, particularly for those radionuclides that will likely be the primary decision drivers (e.g., Cesium-137 [Cs-137] and Sr-90). Whether data from field deployable techniques can be used for FSS compliance demonstration will depend on whether FSS data quality standards can be achieved and documented. There may be cases where a particular field-deployable technique may not have sufficient data quality for FSS purposes, but where the technique still serves an important and useful role as a screening tool for identifying an elevated area of concern, or as part of pre-FSS/remedial action support survey collection to determine that an area is ready for FSS data collection.
- *Use of CSAP Data for FSS Purposes*. The CSAP has been developed so that data generated by the CSAP, when appropriate, meet the data quality objectives (DQO) specified by this FSSP. The intent is that data associated with the CSAP, if collected consistent with FSSP protocols and data quality standards, can potentially be used for FSS purposes if contamination levels requiring remediation are not identified.

3.0 DATA QUALITY OBJECTIVES

The DQO for the WVDP Phase 1 FSS process are provided below to establish a systematic procedure for defining the criteria that must be met by the data collection design. 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 has the following 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 WVDP Phase 1 FSS data collection

3.1 State the Problem

This FSSP will be used to determine whether radionuclide activity concentrations in surface and subsurface soils at the WVDP premises for selected areas comply with CGs as described by the Phase 1 DP and shown in Table 1. The CGs for the WVDP premises are derived from dose goals; they were developed to limit the annual dose to less than 25 mrem/year. The CG_w refers to a wide area average requirement that must be met for areas the size of a FSS unit. The CG_{emc} refers to an elevated measurement comparison requirement that addresses more localized elevated areas that may exceed the CG_w at specific locations but not when averaged over a survey unit. The CGs were developed so that post-remediation residual activity concentrations are consistent with the dose goals derived for the project premises. As discussed in the Phase 1 DP, CGs were derived for surface soils (defined as the upper one m) and for deep subsurface soils that will be exposed by the WMA 1 and WMA 2 excavations. While the

Phase 1 DP also includes derived stream sediment CGs, there will be no FSS data collection in Franks Creek or Erdman Brook as part of the Phase 1 activities.

Compliance with the CGs will be demonstrated by using guidance found in MARSSIM (EPA 2000). Specifically, compliance will be demonstrated by performing gamma surface scans and collecting systematic (i.e., samples associated with a grid) and biased (i.e., samples targeting specific areas of concern) soil samples consistent with MARSSIM guidance.

3.2 Identify the Goals of the Study

The goal of the Phase 1 FSSP and associated FSS data collection is to establish that, for selected areas of the WVDP premises, Phase 1 DP CGs (Table 1) have been met.

3.3 Identify Information Inputs

The following information will be gathered and used as the basis for FSS decision-making:

- Historical information pertaining to area-specific land use and contamination releases (e.g., historical aerial photography analysis, anecdotal information, etc.).
- Results from planned CSAP field work, which will include gamma walkover data, intrusive subsurface soil sampling data and surface soil sampling data.
- Results from remedial action support survey collection for those areas where excavation takes place as part of Phase 1 decommissioning activities. Remedial action support survey collection will include gamma walkover surveys (GWS) and soil sampling results.
- FSS data collection, which will include gamma surveys of exposed surfaces, and biased soil sampling that target locations of particular contamination concern, and systematic surface soil sampling.

Historical, CSAP, and remedial action support survey collection will be used primarily to confirm the appropriate FSS unit classification designation for specific areas of interest. FSS data collection will be used to address FSS decision-making. CSAP data (e.g., remedial action support survey collection) may be used for FSS decision-making if the CSAP data is collected consistent with FSS protocols and data quality requirements.

3.4 Define the Boundaries of the Study

Phase 1 FSSP activities will address selected portions of the WVDP premises. These will include the excavation floors and soils sloping up to the walls of the WMA 1 and WMA 2 excavations. They may include surface soils outside of the WMA 1 and WMA 2 excavations exposed by Phase 1 removal activities (e.g., hardstand or foundation removals) and other surface soils that likely meet Phase 1 DP CG requirements. Outside of the WMA 1 and WMA 2 excavations, the Phase 1 FSSP activities will address surface soils areas at DOE discretion. Alternatively, DOE may postpone FSS data collection for these surface areas until Phase 2 decommissioning activities.

The Phase 1 FSSP is **not** applicable to any areas outside the WMA 1 and WMA 2 excavations where there is evidence of contamination impacts above background conditions at depths exceeding one m. The exception to this rule are areas to be used for contaminated soil lay down during Phase 1 activities; after removal of those soils, the lay down areas will undergo Phase 1 FSS data collection to document their contamination status regardless of whether subsurface soil contamination is known to be present.

The exact footprint of Phase 1 FSSP activities will primarily depend on the results of CSAP data collection, Phase 1 soil excavations, and DOE's planning processes. Definitive Phase 1 FSS unit footprints will be established prior to the initiation of Phase 1 FSS data collection. All areas within the Phase 1 FSSP footprint will be associated with a FSS unit.

FSS data collection within FSS units applies to exposed soils to a depth of one m.

3.5 Develop the Analytical Approach

The analytical methods to be employed for soil analyses, along with required detection limits, are described in detail in Section 6. Where advantageous, an on-site laboratory may be used for some radionuclides during the FSS process if the data quality standards achieve those prescribed by Section 6. An on-site laboratory may prove particularly useful for Cs-137 and Sr-90, since these two radionuclides are expected to be of primary concern from a FSS perspective. These are the two radionuclides that have been consistently identified in historical soil sample analyses. The assumption that these are the two radionculides of primary concern will be tested by CSAP data collection.

An appropriate gross gamma detector or detectors will be used to perform surveys of exposed surfaces to evaluate the presence and spatial distribution of ROIs as part of the FSS process. Several of the ROIs are either not detectable by gamma surveys or are marginally detectable (i.e., detectable but at activity concentrations higher than CG requirements). To address lower-energy, marginally detectable radionuclides such as the various plutonium isotopes and Americium-241 (^{241}Am), at a minimum a Field Instrument for Detecting Low Energy Radiation (FIDLER) or equivalent detector will be deployed. Expected minimum detectable activity concentrations for gamma scans are presented in greater detail in Section 6.

3.6 Specify Performance or Acceptance Criteria

Section 7 describes the decision-making process for FSS units in detail.

Individual FSS units must comply with two distinct CG requirements, the CG_w and the CG_{emc}.

In the case of the CG_w, an individual FSS unit will be considered in compliance if:

- The average SOR result for systematic soil samples obtained from the FSS unit is less than one (assuming the Sign test is to be used for statistical purposes), or that the difference between the average SOR for the reference area and the average SOR for the FSS unit is less than one (assuming the WRS test is to be used for statistical purposes).
- The systematic soil sample results from the FSS unit satisfy the appropriate statistical test at the appropriate confidence level. The Sign test will be used as the statistical test unless the CG requirements are modified such that a WRS test is required. The null hypothesis is that the unit is contaminated. The required Type I error rate is 0.05.

In the case of the CG_{emc}, an individual FSS unit will be considered in compliance if:

- GWS results do not indicate any anomalous areas that have not been addressed by biased sampling.
- Individual biased sample results are less than the CG_{emc}.

- Individual systematic sample results are less than the CG_{emc} as calculated using area factors, with the area factor reflecting the area represented by each systematic sample. Area factors to be used in this adjustement are provided in Section 4.

3.7 Develop the Plan for Obtaining Data

Detailed plans for obtaining the required data are presented in Section 4 (general data collection activities) and Section 5 (field activities).

4.0 DATA COLLECTION PLAN

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

4.1 Classification of Survey Units

Before FSS data collection can take place, the area of interest must be divided into MARSSIM FSS units. MARSSIM defines three types of FSS units. Class 1 units include areas that required remediation and areas where historical data indicate CG exceedances likely existed prior to remediation. Class 1 units can range up to 2,000 m^2 in size. Class 2 units include areas that are impacted but are not expected to require remediation (i.e., no historical evidence that contamination would exceed CG activity concentrations). Class 2 units can range up to 10,000 m^2 in size. Class 3 units include areas where there is no historical evidence of significant impacts. There is no size limit to Class 3 areas.

Phase 1 FSS unit layout will occur after CSAP data collection (for those areas that will not require remediation) or after remediation is complete (for those areas where soil/foundation activities will take place). Phase 1 FSS units will include Class 1 units, and may include Class 2 and Class 3 units, depending upon the results of CSAP data collection.

Individual FSS units will define areas that are believed to be relatively homogenous in their physical characteristics and in their assumed contamination status.

Outside of the WMA 1 and WMA 2 excavations, only those areas likely to satisfy Phase 1 FSS requirements and where there is no evidence of soil contamination deeper than one m in depth will be candidates for Phase 1 FSS unit designation and subsequent FSS data collection. . The exception to this rule are areas to be used for contaminated soil lay down during Phase 1 activities; after removal of those soils, the lay down areas will undergo Phase 1 FSS data collection to document their contamination status regardless of whether subsurface soil contamination is present.

4.2 Derived Concentration Guideline Levels

Table 1 provides CG_w and CG_{emc} standards for surface and subsurface soils. For the purposes of this plan, these CG values are the equivalent of MARSSIM DCGL values. The CG_{emc} values listed in Table 1 are applicable to one m^2 areas. In addition to these explicit standards, the Phase 1 DP also provides area factors for determining CG_{emc} equivalents for systematic or biased FSS samples representative of areas larger than one m^2. These area factors are provided in Tables 9.1 and 9.2 of the Phase 1 DP and are reproduced as Tables 2 and 3 in this plan. In the event that a FSS sample area does not correspond to a particular area presented in these tables, the area factor to be used would be a linear interpolation based on the data contained in these tables.

The following subsections discuss the applicability of the CG standards.

4.2.1 Subsurface Soils

The subsurface soil CG standards are only applicable to the excavation floors and sides of the WMA 1 and WMA 2 excavations from the excavation bottom to a point 1 m below the ground surface. They will be applied to a 1-m deep soil interval.

4.2.2 Surface Soils

The surface soil CG standards are only applicable when there is no evidence of contamination impacts extending beyond one m in depth. Although they were derived assuming a 1-m deep contamination interval, they will be applied to both a 1-m deep soil interval, and to a 15-cm deep soil interval. The latter addresses the possibility of a thin but highly elevated surface soil contamination layer that potentially poses a direct exposure concern but that would be diluted if only 1-m deep soil samples were collected.

The objective of sampling two different depth intervals is to address the possibility of isolated contamination being present in the top few centimeters of soil that would result in a direct exposure dose concern that might not be identified in samples collected from a 1-m depth. The fundamental issue is that the primary pathway for the different radionuclides of interest differs, but a 1-m surface soil depth interval was used across radionuclides for CG derivation. This is appropriate for radionuclides where plant uptake and groundwater are the primary dose drivers, but not as appropriate for radionculides where direct exposure is the principal concern.

However, in either case the CG_w is an area-averaged concept, and the averaging area is identical, regardless of the pathway. Consequently, there is a concern of vertical dilution, but lateral dilution by combining soil increments into composites is not a CG_w issue. It potentially could be a CG_{emc} issue, but that is addressed through the use of appropriate area factors – as the area represented by a composite sample grows, its area factor shrinks and the corresponding CG_{emc} becomes more restrictive.

Table 2 Area Factors for Surface Soils (source: WVDP Phase 1 Decommissioning Plan, Revision 2, Table 9-1)

Nuclide	$DCGL_W$ 10,000 m^2 (pCi/g)	Area Factors ($DCGL_{EMC}/DCGL_W$)	
		100 m^2	1 m^2
Am-241	2.6E+01	1.5E+01	1.5E+02
C-14	1.5E+01	2.8E+02	1.1E+05
Cm-243	3.1E+01	3.0E+00	2.4E+01
Cm-244	5.8E+01	1.8E+01	2.1E+02
Cs-137	1.4E+01	2.8E+00	2.2E+01
I-129	2.9E-01	3.8E+01	2.1E+03
Np-237	2.3E-01	6.0E+00	3.2E+02
Pu-238	3.6E+01	1.7E+01	2.1E+02
Pu-239	2.3E+01	2.5E+01	3.0E+02
Pu-240	2.4E+01	2.4E+01	2.9E+02
Pu-241	1.0E+03	1.3E+01	1.3E+02
Sr-90	3.7E+00	2.6E+01	2.1E+03
Tc-99	1.9E+01	2.2E+01	1.4E+03
U-232	1.4E+00	5.4E+00	4.4E+01
U-233	7.5E+00	3.7E+01	1.1E+03
U-234	7.6E+00	4.1E+01	2.1E+03
U-235	3.1E+00	2.6E+01	1.9E+02
U-238	8.9E+00	2.9E+01	3.3E+02

Table 3 Area Factors for Subsurface Soils (source: WVDP Phase 1 Decommissioning Plan, Revision 2, Table 9-2)

Nuclide	$DCGL_W$ 2,000 m^2 (pCi/g)	Area Factors ($DCGL_{EMC}/DCGL_W$)	
		92 $m^{2(2)}$	1 m^2
Am-241	2.8E+03	1.1E+00	4.3E+00
C-14	4.5E+02	1.2E+01	1.8E+02
Cm-243	5.0E+02	3.2E+00	8.0E+00
Cm-244	9.9E+03	1.5E+00	4.5E+00
Cs-137	1.4E+02	9.3E+00	1.2E+01
I-129	3.4E+00	4.7E+00	9.9E+01
Np-237	4.5E-01	4.2E+00	9.6E+01
Pu-238	5.9E+03	1.0E+00	4.8E+00
Pu-239	1.4E+03	1.6E+00	1.9E+01
Pu-240	1.5E+03	1.5E+00	1.7E+01
Pu-241	1.1E+05	2.3E+00	6.2E+00
Sr-90	1.3E+02	2.6E+00	5.6E+01
Tc-99	2.7E+02	8.1E+00	5.7E+01
U-232	3.3E+01	2.1E+00	1.3E+01
U-233	8.6E+01	3.6E+00	1.1E+02
U-234	9.0E+01	3.6E+00	1.0E+02
U-235	9.5E+01	3.5E+00	3.5E+01
U-238	9.5E+01	3.6E+00	1.0E+02

4.3 Role of Incremental/Composite Sampling

Incremental composite soil sampling will be used to form composite soil samples that will be submitted for analysis during FSS data collection. One purpose of incremental composite soil sampling is to control for short-scale heterogeneity. Incremental composite sampling forms a composite sample from a set of soil samples ("increments") systematically distributed over the area of interest. The result is that the composite sample is more representative of the area than a single discrete grab sample. Consequently, incremental composite sampling improves both the performance of CG_{cmc} identification via soil sampling, and the overall performance of the CG_w evaluation (e.g., reduced Type II error rates). This is particularly important for the WVDP since some of the ROIs are not detectable with gross gamma surveys.

A five-increment sampling pattern will be used for each composite sample. For each composite formed, the five increments contributing to the composite will be systematically distributed over the area the composite represents. In the case of biased samples, the area will be a judgment call based on the evidence for targeting a particular area for a biased sample (e.g., a GWS anomaly, or visual evidence of potential contamination impacts). For systematic samples from FSS units, the area will be that portion of the survey unit the systematic sample represents. As an example, if a Class 1 survey unit is 2,000 m^2 in size, and a sample number analysis indicates twelve systematic sampling locations are required to satisfy MARSSIM CG_w requirements, then each sampling location would represent 167 m^2. For each sampling location, at least one composite would be formed comprised of five soil increments distributed over the 167 m^2 area. For surface soils, there would be two composites from each systematic sampling location, one representative of a 1-m soil depth interval, and one representative of the upper 15-cm soil depth interval. For subsurface soils in the WMA 1 and WMA 2 excavations, there would be one composite from each systematic sampling location representative of a 1-m soil depth interval. Figure 3 illustrates this concept.

Section 5 discusses soil sampling protocols, including those applicable to forming composites, in more detail.

4.4 Role of Gamma Surveys

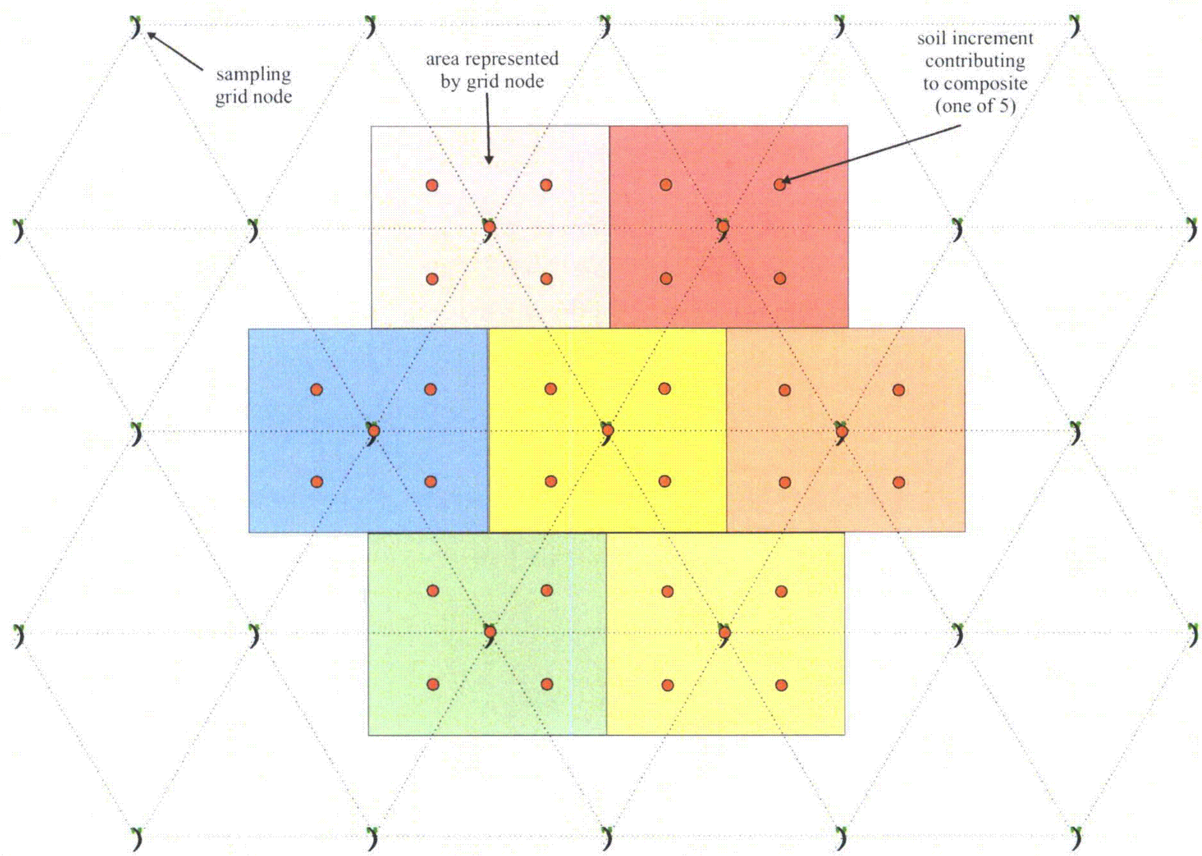
GWS data will be collected from all exposed soil surfaces as part of the FSS data collection process. GWS will be conducted with at least one detector suitable for detecting low energy gamma-emitting radionuclides (e.g., a FIDLER). Field experience with the combined use of FIDLER and 2×2/3×3 sodium iodide (NaI) detectors at several other sites where both low energy (e.g., uranium, plutonium, and americium) and high energy (e.g., Ra-226, Ra-228, and Th-232) gamma emitting radionuclides exist is that the FIDLER matches 2×2 NaI performance for higher energy radionuclides, and significantly exceeds performance for lower energy radionuclides. The former is true because, while less sensitive to higher energy gamma rays, the FIDLER is more sensitive to Compton scatter, and in a soil setting with radionuclide contamination extending into soil profiles, the contribution of Compton scatter to the overall gross activity observed is significant. The FIDLER also provides significant advantages when geometry is a potential issue (e.g., shine from excavation walls or buildings) since it is less sensitive to gamma ray sources that are not directly below the detector face. That experience is expected to be confirmed on the WVDP project premises by CSAP data collection activities. A FIDLER and a 2×2 NaI detector will be used for CSAP purposes for at least a portion of the project premises where Cs-137 is the principal concern. Based on these CSAP results, if a FIDLER cannot achieve sufficiently low detection limits for Cs-137 given its CG requirements, but a 2×2 NaI detector can, a 2×2 NaI detector or similar detector will be used for CSAP and FSS data collection in conjunction with a FIDLER.

GWS data will be electronically logged and matched with coordinate information. GWS will be conducted so that complete coverage is obtained for exposed surface soils within a FSS unit. Section 5 provides greater detail about FSS GWS requirements.

As part of the FSS process, GWS serve three primary roles: (1) to establish that an area is ready for FSS soil sampling (i.e., no significant evidence of elevated gross activity that may indicate CG exceedances), (2) to identify surface soil gross activity anomalies that might be indicative of CG_{emc} exceedances within FSS units, and (3) to identify spatial trends in gross activity within or across FSS survey units that would assist in interpreting systematic soil sampling results if there are CG_w exceedances in systematic sampling results. Because of detection sensitivity limitations for some of the radionuclides of interest, the GWS may not be able to completely satisfy all three goals.

A surface soil background reference area (Section 4.8) will be established prior to the onset of FSS data collection. This background reference area will be surveyed to determine background responses of the instruments to be used for FSS GWS data collection. Gamma walkover data from the background reference area will be used to develop gross activity field investigation levels that indicate when a gamma walkover reading collected during the FSS process is not consistent with background conditions. This background area will also be used as a reference area for the WRS test if that statistical test is required to demonstrate CG_w compliance.

Figure 3 Conceptual Layout of Soil Increments Contributing To Composite Samples



4.5 Role of Biased Samples

Biased samples will be collected to target specific locations where there is concern about potential CG_{emc} exceedances within FSS units. Biased sampling locations may be selected based on a variety of factors, such as an elevated GWS result, visual evidence of contamination, the presence of physical infrastructure that still exists within the FSS unit footprint, etc. Section 5 contains details about soil sampling protocols.

As discussed in Section 4.3, biased samples will be formed using an incremental sampling approach, resulting in a composite sample representative of the area of concern. In general, unless location-specific characteristics indicate otherwise (e.g., the location abuts against a building foundation or excavation wall), a five increment composite sampling approach will be used with the five increments distributed systematically over the area of interest.

For FSS units associated with the excavation floors and sloped soil surfaces of the WMA 1 and WMA 2 excavations, biased samples will represent a one-m deep soil interval, consistent with the subsurface CG derivation for this area. For FSS units associated with surface soils outside the WMA 1 and WMA 2 excavations for each location requiring biased sampling, two samples will be collected, one representing a one-m deep soil interval, and one representing a 15-cm deep soil interval.

Biased sampling will also be a key component of soil sampling along remaining foundation pilings locations in the WMA 1 and WMA 2 excavations to address the concern that those foundation pilings may have presented preferential contamination migration pathways deeper into the subsurface. The details of this are described in Section 5.0.

The analytical results from biased samples will be compared to the appropriate CG_{emc} standards. Section 6 contains details about analytical requirements. Typically, this standard will be the CG_w multiplied by the appropriate area factor contained in Tables 2 an 3 to reflect the area the biased sample was intended to represent.

4.6 Role of Systematic Samples

FSS systematic samples will be used to evaluate compliance with CG_w requirements and to confirm that CG_{emc} exceedances are not an issue for the areas each systematic sample represents. Section 4.7 calculates the generic number of systematic sampling locations required for survey units; these numbers may be revised if area-specific conditions turn out to be significantly different than the assumptions used for the sample number calculations. Section 5 contains details about soil sampling protocols.

For FSS units associated with the floors of the WMA 1 and WMA 2 excavations, systematic samples will represent a one-m deep soil interval, consistent with the subsurface CG derivation for this area. For FSS units associated with surface soils outside the WMA 1 and WMA 2 excavations for each location requiring a systematic sample, two samples will be collected, one representing a one-m deep soil interval, and one representing a 15-cm deep soil interval.

As discussed in Section 4.3, systematic samples will be formed using an incremental sampling approach, resulting in a composite samples representative of the portions of the FSS unit the systematic sample represents. In general, unless location-specific characteristics indicate otherwise, a five increment composite sampling approach will be used with the five increments distributed systematically over the area represented by the systematic sampling location.

Systematic sample analytical results will be compared first to CG_{emc} requirements, using the CG_w multiplied by the appropriate area factor contained in Tables 2 and 3. Section 6 contains details about analytical requirements. If there are no CG_{emc} exceedances, systematic sample analytical results will be used to evaluate CG_w compliance. Details of this analysis are contained in Section 7.

4.7 Sample Number Calculations

Because all CG_w requirements are either associated with radionuclides that are not naturally occurring or are an order of magnitude greater than background activity concentrations, the Sign test will be used to evaluate CG_w compliance. The following sample number derivation is based on the assumption that the Sign test will be used; if the CG_w values change significantly from what are contained in the Phase 1 DP (Revision 2), (and, in particular, if they are closer to background conditions for naturally occurring radionuclides), the WRS test may be required. In that event, the following sample number calculations will be revisited. Also, the sample number calculations presented below are based on certain assumptions about the condition of exposed soils at the start of the FSS data collection process. If project premises conditions that are encountered differ significantly from these assumptions, the appropriate number of systematic samples will need to be revisited.

The null hypothesis for the Sign test is that the FSS unit is not in compliance with the CG_w requirement. The required Type I error probability is 0.05 (i.e., deciding to continue to remediate when the FSS unit actually has met the CG_w requirements). Based on these assumptions, the minimum number of systematic sampling locations and associated analytical results is five (Table I.3, Appendix I, MARSSIM, 2000).

Depending on the FSS unit contamination conditions, five sampling locations are not likely to result in an acceptable Type II error probability (i.e., the probability of incorrectly determining a FSS unit does not meet CG_w requirements), nor does it address the potential issue of sample loss/sample set incompleteness. Table 5.5 of MARSSIM provides sample number estimates for different combinations of relative shift, Type I error rates, and Type II error rates. The sample numbers contained in Table 5.5 include 20% more than absolutely required to account for the possibility of incomplete sample sets.

The Type I error rate for the Phase 1 FSS process has been set to 0.05. The Type II error rate is an engineering decision that is a function of costs and DOE's risk tolerance. In the case of the WMA 1 and 2 excavations, for example, DOE would likely require much lower Type II error rates since the schedule and budget implications of a FSS unit failure are much greater in that instance than for surface soils elsewhere on the project premises. The relative shift is a function of the LBGR, the CG_w, and the variability one would expect to see in systematic sampling results. In the case of the WVDP Phase 1 FSS activities, the LBGR is the average SOR score one would expect to see in a set of FSS systematic samples collected from a FSS unit.

The variability expected in systematic soil sample results will be significantly less for composite samples formed as previously described than it would be for discrete soil sample results, which is one of the advantages the FSS compositing strategy provides. If it is assumed an LBGR SOR of 0.25, a CG_w SOR of 1.0, and an expected SOR standard deviation of 0.25, the relative shift would be 3. Using Table 5.5, depending on the Type II error rate specified, sample numbers range between 8 and 20. In practice, these would represent composite sample locations; the actual number of soil increments collected across any particular survey unit would be five times these numbers, which would provide an equivalent Type II error rate performance for composite samples for a relative shift as low as 0.6.

As a point of comparison, there are limited data available for subsurface soil samples collected from the Lavery till interface. Table C-4 of the Phase 1 DP provides the activity concentrations observed for these samples within the WMA 1 and WMA 2 excavation footprints. The radionuclide with values closest to subsurface CG requirements was Sr-90. In the case of WMA 1, there were 13 soil cores with observed results that ranged from less than 1 pCi/g up to 450 pCi/g, with 11 of the 13 with activity concentrations less than 20 pCi/g and an average of approximately 43 pCi/g. In the case of WMA 2, there were seven soil cores with observed results that ranged from less than 1 pCi/g up to 180 pCi/g and an average of approximately 30 pCi/g. These values are likely higher than what will be encountered because the majority of the samples were collected in 1993 with decay having taken place, because these samples typically straddled the till interface and so included more portions of the more heavily-contaminated soils above the till, and because the proposed excavations will progress some depth into the till (with the assumption that activity concentrations will decrease with depth into the till). The CG_w and CG_{emc} for Sr-90 (Phase 1 DP Table 5-14) are 130 pCi/g and 470 pCi/g, respectively. Based on the observed standard deviations these would correspond to relative shifts of 0.7 for WMA 1 and 1.5 for WMA 2.

Pre-Excavation CSAP data results will provide more definitive information about the actual LBGR and variability that can be expected in surface soils outside the WMA 1 and WMA 2 excavations. Likewise, CSAP remedial action support survey collection during the WMA 1 and WMA 2 excavations will also provide useful information about the contamination status of the excavation floors at the completion of those excavations. FSS systematic sample numbers will be established based on those data sets and may vary from area to area to reflect the realities of the residual contamination levels in area.

The following provides an example of the calculation to be used to determine the appropriate Type II error rate and corresponding systematic sample requirements. The numbers provided are for illustration purposes only. Assume excavation, transportation, and disposal costs are $1,000/cubic yard ($yd^3$) of soil in situ. Assume that the cost of collecting and analyzing one systematic FSS soil sample is $600. Assume that the WMA 1 excavation yields an exposed excavated surface with residual contaminant concentrations equivalent to a relative shift of 1.0. MARSSIM Table 5.5 provides sample number requirements for the Sign test; for a Type 1 error rate of 0.05 and a relative shift of 1.0, sample numbers range from 15 for a Type II error rate of 0.25 and up to 41 for a Type II error rate of 0.01. Assume that if a Type II error occurs, one fourth of the offending FSS unit would require excavation to a depth of 0.5 m, representing an in situ volume of 327 yd^3 at a cost of $327,000. The number of systematic samples should be selected to balance this potential cost; in other words, the cost of systematically sampling the unit should be equal to the expected cost associated with a Type II error.

The expected cost of a Type II error is the probability of an error occurring multiplied by the cost that would be incurred. In the case of a relative shift of 1.0 and the costs as described, the appropriate number of samples that would be associated with a Type II error rate of 0.025, and would be approximately 30 per survey unit. This analysis neglects the cost of maintaining an open excavation while awaiting FSS sampling results; this cost would be negligible for surface soils, but will likely be significant for the WMA 1 and WMA 2 excavations. The net effect would be to increase systematic sampling requirements per survey unit for the WMA 1 and 2 excavations, as compared to surface soil excavations elsewhere on the project premises.

This analysis is driven, in part, by the relative shift. Higher relative shifts result in lower FSS systematic sampling requirements. In the case of the WMA 1 and 2 excavations, a higher relative shift can be achieved by excavating or scrapping additional till material to lower the final average residual activity concentrations remaining in the exposed excavated soil surface. In the example provided above, a relative shift of 2.0 would reduce the number of required samples to approximately 18 per survey unit. This reduction in FSS sample numbers would be at the expense of additional till excavation prior to FSS data collection.

CSAP remedial action support survey data will provide information regarding the contamination status of excavated surfaces (e.g., average activity concentration and the degree of variability in sample results likely present). DOE will use this information along with cost data to determine the appropriate Type II error rate and associated systematic sampling numbers.

4.8 Reference Area

A 2,000 m^2 reference area will be identified and finalized prior to the initiation of FSS data collection activities. Final selection of the reference area will be based on CSAP data collection results. The reference area will be chosen such that there is no measurable evidence of impacts from historical Nuclear Fuel Services (NFS) or WVDP activities.

The reference area will serve potentially multiple purposes. It will be used to generate background data sets for gross gamma activity detectors deployed in support of FSS data collection. These data sets, in turn, will be used to derive detector-specific field investigation levels that can be used to identify FSS results inconsistent with background conditions. As a contingency, it may also be used to generate surface soil samples to be used as part of a WRS test evaluation during FSS data analysis if that statistical test turns out to be necessary. However, at this time the Sign test is expected to be adequate for the Phase 1 FSS closure process. In the event that a WRS test becomes necessary, soil sample collection from the reference area will be consistent with the sampling protocols proposed for the Phase 1 FSS units. Because the subsurface CG_w values are more than order of magnitude above background, the WRS test will not be necessary for the WMA 1 and 2 excavation footprints; hence, a reference area is not required for these areas. Background detector responses for subsurface soils will be developed when excavations expose subsurface soils at depth that appear to be un-impacted.

5.0 FIELD ACTIVITIES

The Phase 1 FSS field activities follow the same general approach for every FSS unit and include the following: (1) initially collecting FSS GWS data; (2) verifying that the GWS data do not identify gross activity levels that would be of potential concern from a FSS perspective; (3) performing biased sampling as necessary with evaluation of biased samples by on-site laboratory analysis or quick turn-around off-site laboratory analysis (gamma spectroscopy and Sr-90 liquid scintillation) to determine if elevated area concerns (i.e., CG_{emc}) exist that require additional remediation; and (4) systematic sampling with off-site laboratory analyses to support CG_w evaluations. An on-site laboratory may be used for systematic sampling analyses if that laboratory can produce data of equivalent quality to those obtained by off-site laboratory analyses.

Besides these general activities, in the case of WMA 1, excavation footprint sampling targeting soils adjacent to remaining pilings will take place. A detailed description of field activities, organized by survey unit type is provided in the subsections below.

5.1 Class 1 Soil Survey Units

All areas undergoing excavation to remove contamination that have historical data indicating CG exceedances or where historical information indicates there is a chance of encountering contamination above CG levels will be classified as Class 1 FSS areas and divided, as appropriate, into Class 1 FSS units. Consistent with MARSSIM, these units will not exceed 2,000 m^2 in size.

5.1.1 WMA 1 Excavation Footprint

Figure 4 shows conceptual cross-sections of the planned WMA 1 excavation. Cross-section A-A' provides a west-to-east profile view of the proposed excavation. Cross-section B-B' provides a north-to-south profile view of the proposed excavation. The eastern portion of the excavation, the floor of the excavation will extend to the slurry wall. In the northern, southern, and western portion of the excavation, the excavation will be sloped at an expected 45 degree angle up to land surface.

Figure 5 shows a conceptual layout of Class 1 survey units for the footprint of the WMA 1 excavation. Actual Class 1 survey unit boundaries will be defined when excavation is complete and the excavation footprint finalized. WMA 1 Class 1 units will not exceed 2,000 m^2 in size. Biased and systematic FSS soil sampling will target a 1-m depth interval, consistent with the subsurface CG derivation. More details regarding soil sampling protocols can be found in following sections. Along the northern, western, and southern portions of the excavation, the Class 1 units will include the sloped surfaces up to one meter below land surface. The WMA 1 FSS Unit 1 also shows how systematic sampling would be done using composites. In this example, 18 systematic composite sampling locations have been placed on a random start grid. Each composite sample is formed from five soil increments, with the five increments collected to be representative of the area associated with composite sampling locations.

The eastern and northeastern wall of the WMA 1 excavation is expected to be nearly vertical since the excavation floor is expected to extend to the slurry wall and there may even be some removal of contaminated material from the wall itself. The slurry wall face will be its own final status survey unit. Its exposed face is expected to be approximately 150 m long by approximately 10 m high, for an area of 1,500 m^2. Physical samples obtained from the wall for FSS purposes will be retrieved perpendicular to the exposed wall face. It is possible that contamination may be entrained in the wall by the wall placement process (this would be particular true for deep portions of the wall); in the event that the slurry wall fails to meet subsurface CG standards, the FSS data collected will serve to document the contamination status of the wall for Phase 2 purposes.

The top one meter of the northern, western, and southern portions of the sloped surfaces and the top 1 m of the slurry wall will not be included in formal WMA 1 FSS units, but will be scanned and potentially sampled as part of CSAP remedial support activities. If surface soils adjacent to the WMA 1 excavation in these areas appear to meet surface soil CG requirements and there is no evidence of subsurface contamination based on CSAP data collection, DOE may choose to implement Phase 1 FSS protocols for those surface soils, in which case the scans of the top one meter of sloped surface will be included as part of the FSS data sets. If not, then scans of the top one meter of sloped surface will simply document the contamination status of these soils for Phase 2 decision-making.

The initial FSS field activity for the WMA 1 FSS units will be the collection of FSS GWS data. These data will be reviewed for any evidence of gross gamma activities inconsistent with background conditions. Inconsistency is defined as gross activity results that are unlikely to be associated with background conditions as observed in excavated areas where there is no evidence of contamination impacts.

In the event that either visual evidence (e.g., staining, etc.) or gamma walkover data indicate the potential for contamination impacts, biased samples will be collected that target the locations/areas of concern. Biased samples will consist of 5-point incremental composite samples representative of the area of concern. These samples will either be submitted for gamma spectroscopy/Sr-90 analyses at an on-site laboratory or sent off-site for the same analyses with quick turnaround. If these analyses indicate contamination levels exceeding CG_{emc} requirements, remediation will take place prior to additional FSS data collection. If additional remediation is necessary, the areas of concern will be excavated, the exposed surface re-scanned, and biased sampling will occur to demonstrate the location meets CG_{emc} requirements before FSS data collection continues. If neither the gamma spectroscopy nor Sr-90 analyses indicate CG_{emc} exceedances, the remaining sample mass will be analyzed for the balance of the ROI for the WMA 1 FSS units, as described in Section 6.

The rational for using five soil sample increments to form each composite is based on the following assumptions: if one or more increments encounters contamination above the CG_{emc}, the composite will yield a result above the CG_{emc} and the probability of any single increment encountering contamination at levels that would result in a composite value greater than the CG_{emc} is 0.5. Under these conditions, a 5-increment composite will have < 5% chance of missing a CG_{emc} exceedance. For typical FSS units that have at least eight systematic composite soil samples submitted for analysis, there will be at least 40 soil sample increments that are collected. For the WRS test, when the relative shift is one, 40 soil increments would result in a Type II error rate of only 0.01. The expectation is that the relative shift for the deep excavation soil surfaces will be significantly greater than one, which means the Type II error rate would be even lower than 0.01. Low Type II error rates are important because of the cost implications of concluding FSS units in the WMA 1 excavation do not meet CG requirements when in fact they actually do meet the requirements.

Within the WMA 1 FSS units there are expected to be some 476 foundation pilings extending deeper into and, in some cases, through the Lavery Till. Figure 5 shows the locations of the foundation pilings based on historical engineering drawings. There are concerns that these pilings may have provided vertical preferential flow pathways for contaminated groundwater into the Lavery Till, resulting in soil contamination at levels of potential concern within the till. This issue will be addressed both by remedial action support survey collection described in the CSAP, and by data collection as part of the FSS process for FSS units that include foundation pilings

Figure 4 Conceptual Cross-Sections of WMA 1 Excavation

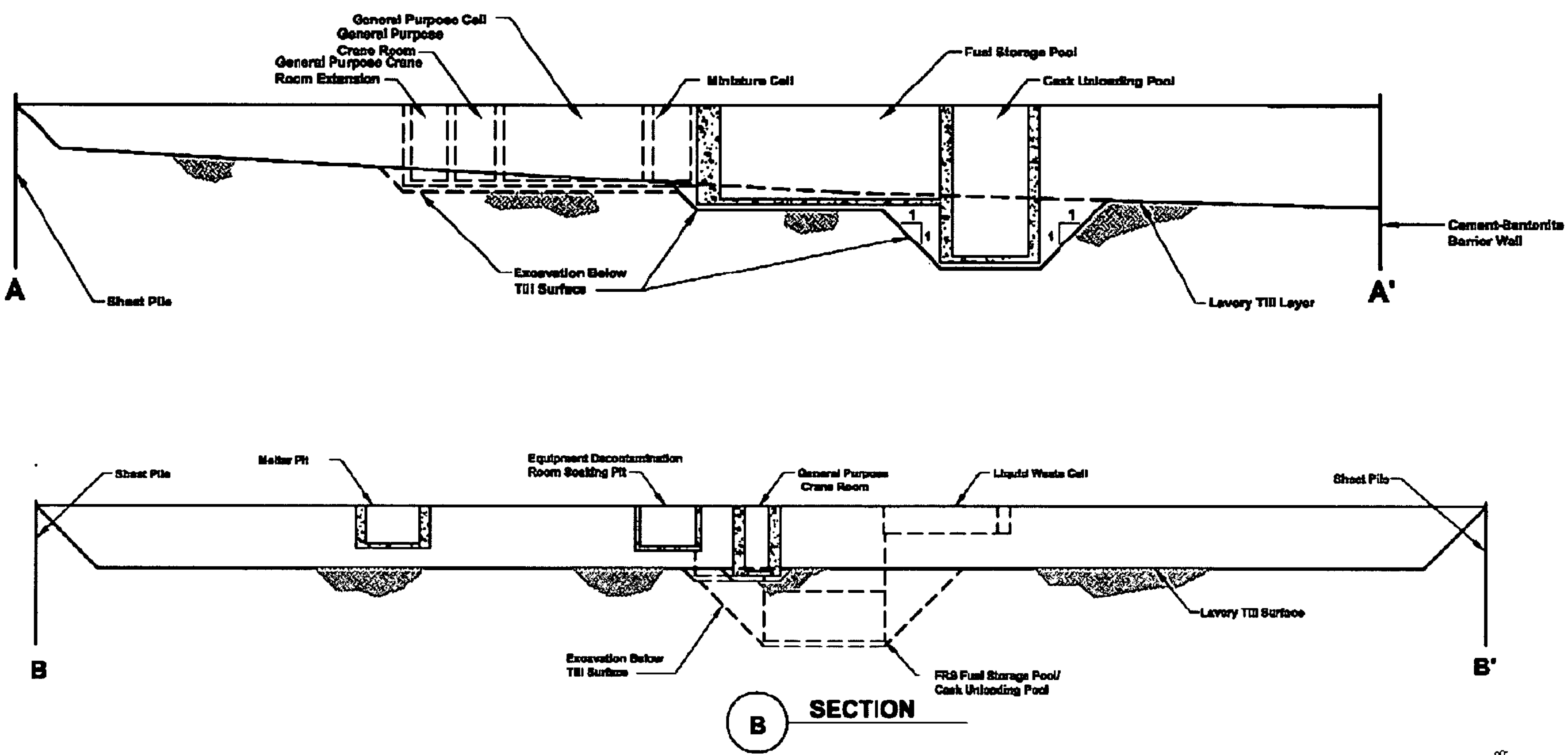


Figure 5 Conceptual Layout of WMA 1 FSS Class 1 Units

If foundation pilings did serve as preferential pathways for contamination entry into the Lavery Till, the following would be expected to be true:

- Contamination would have occurred between the piling and surrounding soil.
- Contamination that penetrated into the till would have left evidence at the till/overburden interface (i.e., soil contamination at that interface).
- The possibility for till contamination to occur would have been greatest where groundwater contamination was the greatest – beneath the original release point and immediately down gradient within the boundaries of the North Plateau Groundwater Plume.

Based on these assumptions, the FSS process for demonstrating that there are no significant till contamination concerns associated with pilings has the following components:

- Excavation work and associated remedial action support survey collection will identify the exact locations of pilings and will determine where contaminated soil at levels of concern existed immediately above the Lavery Till.
- Pilings will be broken into two groups: pilings that are within the greater-than-CG footprint of contaminated soils immediately above the Lavery Till and pilings that are not. FSS data collection will target those pilings that are within the greater-than-CG footprint.
- In this set of pilings, there will be a combination of biased and systematic data collection:

    - Ten piling locations per survey unit will be selected for biased sampling to determine if there are CG_{emc} exceedances. This selection will target those pilings most likely to exhibit till contamination, if it existed. The selection will be based on a combination of factors, including proximity to the original release event, level of soil contamination as identified by remedial support sampling immediately above the till, visual evidence of "spaces" between till material and pilings that might have provided preferential flow pathways, etc.
    - The justification for ten pilings is that if they all turn out to have contamination $< CG_{emc}$ requirements then there is less than a 5% probability that more than 25% of the piles are contaminated at CG_{emc} levels.
    - A minimum of eight of the pilings per survey unit would be selected for each FSS unit at random for CG_w sampling. In the event that this random selection process identifies a piling already selected for biased sampling, the sample collected from that piling will be used for both CG_{emc} and CG_w compliance demonstration purposes.
    - The justification for selecting 8 pilings is that this number combined with a Sign test will give a 95% confidence level that less than half of the pilings and associated till soils have contamination $> CG_w$, the same level of certainty required for the exposed till itself.

For those pilings selected for sampling (either biased or systematic), the sampling will focus on obtaining a discrete soil sample from immediately along the piling at a depth of one m below the excavation surface. These samples will either be submitted for gamma spectroscopy/Sr-90analyses at an on-site laboratory or sent off-site for the same analyses with quick turnaround. If any sample indicates contamination levels exceeding CG_{emc} requirements, remediation will take place at the affected piling(s) prior to additional FSS data collection. If additional remediation is necessary, biased sampling of the remediated area will occur and the sample location must demonstrate meeting CG_{cmc} requirements before FSS data collection continues. If neither the gamma spectroscopy nor Sr-90 analyses indicate CG_{cmc} exceedances, the remaining sample mass will be analyzed for the balance of the ROI for the WMA 1 FSS units, as described in Section 6.

For each FSS unit that includes pilings within the greater-than-CG overburden footprint, the systematic sample results from pilings will be evaluated using the Sign test. If the pilings satisfy the Sign test and there are no biased piling samples with CG_{cmc} exceedances, till contamination associated with pilings will not be considered an issue for that FSS unit. If fewer than eight systematic piling samples are available, rather than the Sign test all systematic piling samples will be compared to the CG_w requirement. If none are above, then till contamination associated with pilings will not be considered an issue for that FSS unit.

Systematic soil sampling will also take place for exposed soils. As described in Section 4.7, the number of required systematic locations will be determined based on remedial action support survey collected as excavation proceeds. The number of systematic locations will not be less than eight per FSS survey unit. Systematic locations will be placed on a random start triangular grid. One 5-point composite sample will be collected from each location, with the five increments collected in a manner representative of an area equal to the size of the survey unit divided by the number of systematic locations. Systematic soil samples will be representative of a depth of 0 to 1 m. There will be no 0 to 15 cm samples required since direct exposure is not a concern for the WMA 1 excavated surface. Figure 5 illustrates the placement of 18 systematic composite sample locations along with the supporting soil increment locations used to form the composites for one of the WMA 1 final status survey units. Each systematic composite soil sample will be submitted for off-site analysis of all ROI in the WMA 1 excavation, as described in Section 6. If remedial action support survey collection indicates that Sr-90 above CG_w requirements is a significant concern for the final excavated surface, DOE may choose to perform an on-site analysis for Sr-90 to identify potential problems requiring additional soil excavation prior to off-site laboratory analyses.

The decision logic applied to biased and systematic soil sampling results, as well as discrete samples collected along pilings, is described in Section 7.

5.1.2 WMA 2 Excavation Footprint

Figure 6 shows a conceptual layout of Class 1 survey units for the footprint of the WMA 2 excavation. Actual Class 1 survey unit boundaries will be defined when excavation is complete and the excavation footprint finalized. Biased and systematic FSS soil sampling will target a 1-m depth interval, consistent with the subsurface CG derivation. More details regarding soil sampling protocols can be found in following sections. Along all edges where sloped surfaces exist, Class 1 units will include the sloped surfaces up to one meter below land surface.

The eastern, western and northern wall of the WMA 2 excavation is expected to be nearly vertical since the excavation floor is expected to extend to the slurry wall and there may even be some removal of contaminated material from the wall itself. The slurry wall face will be its own final status survey unit. Its exposed face is expected to be approximately 380 m long by approximately 5 m high, for an area of 1,900 m^2. Physical samples obtained from the wall for FSS purposes will be retrieved perpendicular to the exposed wall face. It is possible that contamination may be entrained in the wall by the wall placement process; in the event that the slurry wall fails to meet subsurface CG standards, the FSS data collected will serve to document the contamination status of the wall for Phase 2 purposes.

The top one meter of the sloped surfaces and the slurry wall will not be included in formal WMA 2 FSS units, but will be scanned and potentially sampled as part of CSAP remedial support activities. If surface soils adjacent to the WMA 2 excavation in these areas appear to meet surface soil CG requirements and there is no evidence of subsurface contamination based on CSAP data collection, DOE may choose to implement Phase 1 FSS protocols for those surface soils, in which case the scans of the top one meter of sloped surface will be included in those FSS data sets. If not, then scans of the top one meter of sloped surface will simply document the contamination status of these soils for Phase 2 decision-making purposes.

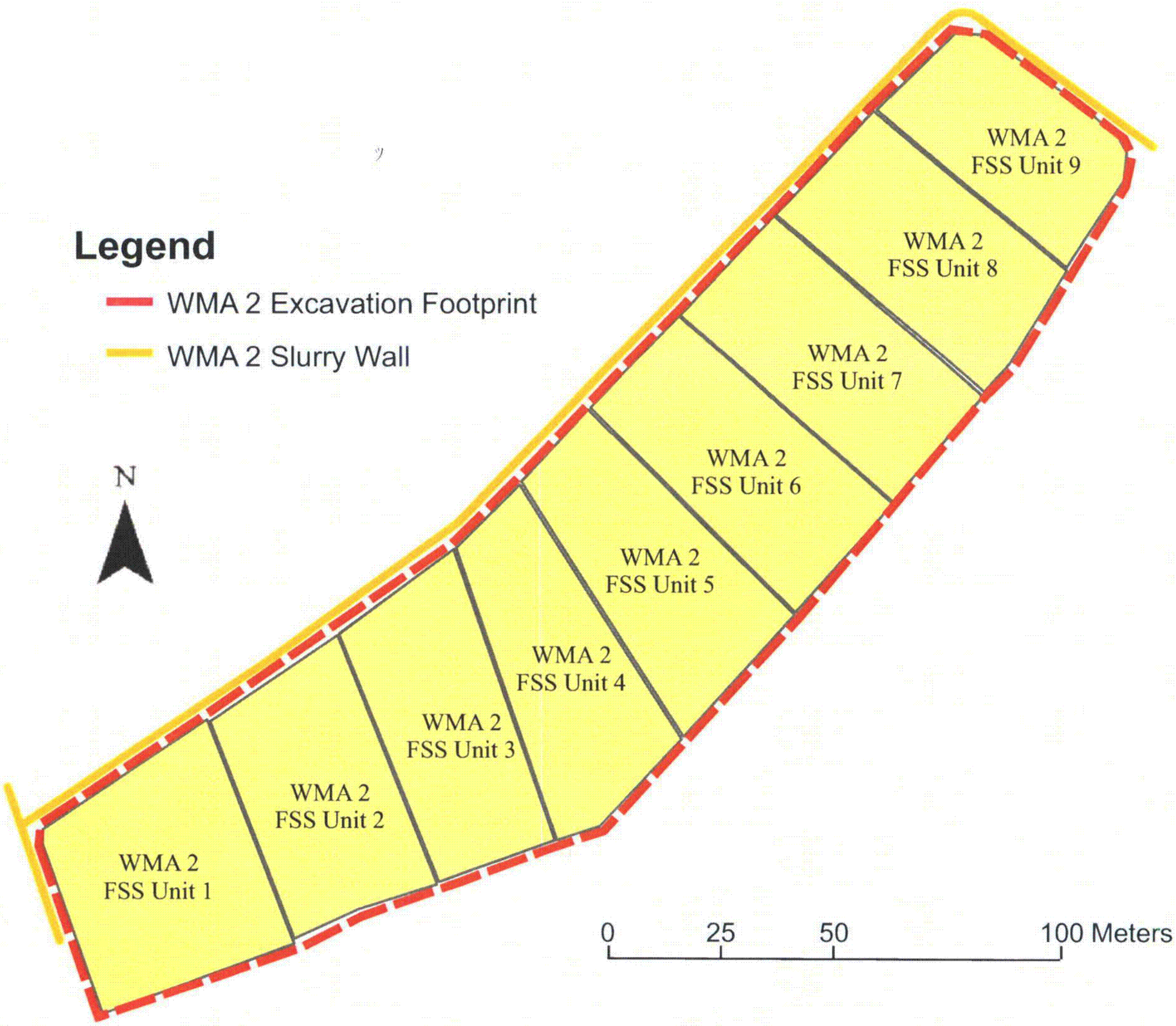
The initial FSS field activity for the WMA 2 FSS units will be the collection of FSS GWS data. These data will be reviewed for any evidence of gross gamma activities inconsistent with background conditions. Inconsistency is defined as gross activity results that are unlikely to be associated with background conditions as observed in excavated areas where there is no evidence of contamination impacts.

In the event that either visual evidence or gamma walkover data indicate the potential for contamination impacts, biased samples will be collected that target the locations/areas of concern. Biased samples will consist of 5-point incremental composite samples representative of the area of concern. These samples will either be submitted for gamma spectroscopy/Sr-90 analyses at an on-site laboratory or sent off-site for the same analyses with quick turnaround. If these analyses indicate contamination levels exceeding CG_{cmc} requirements, remediation will take place prior to additional FSS data collection. If additional remediation is necessary, biased sampling of the remediated area will occur, the affected area re-scanned, and the location demonstrated to meet CG_{cmc} requirements before FSS data collection continues. If neither the gamma spectroscopy nor Sr-90 analyses indicate CG_{cmc} exceedances, the remaining sample mass will be analyzed for the balance of the ROI for the WMA 2 FSS units, as described in Section 6.

Systematic soil sampling will also take place for exposed soils. As described in Section 4.7, the number of required systematic locations will be determined based on remedial action support survey collected as excavation proceeds. The number of systematic locations will not be less than eight per final status survey unit. Systematic locations will be placed on a random start triangular grid. One 5-point composite sample will be collected from each location, with the five increments collected in a manner representative of an area equal to the size of the survey unit divided by the number of systematic locations. Each systematic composite soil sample will be submitted for off-site analysis of all ROI in the WMA 2 excavation, as described in Section 6. If remedial action support survey collection indicates that Sr-90 above CG_w requirements is a significant concern for the final excavated surface, DOE may choose to perform an on-site analysis for Sr-90 to identify potential problems requiring additional soil excavation prior to off-site laboratory analyses.

The decision logic applied to biased and systematic soil sampling results is described in Section 7.

Figure 6 Conceptual Layout of WMA 2 FSS Class 1 Units



5.1.3 Class 1 Surface Soil Survey Units

For Phase 1, Class 1 surface soil FSS units may be identified based on the results of the CSAP and at DOE's discretion. Candidates for the Phase 1 Class 1 surface soil FSS units are areas where exposed soils are not contaminated above CG requirements, there is no evidence of contamination impacts more than one m in depth, but there is the possibility that soils exceeding CG requirements exist. Any area that historically required contamination removal or that was excavated as part of Phase 1 activities to address contamination concerns will be considered a Class 1 area.

The layout of Class 1 surface soil FSS units will take place after CSAP data collection and any Phase 1 soil/hardstand/foundation removals that might take place outside of the WMA 1 and WMA 2 excavations. Surface soil Class 1 FSS units will not exceed 2,000 m^2 in size.

The initial FSS field activity for Class 1 surface soil FSS units will be the collection of FSS GWS data, if these data do not already exist as part of CSAP efforts or if additional FSS gamma walkover data are needed to supplement the CSAP data set. Gamma walkover data will be reviewed for any evidence of gross gamma activities that might be indicative of CG exceedances.

In the event that either visual evidence (e.g., staining, saturated soil conditions at depth along pilings, etc.) or gamma walkover data indicate the potential for contamination impacts, biased samples will be collected that target the locations/areas of concern. If biased soil samples are collected, two samples will be collected and analyzed for each biased sampling location: one that is representative of the top 15 cm of exposed soils, and one that is representative of a one m soil depth. Biased samples will consist of 5-point incremental composite samples representative of the area of concern. These samples will either be submitted for gamma spectroscopy/Sr-90 analyses at an on-site laboratory or sent off-site for the same analyses with quick turnaround. If these analyses indicate contamination levels exceeding CG_{cmc} requirements, remediation will take place prior to additional FSS data collection. If additional remediation is necessary, the areas of concern will be excavated, the exposed surface re-scanned, biased sampling will occur, and the location demonstrated to meet CG_{cmc} requirements before FSS data collection continues. If neither the gamma spectroscopy nor Sr-90 analyses indicate CG_{cmc} exceedances, the remaining sample mass will be analyzed for the balance of the ROI for the Class 1 unit, as described in Section 6.

Systematic soil sampling will also take place. As described earlier, the number of required systematic locations will be determined based on CSAP data available for the area and/or historical information. The number of systematic locations will not be less than eight per final status survey unit. Systematic locations will be placed on a random start triangular grid. Two composite samples will be formed from systematic location using 5-point composite samples, with the five increments collected in a manner representative of an area equal to the size of the survey unit divided by the number of systematic locations. One composite sample will be representative of soils to a depth of 15 cm and one representative of soils to a depth of one m. Each systematic composite soil sample will be submitted for off-site analysis of all ROI applicable to the area of interest, as described in Section 6.

The decision logic applied to biased and systematic soil sampling results is described in Section 7.

5.1.4 Class 1 Lay Down Areas

Phase 1 decommissioning activities will result in the removal and staging of contaminated soils. As part of those activities, specific areas will be identified and used for contaminated soil lay down. For these areas, after soil lay down activities are completed, the area will undergo Phase 1 FSS data collection consistent with the protocols described in Section 5.1.3. In these cases, if CSAP data collection from these areas did not identify subsurface contamination at depths greater than one meter, and Phase 1 FSS data collection indicates CG standards have been met, these data may be used to demonstrate CG compliance for FSS purposes. If CSAP data collection indicates subsurface contamination at depths greater than one meter, or FSS data collection indicates residual contamination above Phase 1 CG standards, then the data collected as part of the Phase 1 FSS process will simply be used to document the contamination status of these areas.

5.2 Class 2 Soil Survey Units

For Phase 1, Class 2 surface soil FSS units may be identified based on the results of the CSAP and at DOE's discretion. Candidates for Class 2 surface soil FSS units are areas where there is no evidence of surface soil contamination above CG requirements and there is no evidence of contamination impacts more than one m in depth. Any area that historically required contamination removal or that was excavated as part of Phase 1 activities to address contamination concerns cannot be considered a Class 2 area.

The layout of Class 2 surface soil FSS units will take place after CSAP data collection and any Phase 1 soil/hardstand/foundation removals that might take place outside of the WMA 1 and WMA 2 excavations. Surface soil Class 2 FSS units will not exceed 10,000 m^2 in size.

The initial FSS field activity for Class 2 surface soil FSS units will be a review of FSS GWS data, which will have been collected as part of CSAP efforts. Gamma walkover data will be reviewed for any evidence of gross gamma activities that might be indicative of CG exceedances. In the event that either visual evidence or gamma walkover data indicate the potential for contamination impacts, biased samples would have been collected as part of the CSAP effort that targeted the locations/areas of concern. If biased soil samples were collected, two samples would have been collected and analyzed for each biased sampling location: one representative of the top 15 cm of exposed soils and one representative of a 1-m soil depth. Biased samples would have consisted of 5-point incremental composite samples representative of the area of concern. These samples would either have been submitted for gamma spectroscopy/Sr-90 analyses at an on-site laboratory or sent off-site for the same analyses with quick turnaround. If these analyses had indicated contamination levels exceeding CG requirements, the area would be addressed as a Class 1 FSS survey unit, not a Class 2 unit.

Assuming GWS data do not exhibit characteristics inconsistent with a Class 2 FSS designation, systematic soil sampling will take place. As described earlier, the number of required systematic locations will be determined based on CSAP data available for the area and/or historical information. The number of systematic locations will not be less than eight per final status survey unit. Systematic locations will be placed on a random start triangular grid. Two composite samples will be formed from each systematic location using 5-point composite samples, with the five increments collected in a manner representative of an area equal to the size of the survey unit divided by the number of systematic locations. One composite sample will be representative of soils to a depth of 15 cm and one representative of soils to a depth of one m. Each systematic composite soil sample will be submitted for off-site analysis of all ROI for the Class 2 area, as described in Section 6.

The decision logic applied to biased and systematic soil sampling results is described in Section 7.

5.3 Class 3 Soil Survey Units

Class 3 surface soil FSS units will be addressed in a manner almost identical to that described for Class 2 surface soil FSS areas with the following differences.

Candidates for Class 3 surface soil FSS units are areas where there is no evidence of surface soil contamination that is more than 10% of the CG requirements and there is no evidence of contamination impacts more than one m in depth.

The layout of Class 3 surface soil FSS units will take place after CSAP data collection. Surface soil Class 3 FSS units may potentially be of any size, but will be selected such that they represent relatively homogenous areas.

Systematic soil sampling for Class 3 surface soil survey units will rely on random placement of samples rather than a random start triangular grid per MARSSIM guidance.

5.4 Gamma Surveying Protocols

GWS will be conducted with at least one detector capable of detecting low energy gamma-emitting radionuclides such as ^{241}Am (e.g., a FIDLER). GWS will be performed in a manner that provides complete coverage of exposed soil surfaces, with a data density of, on average, at least one measurement per m^2. All FSS GWS will be electronically logged with suitable coordinate recording equipment that provides a minimum precision of +/- one m accuracy. GWS should be conducted with the detector approximately six inches above the ground.

In the event that elevated activities are encountered, stationary readings will be collected for a minimum of 30 seconds over the location of interest.

In addition, for each location where a biased soil sample is collected, a static 30-second reading from a height of six inches will be collected above each soil sampling location. If these soil samples are composites, then a static 30-second reading from a height of six inches will be collected above each location contributing a soil increment. In this case the gamma reading will be recorded in a way that allows matching it with the laboratory analytical result corresponding to the composite sample that was formed.

Prior to the use of any particular detector for FSS purposes, that detector will conform to these minimum quality control (QC) standards:

- The reference area will be surveyed with the detector and data logged consistent with protocols to be used for FSS data collection purposes. These data will be reviewed and compared with existing data sets from similar detectors (if available) to confirm consistency in general detector behavior (average gross activity concentration recorded and observed variability in detector response).

- QC control data will be obtained from a fixed QC point at a height of six inches above exposed soils from a point established for this purpose outside any areas expected to be remediated. These data will be used to construct a control chart that can be used for QC purposes for subsequent deployments of the detector as part of FSS work.

During FSS data collection activities, QC will consist of, at a minimum, the following for each detector in use:

- A stationary reading will be taken each day from the QC point at the start and end of each day a detector is in use. These QC data will be compared to the control chart to determine that the detector response is consistent with historical responses from that location. If a QC measurement results in a detector response "out of control" at the start of the day, the measurement will be repeated. If the subsequent measurement is still "out of control", the reason for the discrepancy will be established before the detector is used. If the "out of control" event occurs at the end of the day and verified by a subsequent measurement, the reason for the discrepancy will be established before the data collected that day with that detector are considered acceptable for FSS purposes. "Out of control" is defined as a result more than two standard deviations above or below the average historical detector response at that control point.
- Electronically logged data will be reviewed for completeness (e.g., evidence of spatial "holes" in collected data), evidence of erratic detector behavior (e.g., sequential readings during a moving survey that show a marked increase or decrease in gross activity not confirmed by spatially adjacent measurements), or evidence of shine (e.g., systematically elevated readings proximal to structures, buildings, soil piles, or excavated soil walls). In the case of incomplete data, data collection will be conduced to fill the gap. In the event of erratic behavior, the cause will be investigated, suspect data flagged as such, and additional data collection conducted to address affected areas as appropriate.

All FSS gamma walkover data that satisfy QC requirements will be archived electronically in a readily retrievable format along with appropriate meta data (e.g., date collected, detector id, technician id, purpose of survey, and any necessary explanatory notes).

There may be portions of the project premises where shine from adjacent buildings or excavation walls interferes with gross gamma activity scans. In such areas, the presence and significance of interfering shine will be evaluated (e.g., through a combination of shielded measurements and unshielded measurements). In areas where shine has an unacceptable impact on gamma scan data quality, mitigating strategies will be used. Examples of mitigating strategies include using a collimated detector or developing shine corrections that can be applied to acquired data sets.

5.5 Soil Sampling Protocols

Systematic and biased FSS soil sampling, in general, will follow the protocols outlined below. Exceptions may be made for biased soil samples where the nature of the location (e.g., adjacent to infrastructure, excavation walls, etc.) requires an adjustment. In those cases, the reason for the deviation and the nature of the deviation must be noted in a preservable manner (e.g., field notebook dedicated to this purpose). Additional details about sampling tools and related field protocols will be described in standard operating procedures to be developed by the contractor responsible for FSS data collection.

Within the WMA 1 and WMA 2 excavation footprints, FSS soil sampling will be conducted in a manner that results in a sample representative of a 1-m depth interval for each required location. As previously described, in most cases these samples will be 5-point composite samples formed from five increments representative of a specific area. The five increments will be collected with one increment centered on the location of interest, and the other four increments equally spaced along diagonals associated with a square centered on the location of size equal to the area to be represented. Soil increment mass must be identical for each of the five increments. The total mass of each composite sample collected must be sufficient to allow analysis of the composite for all 18 ROI, if necessary. Sampling tools must be thoroughly decontaminated (if reused) between composite samples; however, between increments for any given composite sample wiping the tool clean of visible dirt will be sufficient.

For all other areas undergoing Phase 1 FSS data collection, FSS soil sampling will be conducted in a manner that yield two samples for each required location. The first sample should be representative of a 0 to 1-m depth interval. The second sample should be representative of a 0 to 15-cm depth interval. As previously described, in most cases, each of these two samples will be 5-point composite samples formed from five increments representative of a specific area. The five increments will be collected with one increment centered on the location of interest, and the other four increments equally spaced along diagonals associated with a square centered on the location of size equal to the area to be represented. Soil increment mass must be identical for each of the five increments for any given composite sample. The total mass of each composite sample collected must be sufficient to allow analysis of the composite for all 18 ROI, if necessary. Sampling tools must be thoroughly decontaminated (if reused) between composite samples; however, between increments for any given composite sample, wiping the tool clean of visible dirt will be sufficient.

5.6 Quality Assurance Procedures

5.6.1 Contractor Quality Assurance Program

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

- *Preparatory Phase:* The preparatory phase of the RQC program is documented by the RQC 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 RQC program is conducted by the RQC 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 RQC program is conducted by the RQC representative and includes the daily performance of the activities noted in the initial phase until completion of the specific definable feature of work.

5.6.2 Daily Quality Control Reports

The FSS contractor will prepare daily quality control reports (DQCRs) that will be signed and dated by the RQC representative. Daily reports then will be submitted to the DOE Project Manager and DOE Contracting Representative on a weekly basis. Each DQCR will address topics including a summary of work performed, weather conditions, and departures from the FSSP. Any deviation that may affect the project outcomes or performance objectives will be immediately forwarded to the DOE Project Manager and DOE Contracting Representative.

5.6.3 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 that supports the FSS field activities.

5.7 Sample Chain-of-Custody/Documentation

5.7.1 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 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 Phase 1 FSS 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 to and departure from the work site;
- Purpose of the FSS 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 sampling locations, including a sketch map illustrating the sampling locations (in the case of composite samples, this includes the locations of contributing soil increments);
- Field observations;
- Types of field instruments used and purpose of use, including calibration methods and results;
- Any field measurements made that were not recorded electronically;
- Sample identification number(s); and
- Sample documentation information.

5.7.2 Photographs

Photographs can be an important source of supplemental information for the FSS process. Examples where photographs are appropriate include visual evidence of potential contamination, evidence of obstructions that require moving sampling locations, documentation of sampling points, and anomalous conditions that might affect either data quality or data interpretation. Photographs taken during the FSS activities will be noted in the field logbook in accordance with the requirements of the field procedure. If photographs are taken to document sampling points to facilitate relocating the point at a later date, two or more permanent reference points should be included within the photograph. In addition to the information recorded in the field logbook, one or more site photograph reference maps will be prepared as required.

5.7.3 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, however, will be numbered so that they can be readily identified.

5.7.4 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:

- Sample identification number,
- Sample type,
- Sampled interval (e.g., 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.

5.7.5 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 project QAPP. 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.

5.7.6 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 possession,
- The sample was in the sampler's possession and then was placed into a locked area to prevent tampering, and
- 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 project premises 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 the case where 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 project premises 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 project premises for the duration of the 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 sample tampering occurs 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.

5.7.7 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.

5.8 Documentation Procedures

The tracking procedure to be utilized for documentation of 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.
- Complete sample documentation information in the field logbook.
- Complete project and sampling information sections of the chain-of-custody form(s).
- Complete the air bill 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) and place the form(s) into cooler.
- Place chain-of-custody seals on the exterior of the cooler.
- Package and ship the cooler to the laboratory.
- 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 final analytical results from laboratory.

5.9 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.

5.10 Sample Packaging and Shipping

5.10.1 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.

5.10.2 Additional Requirements for Samples Classified as Radioactive Material

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

The cooler must have the shipper and receiver addresses affixed to it in case the Federal Express air bill is lost during shipping.

- Samples will be screened prior to packing 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 173.421.
    - A notice must be enclosed on the inside of the cooler that includes the name of the consignor and the statement "This package conforms to the conditions and limitations specified in 49

CFR 173.421 for radioactive material, excepted package-limited quantity of material, UN2910." The outside of the inner packaging or, if there is no inner packaging the outside of the package itself, must be labeled "Radioactive."

- The following labels will be placed on the cooler:
  - Appropriate hazard class label; and
  - "Cargo Aircraft Only," if applicable.
- The air bill 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.

5.10.3 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 via Federal Express, similar courier, or laboratory courier.

5.11 Investigation Derived Waste

The field activities described in this plan will generate IDW materials. The materials generally consist of soil, sludge, water, and spent personal protective equipment (PPE) resulting from sampling and associated project premises activities. When accumulated, these materials must be managed appropriately to minimize the exposure and risks to human health and the environment while adhering to applicable regulatory requirements. IDW will be managed and disposed of consistent with DOE waste management procedures. The objective of this section is to establish specific management practices for the handling and subsequent disposition of these materials.

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 non-indigenous. Indigenous IDW expected to be generated during Phase 1 FSS activities includes primarily soils. Non-indigenous IDW expected to be generated includes decontamination fluid/water and miscellaneous trash, including PPE. When accumulated, the media will managed appropriately to minimize exposure and risks to human health and the environment while adhering to applicable regulatory requirements.

5.12 Field Decontamination

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

In the case of composite samples, wiping sampling equipment clean of visible removable soils will be sufficient between increments for any given composite sample; however full decontamination as described above is required between the collection of composite samples.

Field decontamination will be conducted in an area near the field equipment staging area or in an area approved by the DOE. Decontamination activities will be conducted so that all solid and liquid wastes generated can be containerized and disposed of as described in Section 5.11.

6.0 LABORATORY ANALYSES AND GAMMA WALKOVER DATA

6.1 Laboratory Analyses

FSS soil samples may be screened by an on-site laboratory to verify the absence of significant contamination issues (e.g., gamma spectroscopy for Cs-137 and/or liquid scintillation for Sr-90). This would allow corrective actions (e.g., additional remediation and re-sampling) to be taken immediately before committing resources to off-site laboratory analyses. Data from an on-site laboratory would not be used to demonstrate CG compliance unless a quality assurance/quality control (QA/QC) program is established and demonstrated to produce results equivalent to an offsite contract laboratory.

FSS samples will be shipped to an offsite contract laboratory for analysis. Laboratory methods, instruments, and sensitivities will be in accordance with New York State protocols for environmental analysis. Any laboratory used for environmental sample analysis will have appropriate New York State Department of Health Environmental Laboratory Approval Program certification or equivalent. Table 4 indicates the target minimum detectable concentrations (MDC) for radionuclides in laboratory analyses of soil samples as well as the analytical methods to be used. MDC requirements are set to whichever is lower: (1) approximately 10 percent of the most restrictive radionuclide-specific CG, (2) 25 percent of background for naturally occurring radionuclides, or (3) standard laboratory MDCs. All laboratory instrumentation will be calibrated using NIST-traceable standards.

Activity concentrations in soil will be reported in units of pCi/g. Other quality control activities are incorporated into specific field survey procedures.

Table 4 Radionuclide Target Sensitivity for Laboratory Sample Analysis

Nuclide	Instrument/Method	Target Sensitivity pCi/g[(1)]
Am-241	Alpha and/or gamma spectrometry	1[(4)]
C-14	Sample oxidizer and liquid scintillation	2[(4)]
Cm-234/244	Alpha and/or gamma spectrometry	1[(4)]
Cs-137	Gamma spectrometry	0.1[(4)]
I-129	Gamma spectrometry	0.06[(2)]
Np-237	Alpha and/or gamma spec	0.01[(2)]
Pu-238	Alpha spectrometry	1[3]
Pu-239/240	Alpha spectrometry	1[3]
Pu-241	Liquid scintillation	15[3]
Sr-90	Liquid scintillation	0.9[(2)]
Tc-99	Gas flow proportional counting	3[(2)]
U-232	Alpha spectrometry	0.5[(2)]
U-233/234	Alpha spectrometry	0.2[(3)]
U-235 (-236)	Alpha spectrometry	0.1[(3)]
U-238	Alpha spectrometry	0.2[(3)]

NOTES:

1 Dependent on sample size, counting time, etc.

2 Approximately 10 % of the most restrictive radionuclide-specific cleanup goal identified in Table 5-14

3 25% of background for naturally occurring radionuclides

4 Standard laboratory MDCs

6.2 Scan Minimum Detectable Concentrations

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.*

To assist with FSS planning activities, estimated scanning MDCs in soil for the ROIs were obtained by reviewing available information; these values are shown in Table 5. Information is only provided for 14 of the 18 radionuclides, as four have no or minimal photon (gamma ray and X-ray) emissions, making them impractical to detect with field scanning instruments. Field survey instruments for soil contamination are generally limited to those that can detect photons given the uneven terrain and conditions encountered in the field. This is in contrast to survey instruments that can be used for buildings, many of which allow for the detection of alpha and beta contamination as well as gamma emissions.

Comparing the estimated MDCs in Table 5 with the CG requirements in Table 1 for all 14 radionuclides potentially detectable by gamma surveys, the estimated MDCs are less than the respective CG_{emc}. In some cases (e.g., Am-241, Cm-243, Cm-244, and Cs-137) the MDCs are less than or in the range of the CG_w. The conclusion is that for the majority of the ROIs, gamma scans will provide a high level of confidence that CG_{emc} concerns are not present in surface soils. For those ROIs where this is not the case, CG_{emc} compliance will be demonstrated via sampling, as described earlier in the plan.

In practice, the response of any particular instrument varies by radionuclide; for the WVDP premises it is likely radionuclides will be commingled. Consequently, the implementation of scans will be based on identifying scan readings that are not consistent with background conditions. Those instances will be followed by biased sampling to resolve what radinuclides are present and at what activity concentrations.

Table 5 Estimated Scanning Minimum Detectable Concentrations (MDCs) of Radionuclides in Soil

Radionuclide	Type of detector	Scan MDC (pCi/g)
Am-241	FIDLER	30
C-14	NA(1)	-
Cm-243	2" by 2" NaI	50
Cm-244	FIDLER	300
Cs-137	2" by 2" NaI	7(2)
I-129	FIDLER	60
Np-237	FIDLER	30
Pu-238	FIDLER	100(3)
Pu-239	FIDLER	200(3)
Pu-240	FIDLER	100
Pu-241	NA(1)	-
Sr-90	NA(1)	-
Tc-99	NA(1)	-
U-232	FIDLER	60
U-233	FIDLER	500
U-234	FIDLER	60
U-235	FIDLER	30
U-238	FIDLER	60

NOTES:

1 NA means not applicable; either there are no photons associated with the radionuclide or the photon yield is too low to allow for detection by field scanning instruments.

2 A specific calculation of scanning minimum detectable count rate for Cs-137 in soil performed in connection with preparation of the Phase 1 Decommissioning Plan yielded a value equivalent to 7 pCi/g Cs-137. A comparable value of 6.4 pCi/g is given in Table 6.7 of the MARSSIM when units are given in pCi/g.

3 While scan MDCs of 10 and 20 pCi/g are reported for Pu-238 and Pu-239, respectively, in Appendix H of MARSSIM, much larger values were reported elsewhere. The values given here are those expected to be reasonably achievable under field conditions.

7.0 DECISION LOGIC

Through the course of the FSS design, implementation, and data collection process there are a number of generic key decision points. These include:

- Identification of appropriate FSS area designation (i.e., Class 1, Class 2, or Class 3) and layout of individual FSS units.
- Assigning pertinent ROIs.
- Demonstrating there are no CG_{cmc} exceedances through a combination of gamma scans, biased soil sampling (as necessary), and systematic soil sampling.
- Demonstrating compliance with CG_w requirements through the use of systematic samples from FSS units and statistical tests such as the Sign test or WRS test.

Currently CG_w levels are such that the Sign test is appropriate for demonstrating CG_w compliance. However, if CG_w levels are reduced, then the WRS test may be necessary.

7.1 FSS Area Designation

The first FSS decision that must be made is what the appropriate FSS designation is for areas that are candidates for Phase 1 FSS data collection. FSS class designation has already been discussed in previous sections of this FSSP. In summary, any area where excavation has taken place to address contamination concerns for ROI, or characterization data (including CSAP-generated data) indicate CG_w exceedances exist, or historical information (e.g., anecdotal evidence of an environmental release) indicates a possibility that contamination may exist above CG_w requirements will be classified as a Class 1 area. Area designation will not take place until after soil remediation is complete for that area (if remediation was necessary).

Areas not meeting the Class 1 area definition but showing some evidence of contamination impacts based on historical information or on characterization data will be classified as Class 2 areas.

Areas not meeting the Class 1 or Class 2 area definitions (i.e., either showing no evidence of contamination impacts or showing minimal evidence) will be classified as Class 3 areas.

After an area has been designated as a Class 1, Class 2, or Class 3 area, it will be divided into one or more FSS units. Class 1 units may range up to 2,000 m^2 in size. Class 2 units may range up to 10,000 m^2 in size. There is no size limitation for Class 3 units. All areas that are included in the Phase 1 FSS process will be completely encompassed in either Class 1, Class 2, or Class 3 units (or some combination).

In the event that contamination is encountered in a Class 2 or Class 3 area during the FSS process that requires remediation, the affected area will be re-classified as a Class 1 area and FSS data will be collected consistent with the Class 1 FSS unit protocols after remediation is complete.

7.2 Pertinent ROIs

The ROI list contains 18 radionuclides. Currently there is insufficient information to determine whether all 18 radionuclides are applicable across the entire WVDP premises. One goal of the CSAP data collection effort is to collect the data necessary to make this determination for individual areas that are candidates for the Phase 1 FSS process. Consistent with NRC guidance in Section 3 of NUREG-1757, Volume 2 (NRC 2006), if, based on CSAP data, a radionuclide contributes no greater than 10 percent to the observed dose, it will be considered an insignificant contributor and will not be carried into the FSS process for that area. This determination will be made based on the SOR calculations described in Section 7.2. In particular, if CSAP data from an area indicate that one of the 18 ROI contributes no more than 10% to the observed SOR values and that the radionuclide does not have activity concentrations exceeding the CG_w requirement in that area, it will not be carried forward into the FSS process. The caveat to this is if all ROI appear to be either not present or present at levels close to background conditions such that none contribute more than 10% to the observed SOR values, at a minimum Cs-137 and Sr-90 will be carried into the FSS process, reflecting the fact that there are known environmental impacts at levels of concern for those two radionuclides across the WVDP premises.

7.3 Sum of Ratios Calculation

Because there are multiple ROIs, a SOR calculation will be used to address cumulative dose concerns. For any individual sample, the corresponding SOR value is the sum of the observed activity concentration for each pertinent ROI divided by the appropriate CG value. In the case of SOR calculations for CG_w evaluations, the appropriate CG value would be the CG_w for the radionuclide of interest. In the case of

SOR calculations for CG_{emc} evaluations, the appropriate CG value would be the CG_{emc} for the ROI. Individual sample SOR values greater than or equal to one indicate a CG exceedance.

In the calculation of SOR values, the reported activity concentrations for pertinent ROIs will be used regardless of whether the result has been qualified as a detection or a non-detection.

7.4 Confirming Survey Unit Classification

FSS data sets (gamma walkover data and sampling results) will be reviewed to determine if there is evidence of anomalous results inconsistent with the original survey unit classification for the area from which the data were collected. An example of an anomalous result would be a CG exceedance from the Class 3 area. These anomalous results do not necessarily indicate non-compliance with CG standards, but may indicate the underlying conceptual site model used as a basis for FSS unit classification was incorrect. In these instances, further investigation may take place to ensure that the anomalous result is not indicative of unexpected residual contamination that warrants attention.

7.5 Demonstrating CGemc Compliance

The generic process for demonstrating CG_{emc} compliance is the same for Class 1, Class 2, and Class 3 units. Logged, spatially complete GWS data will be collected for each FSS unit. These data will be compared to a field investigation level derived from the gamma walkover data collected from the reference area. The field investigation level will be selected to allow identification of GWS results inconsistent with background conditions.

Locations flagged as potential anomalies by the gamma walkover data or for any other reason (e.g., visual evidence of contamination, historical information, etc.) will be biased sampled. The biased sample will be a 5-point incremental composite with the area contributing the increments selected to match the feature of interest. Biased sampling will include both a 15-cm deep sample and a 1-m deep sample for surface soils, but only a 1-m deep sample for samples from the WMA 1 or WMA 2 excavation surface. The sample results will be compared to the appropriate CG_w (i.e., surface and subsurface) adjusted by an area factor appropriate for the area that was targeted. If either sample result exceeds this adjusted CG_w, further data may be collected to better define the footprint of the affected area and remediation will take place before the FSS process continues.

Each individual systematic soil sample collected for CG_w compliance evaluation purposes will also be compared to the appropriate CG_{cmc} requirement if the result is above the CG_w. In this instance, the appropriate standard is the CG_w adjusted by an area factor selected to match the area originally represented by the systematic sample. If the sample result exceeds this adjusted CG_w, further data may be collected to better define the footprint of the affected area and remediation will take place before the FSS process continues. Area factors are provided in Tables 2 and 3 of this plan.

7.6 Demonstrating CG_w Compliance

Each survey unit will have systematic samples collected to allow for a CG_w compliance evaluation. Survey units within the WMA 1 and WMA 2 excavation footprints will have one set of systematic samples per survey unit, each set representative of the contamination status of the top one m of the excavated soil surface. Survey units outside the WMA and WMA 2 excavation footprints will have two sets of systematic samples per survey unit, one set representative of the top 15 cm of soil surface and the second set representative of the top one m of soil surface.

If the Sign test is used (as initially planned), the average SOR value will first be calculated for each set of soil sample results. If the average is above the CG_w requirement, the survey unit will be considered not in compliance, the reason investigated, and appropriate action taken. If the average is below the CG_w requirement, then the Sign test will be performed with a Type I error rate set to 0.05 to establish with statistical confidence that, in fact, the unit has met the CG_w requirement. If the unit does not pass the Sign test, the reason why will be investigated and appropriate action taken. If additional remediation is required within a FSS unit, the affected area will be reclassified as a Class 1 area (if not already) and the FSS data collection process will be repeated.

If the WRS test is used, systematic soil samples obtained from a reference area will be compared to each set of systematic FSS samples from a unit. If the average SOR score for the FSS unit is more than one greater than the average SOR score for the background reference area, the survey unit will be considered not in compliance, the reason investigated, and appropriate action taken. If the average SOR scores differ by less than one, then the WRS test will be performed with a Type I error rate set to 0.05 to establish with statistical confidence that, in fact, the unit has met the CG_w requirement. If the unit does not pass the WRS test, the reason why will be investigated and appropriate action taken. If additional remediation is required within a FSS unit, the affected area will be reclassified as a Class 1 area (if not already) and the FSS data collection process will be repeated.

7.7 Class 1 WMA 1 FSS Units

Class 1 WMA 1 FSS units differ from the rest of the project premises in that most will have foundation pilings remaining in the exposed subsurface Lavery Till. There are concerns that preferential flow may have taken place along the pilings that would have resulted in the transport of contaminated groundwater into the till and subsequent till contamination. To address this concern systematic and biased soil samples, as described in Section 5.1.1, will be collected that target specific pilings.

In the case of biased piling soil samples, the CG_{emc} SOR value will be calculated for each sample collected. If the SOR is equal to or greater than one, the level of contamination will be considered unacceptable and additional investigation/remediation take place until remaining till soils at that location meet the CG_{emc} requirement.

In the case of systematic piling soil samples, the average CG_w SOR value will be calculated. If it is equal to or greater than one, the level of contamination will be considered unacceptable and additional investigation/remediation will take place. If it is less than one, the Sign test will be applied to statistically demonstrate compliance. If the number of systematic piling samples is less than the minimum required for the Sign test, then all systematic piling samples must have CG_w SOR values less than one for the unit to pass.

8.0 QUALITY ASSURANCE AND QUALITY CONTROL MEASURES

QA/QC measures are employed throughout the FSS process to ensure that all decisions are made on the basis of data of acceptable quality. As necessary, a QAPP will be prepared to cover all project QA/QC requirements and activities that have not already been addressed by existing QA/QC procedures associated with the Phase 1 decommissioning process, consistent with the Phase 1 DP. Part of the QA/QC process is data validation. Data validation will take place as described in the Phase 1 DP QAPP.

Data quality indicators (DQIs) are quantitative and qualitative measures of the reliability of the selected measurement methods (laboratory and field screening). Such indicators include the accuracy, precision, representativeness, completeness, and comparability of the data. Measurement instruments and methods will be evaluated in terms of these indicators when they are selected. Accuracy addresses the potential for bias in laboratory analytical results and is typically monitored through the use of standards, blanks, and control charts, as appropriate. Precision reflects measurement error; for radio-analytical methods the required precision is reflected by required method detection limits. Required method detection limits are as specified by this FSSP. Representativeness is guaranteed by appropriate sampling and analytical protocols and is monitored by ensuring that those protocols are, in fact, carried out during field and laboratory work. The data completeness goal for this FSSP is 80% which reflects the fact that the MARSSIM CG_w sample number calculations build in a 20% safety factor to account for rejected or missing data. Comparability refers to whether data sets generated by FSS work pertain to the establishing compliance with CG requirements. All FSS CG-related decisions will be supported by laboratory analytical work providing radionuclide-specific activity concentrations for the ROI.

A QA program will be conducted during surveys that, in accordance with established procedures, will specify and measure the performance of measurement methods through the collection of an appropriate number or frequency of QC samples. Such samples could include field and laboratory blanks, field duplicates, laboratory replicates, and spiked samples. Field measurements will be calibrated on National Institute of Standards and Technology (NIST)-traceable standards at a frequency prescribed in the QAPP. Twice-daily response checks will be performed for all field instruments before use. Corrective actions will be conducted if performance falls outside of expected ranges.

All surveys and sample collection for this FSS will be performed in accordance with established QC requirements. Replicate surveys, sample recounts, instrument performance checks, chain of custody, control of field survey data and databases, and QC investigations provide the highest level of confidence in the data collected to support the survey outcome.

In addition, QA/QC measures will ensure that trained personnel conduct survey with approved procedures and properly calibrated instruments. Procedures will cover sample documentation, chain of custody, field and laboratory QC measurements, and data management. The FSSP contractor will be required to develop and supply these procedures either as appendices to this plan, or as stand-along standard operating procedures.

In addition, the expectation is that the NRC will provide for an independent verification contractor as described by the Phase 1 DP in Section 9.2.7.

9.0 REPORT OF SURVEY FINDINGS

Consistent with NRC guidance, one or more Final Status Survey Reports (FSSR) describing and documenting the FSS outcomes for the Phase 1 FSS survey units will be prepared. Given the complexity and the timeframe of Phase 1 activities, DOE may choose to bundle FSS results for sets of survey units into individual FSSRs that are prepared as data from those units become available. At the completion of Phase 1 activities, the set of FSSRs (if more than one) will demonstrate that Phase 1 requirements have been met for those areas that underwent the Phase 1 FSS process.

Each FSSR will include the following information pertinent to the survey units contained in that FSSR:

- A summary of the applicable DCGLs.
- A discussion of any changes that were made in the FSS from what was proposed in the FSSP.
- A description of the method by which the number of samples was determined for each survey unit.
- A summary of the values used to determine the number of samples and a justification for these values.
- The survey results for each survey unit including the following:

  - the number of samples taken for the survey unit;
  - a description of the survey unit, including (a) a map or drawing of the survey unit showing the reference system and random start systematic sample locations for Class 1 and 2 survey units, and random locations shown for Class 3 survey units and reference areas, (b) discussion of remedial actions and unique features, and (c) areas scanned for Class 2 and 3 survey units;
  - the measured sample concentrations, in units that are comparable to the DCGLs;
  - the statistical evaluation of the measured concentrations;
  - biased and miscellaneous sample data sets reported separately from those samples collected for performing the statistical evaluation;
  - a discussion of anomalous data including any areas of elevated direct radiation detected during scanning that exceeded the investigation level or any measurement locations in excess of $DCGL_W$; and

  - a statement that a given survey unit satisfied the $DCGL_W$ and the elevated measurement comparison if any sample points exceeded the $DCGL_W$.

- A description of any changes in initial survey unit assumptions relative to the extent of residual radioactivity (e.g., material not accounted for during site characterization).
- A description of how ALARA practices were employed to achieve final activity levels.

REFERENCES

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APPENDIX A

Composite Sampling Technical Basis

A.1 Background

As part of the Phase 1 decommissioning process, portions of the WVDP premises will be remediated until soil activity concentrations meet the DCGL standards developed in the *Phase 1 Decommissioning Plan for the West Valley Demonstration Project* (Revision 2, December 2009) (Phase 1 DP). The Phase 1 Final Status Survey Plan (FSSP) will be used to demonstrate that in these cases residual activity concentrations in soils are below the applicable Phase 1 DCGL requirements. There are two distinct types of derived concentration guideline level (DCGL) requirements defined by MARSSIM: wide area average requirements ($DCGL_w$) that must be met, on average, over areas the size of final status survey units, and elevated area comparison requirements ($DCGL_{emc}$) that must be met, on average, over areas much smaller than final status survey units. The colloquial term for the $DCGL_{emc}$ requirement is a "hot spot" requirement. The Phase 1 FSSP relies on a combination of scanning data collection and soil sampling and analysis to demonstrate compliance with Phase 1 DCGL requirements. The Phase 1 FSSP is consistent with MARSSIM guidance.

As part of the FSSP, composite sampling has been proposed for soils. Composite sampling refers to collecting a set of individual samples (sometimes referred to as soil increments) in a prescribed manner, and combining those into one or more composite samples that are then homogenized and submitted for laboratory analysis. Composite sampling has been proposed for the Phase 1 FSSP for two reasons: (1) to improve the ability of the FSSP to correctly identify the presence of soils that exceed the $DCGL_{emc}$ requirements, if they exist; and (2) to reduce the Type II error rate that would be associated with $DCGL_w$ evaluations. The Type II error rate refers to situations where one is unable to confidently conclude that the $DCGL_w$ requirements have been achieved for a particular final status survey unit based on available sample results when the reality is that final status survey unit has met the requirements.

The purpose of this appendix is to provide the technical basis for the use of composite sampling. The following basic assumption is made: Analyzing a thoroughly homogenized composite soil sample will produce the same analytical result (neglecting measurement error) as if each of the discrete soil samples contributing to the composite were analyzed and one arithmetically calculated the average result.

A.2 Regulatory Guidance and Technical References

The Phase 1 FSSP is meant to be consistent with MARSSIM. MARSSIM provides no guidance on the use of composite sampling for final status survey; however, there is a rich set of guidance and precedent available from the U.S. Environmental Protection Agency (EPA) regarding the application of composite sampling approaches to hazardous waste site data collection programs, and from academic and research literature.

In 1995 under its Observational Economy Series, the EPA published "Volume 1: Composite Sampling." In this document the EPA noted that "...composite sampling is increasingly becoming an acceptable practice for sampling soils..." One of the identified applications was "...establishing and verifying attainment of remedial cleanup standards in soils..." [EPA 1995:7]

In 1996, ASTM published a standard for conducting composite sampling (ASTM D 6051-96) entitled "Guide for Composite Sampling and Field Subsampling for Environmental Waste Management Activities." That standard identified the following three primary advantages associated with composite sampling: 1) to improve the precision of the estimates of a mean concentration for a given budget; 2) to reduce the cost associated with achieving a desired level of precision associated with a mean estimate; and 3) to reduce errors and improve representativeness of samples intended to reflect the contaminant concentration of a specific area.

In 2002, the EPA published its RCRA waste sampling draft technical guidance. Section 5.3 of that document is dedicated to the implementation of composite sampling strategies to serve a variety of purposes. The guidance notes that composite sampling can be implemented as part of a statistical design to estimate average concentrations for areas of interest. The 2002 EPA RCRA guidance discusses the various approaches to implementing composite soil sampling strategies in the field. Figure A.1 reproduces Figure 20 from that report. In reference to Figure 20, the guidance states: "In fact, compositing samples collected from localized areas is an effective means to control "short-range" (small-scale) heterogeneity (Pitard 1993). When this type of compositing is used on localized areas in lieu of "grab" sampling, it is an attractive option to improve representativeness of individual samples (Jenkins, et al. 1996)." [EPAa, 2002:68]

Also in 2002, the EPA published guidance on selecting sampling strategies plans for environmental data collection. This guidance document devotes a chapter to composite sampling strategies. The main benefit identified is: "...that one can achieve approximately the same precision of an estimated mean at less cost or, one can get more coverage (better representation) of the population at the same cost..." [EPAb 2002:125]

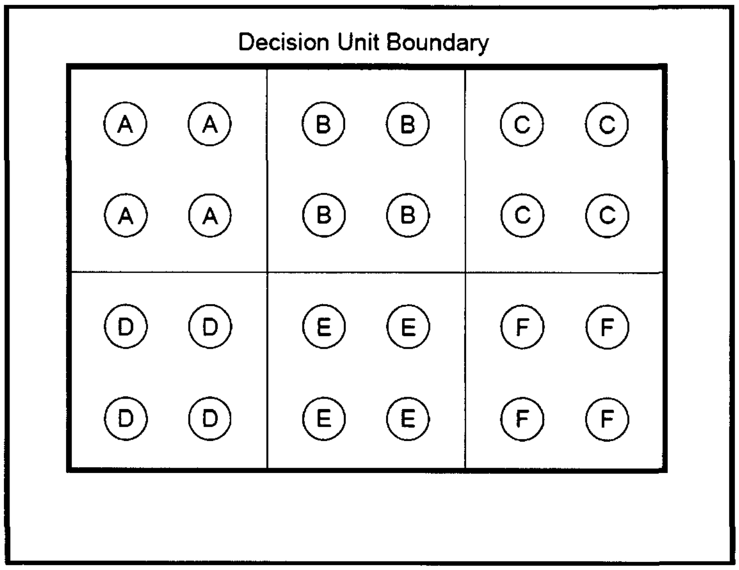

Figure 20. Systematic sampling within grid blocks or intervals. Samples with the same letter are pooled into a composite sample.

Figure A.1 Composite sampling as portrayed in 2002 EPA RCRA guidance Figure 20

In addition to EPA regulatory guidance, there also has been a fairly significant body of research on the efficacy of composite soil sampling for a variety of purposes. For example, Williams, et al. (1989) explored the efficiency of composite sampling as compared to discrete grab sampling for determining average Ra-226 activity concentrations in surface soils. They found that composite sampling significantly outperformed discrete sampling with far fewer sample analyses, with performance measured by the precision of the mean activity concentration obtained for the area of interest. Edland and van Belle (1994) confirmed the improved precision observation, and demonstrated that doubling the number of individual samples (or increments) per composite soil sample decreased the expected size of the confidence interval around the mean by a factor of 1.414.

Jenkins and colleagues at the Army's Cold Regions Research and Engineering Laboratory have published extensively on the application of compositing techniques to the characterization of energetics on firing ranges with the conclusion that composite sampling techniques provide a less-biased and more precise estimate of average concentrations than do discrete samples. Their work led to the revision of RCRA SW-846 Method 8330b, a revision that explicitly incorporated compositing into firing range characterization strategies.

The limitations of composite soil sampling that have been identified by various authors/guidance documents include the following:

- situations where sample handling results in the loss, destruction, or alteration of contaminants (e.g., mercury and volatile organics). None of the WVDP radionuclides of interest fall into this category, i.e., sample handling will not affect the quantity or characteristics of the radionuclides of interest.

- settings where discrete samples are a regulatory requirement. MARSSIM does not specifically require discrete samples for demonstrating DCGL compliance. In fact, MARSSIM provides very little detail or guidance regarding sampling protocols.

- situations where sampling costs are significantly greater than analytical costs. As will be described in the subsequent section, the proposed use of compositing is for surface soils where the cost of obtaining a soil sample is minimal compared with the cost of analyzing that sample for the WVDP radionuclides of interest.

- soil conditions that limit the ability to homogenize a composite sample before analysis. The soils present at the WVDP project premises should not pose any special difficulties from a homogenization perspective. Examples of where this would be an issue are cases where there is a high stone component to samples (e.g., gravels) and sampling other media (e.g., concrete). These types of soils also pose laboratory issues for discrete grab samples; the solution for both composite and discrete grab samples is to either grind the sample or remove aggregates by sieving (typically under the assumption that contamination is associated with fine soil particles) and mass-correct concentrations after analysis to account for the removed material.

Soil sample preparation and homogenization is an important step in the analytical process regardless of whether composite or discrete grab samples are collected since most laboratory methods require sub-sampling to obtain aliquot masses required by specific analytical methods. Sample homogenization can be accomplished in the field, but typically is more effective and efficient if done by the laboratory responsible for the sample analyses.

- settings where samples may be reactive when mixed. There is nothing about the soils at WVDP or the radionuclides of interest that would raise reactivity concerns.

- situations where the cleanup standard is close to detection limits and the desire is to estimate mean concentrations for an area of interest. For all radionuclides of interest, the prescribed laboratory detection limits are well below DCGL values. In addition, in the case of a $DCGL_w$ evaluation, the statistical methods that would be used to demonstrate compliance (the Sign or WRS test) are non-parametric and are insensitive to non-detects as long as the detection limits are well below DCGL standards.

- situations where analytical error is expected to be greater than the variability expected to be seen among discrete samples. Analytical relative variability for radionuclide measurements is typically less than 30% for measurements at the method detection limit, and much less than that for measurements involving elevated contamination activity concentrations. In contrast, relative variability observed for discrete sample results from impacted areas is typically around 100% or more.

- settings where there is a desire to estimate the upper percentile concentration level associated with a discrete sample population. Upper percentile concentration estimation is not a goal of the WVDP Phase 1 FSS process and is not a MARSSIM requirement.

A.3 Proposed Use and Technical Basis

Composite soil sampling is proposed for use as part of the final status survey data collection process for exposed soil surfaces, including the WMA 1 and WMA 2 excavations and surface soil outside the WMA 1 and WMA 2 excavations. The proposed composite soil sampling strategies will be implemented in a manner that results in data that are consistent with MARSSIM $DCGL_w$ and $DCGL_{emc}$ evaluation requirements. In summary, the rationale for using composite soil sampling is to improve the ability of the final status survey process to identify $DCGL_{cmc}$ concerns, if they exist, and to reduce Type II error rates for the $DCGL_w$ evaluation.

A.3.1 Improving Elevated Area Detection Capabilities

The primary reason for using composite soil sampling strategies as part of the WVDP Phase 1 final status survey process is that the eighteen radionuclides of interest include some that are not readily detectable in soils by scanning technologies. Sr-90 is an example. MARSSIM assumes that scanning technologies can be used to at least partially address $DCGL_{cmc}$ concerns. This will probably not be possible at WVDP for areas where Sr-90 is the primary concern. Based on existing historical data, Sr-90 is expected to be the principal radionuclide of concern from a dose perspective in the deep WMA 1 and WMA 2 excavations. It appears unlikely that Sr-90 will exist commingled consistently with other radionuclides such that surrogates might be used for Sr-90 when gross activity scans are done. Consequently, confidently demonstrating compliance with both the $DCGL_w$ and $DCGL_{cmc}$ for Sr-90 will require soil sampling and laboratory analysis.

Experience and research has established that discrete grab soil sampling programs do not necessarily provide a high level of confidence that elevated areas (hot spots) are absent. Figure A.2 is a reproduction of Figure 2 from Jenkins, et al. (1996). In this study, spatial heterogeneity was evaluated for TNT contamination in surface soils within a firing range. Figure A.2 shows surface soil sample TNT results for seven discrete soil samples collected within a 122 cm diameter area. These results ranged over two orders of magnitude. The average concentration was more than 16,000 ppm for these samples. If one assumed a $DCGL_{cmc}$ value of 1,000 ppm, any individual sample from this area would have had only a 43% chance of correctly identifying the existence of contamination levels that likely exceeded the $DCGL_{cmc}$ requirement by more than an order of magnitude.

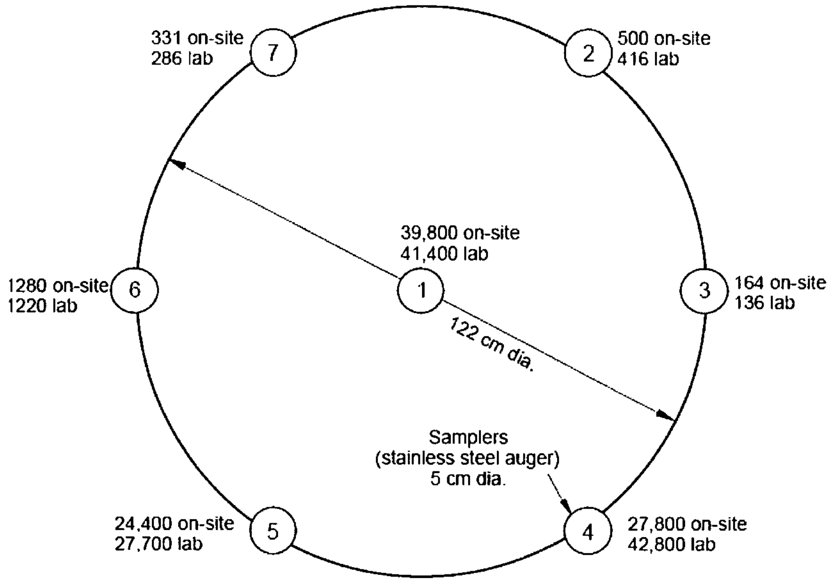

Figure 2. Sampling scheme (TNT concentrations shown are from sampling location 1).

Figure A.2 Discrete sample results for TNT in surface soils from Jenkins, et al. 1996 Figure 2

Figure A.3 is a reproduction from a recent report published by the Kentucky Research Consortium for Energy and Environment (2008). In this particular instance, the concern was total uranium in surface soils. Figure A.3 shows FIDLER results color-coded by activity level, as well as discrete grab sample results for ten locations within a 25 m^2 elevated area that the FIDLER identified. As with the previous example, the discrete samples ranged over two orders of magnitude. For this particular site, the $DCGL_{emc}$ for uranium was defined to be 98 ppm averaged over a 25 square meter (m^2) area. The average for the ten discrete samples was 200 ppm, well above the $DCGL_{emc}$ value. However, any individual discrete grab sample would have correctly identified the presence of the hot spot only 50% of the time.

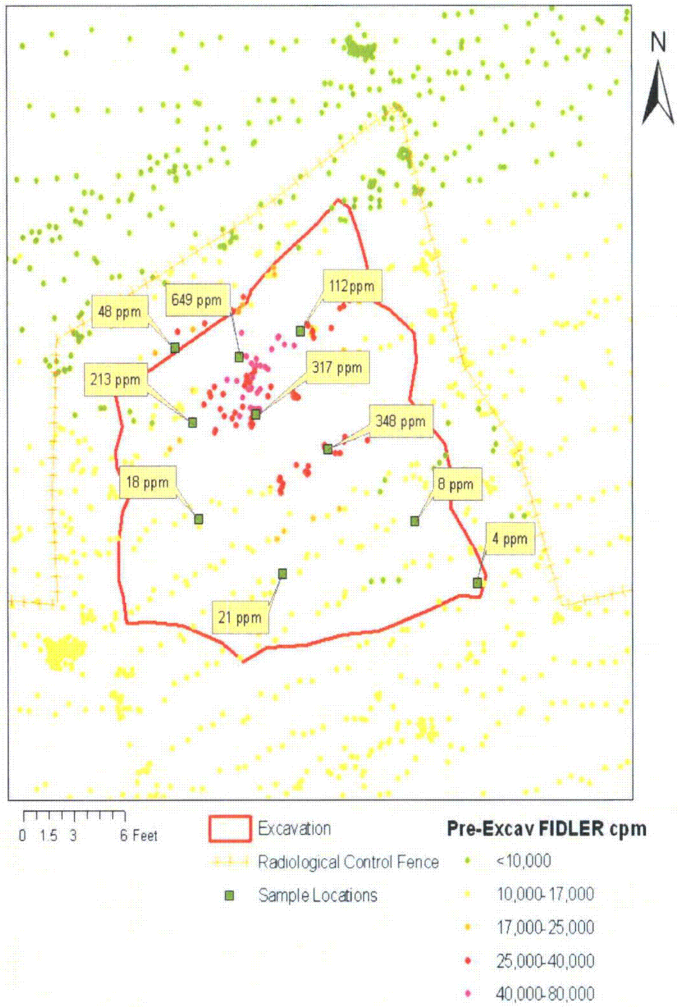

Figure A.3 Discrete sample results for uranium in surface soils from KRCEE 2008 Figure 15

In both the explosives and uranium example, one can perform a Monte Carlo analysis of the available discrete sample results to determine what the elevated area detection performance would have been if composites had been formed from the discrete samples. In the case of the explosives example, the available discrete sample results suggest that a composite formed from three discrete samples collected from the elevated area would have correctly identified this "hot spot" 98% of the time (i.e., would have yielded a composite sample result greater than 1,000 ppm). In the case of the uranium example, the available discrete sample results suggest that a composite formed from five discrete samples collected from the elevated area would have correctly identified this "hot spot" 85% of the time (i.e., would have yielded a composite sample result greater than 98 ppm).

Because elevated contamination concentrations are typically associated with right-skewed underlying population distributions, individual discrete samples potentially have a relatively low probability (<50%) of correctly representing the mean contaminant concentration conditions for the area they are intended to represent when contamination is present. In the two examples above, composite samples improve elevated area detection performance because they produce a sample submitted for analysis that is more representative of the area of interest than any individual grab sample alone would have been, and provide a result that is much more likely to be an unbiased estimate of the true average concentration for the area of interest. [EPAb 2002]

A composite soil sample formed from soil increments (discrete soil samples) systematically spread across an area of interest will always outperform one individual grab soil sample where performance is measured as accurately (i.e., lack of bias) and precisely (i.e., minimal standard error) estimating the true average concentration over an area assuming no contaminant loss or degradation occurs as a product of the compositing process. As more increments/discrete samples are used to form a composite, performance increases. [Edland and van Belle 1994] The Phase 1 FSSP proposes to combine five discrete samples or increments per composite. The rationale for using five soil sample increments to form each composite is based on the following assumptions: if one or more increments encounters contamination above the CG_{emc}, the composite will yield a result above the CG_{emc} and the probability of any single increment encountering contamination at levels that would result in a composite value greater than the CG_{emc} is 0.5. Under these conditions, a 5-increment composite will have < 5% chance of missing a CG_{emc} exceedance present in the area represented by the composite.

A.3.2 Lowering Type II $DCGL_w$ Evaluation Error Rates

Per MARSSIM guidance, compliance with $DCGL_w$ requirements is demonstrated through the use of systematic sampling combined with an appropriate statistical test. The two tests recommended by MARSSIM are either the Sign test, or the Wilcoxon Rank Sum (WRS) test. Both of these tests are non-parametric. In the case of the Sign test, the question is whether more than 50% of a final status survey unit is contaminated above $DCGL_w$ standards. In the case of the WRS test, the question is whether the median of the distribution of systematic sample results from a final status survey unit is more than the $DCGL_w$ value greater than the median of the distribution of sample results from a reference background area. For both tests, MARSSIM recommends collecting soil samples that are systematically distributed on a triangular grid across the final status survey unit.

For both statistical tests, the null hypothesis is that the final status survey unit under evaluation is contaminated above $DCGL_w$ requirements. The objective of the tests is to demonstrate that this null hypothesis is very unlikely to be true given the sample results. If that can be demonstrated, then the alternative hypothesis is accepted (i.e., that the final status survey unit is *not* contaminated above $DCGL_w$ requirements). In this context, two types of decision errors can be made. The first, known as a Type I error, is to reject the null hypothesis when in fact contamination is present above $DCGL_w$ requirements. Simply put, this means concluding a final status survey unit meets the standards when in fact it does not. The Phase 1 WVDP FSS plan has set the acceptable Type I error rate to 5%. The statistical tests will be conducted in a manner that always guarantees that the Type I error rate is met, regardless of the number of systematic samples collected from each survey unit.

The second potential error, known as a Type II error, occurs when the null hypothesis is accepted when it should have been rejected. Simply put, this means concluding a final status survey unit is unacceptably contaminated when in fact it meets the $DCGL_w$ requirement. Type II errors occur when there is insufficient sampling data to demonstrate with a high level of confidence (i.e., Type I error rate of only 5%) that $DCGL_w$ standards have been achieved. Type II error rates are reduced by collecting more systematic samples from a survey unit. It is in DOE's interest to keep Type II error rates low, since a Type II error means that additional actions are required within a final status survey unit when they really are not necessary.

MARSSIM calculates required samples numbers to achieve a specified desired Type II error rate based on the relative shift expected to be present within a final status survey unit. The relative shift is a combination of the variability expected in sample results from the unit and the difference one expects between the average sample result and the $DCGL_w$ requirement. As sample variability goes up, the relative shift goes down and sample number requirements increase. Alternatively, for the same number of systematic final status survey unit samples, as sample variability goes up, the Type II error rate increases (and vice versa). As Edland and van Belle demonstrated in their 1994 paper, the use of compositing reduces sample variability; the net effect is that for the same number of sample analyses per final status survey unit, compositing produces lower Type II errors (a good thing) than an equal number of discrete samples. Again, as Edland and van Belle demonstrated, from a Type II error perspective the driving determinant is not how many systematic analyses are performed per final status survey unit; it is how many discrete samples contributed to those analyses. In other words, one would expect the same Type II error rate from 10 composite samples formed from 50 discrete samples systematically distributed across a survey unit (five per composite) as one would observe if all 50 discrete samples from that unit had been analyzed.

A.3.3 Proposed Composite Sampling Implementation

The Phase 1 WVDP FSSP proposes to use composite sampling to improve both elevated area detection capabilities and reduce Type II $DCGL_w$ error rates. A minimum of eight systematically-placed sampling locations would be established per final status survey unit using a random-start triangular grid. From the area represented by each grid node, a 5-increment composite sample would be formed, with the five increments (discrete soil samples) collected systematically across the area represented by the grid node (Figure A.4). Each composite would be homogenized prior to analysis. Each composite sample result would be compared directly to the appropriate $DCGL_{emc}$ requirement, which would be determined using the area factors presented in the Phase 1 WVDP FSSP. The set of composite sample results for a final status survey unit (minimum of eight) would then be used to conduct the appropriate statistical test to establish confidently that compliance with the $DCGL_w$ requirement had been achieved.

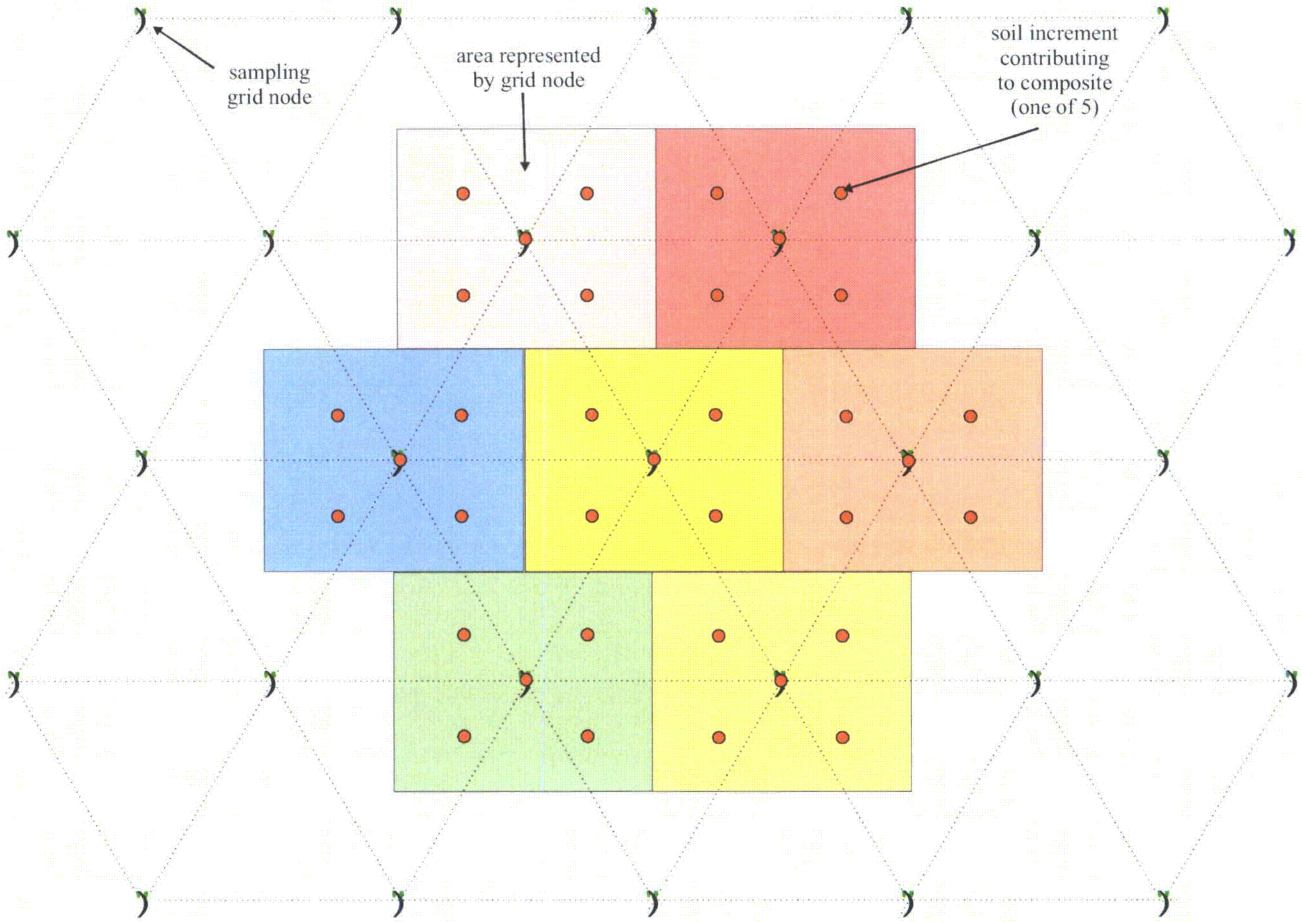

Figure A.4 Proposed composite sampling strategy

Currently, the Sign test appears to be the appropriate statistical test to use for demonstrating $DCGL_w$ compliance. In the event that a determination is made that the WRS test should be used, a reference area that has been sampled using the same compositing protocols will be utilized to support the WRS test evaluation. In the context of the WRS test, it is important that the reference area be sampled in a manner similar to the final status survey units since the WRS test is a distributional test, and assumes that the underlying sample support is the same for the reference area and the final status survey units.

A.3.4 Composite Sampling and Laboratory Detection Limits

Concerns have been raised regarding the laboratory detection limit implications associated with compositing soils samples. These concerns are justified in cases where composite sampling is used to reduce the cost of identifying the occurrence of a relatively rare constituent. [EPA 2002a] In this setting, action levels are set for composite results that are a function of the number of discrete samples contributing to the composite. As the number of samples contributing to a composite grows, the action level is lowered, and consequently the required laboratory detection limits are reduced as well.

However, the proposed use of compositing for Phase 1 WVDP FSSP does not fall into this category. In the proposed application as described, there are no laboratory detection limit implications, for the following reasons.

Analytical laboratory detection limits for individual radionuclides as currently prescribed by the Phase 1 DP and accompanying Phase 1 FSSP are either 10% of the $DCGL_w$, standard laboratory detection limits, or 25% of background levels, whichever is lower. The intent of these detection limits is to ensure data of sufficient quality to allow confident $DCGL_w$ and $DCGL_{emc}$ evaluations.

In the case of a $DCGL_{emc}$ comparison, the results from individual samples are compared to their relevant $DCGL_{emc}$ standard. For a particular soil sample (systematic or biased) collected from a final status survey unit, the relevant $DCGL_{emc}$ standard is the $DCGL_w$ adjusted upwards using an appropriate area factor. The Phase 1 DP provides a table containing area factors intended for this purpose. The area factor corresponds to the area the sample (biased or systematic) was intended to represent. Because the $DCGL_{emc}$ is always greater than the $DCGL_w$, the analytical detection limits specified by the Phase 1 DP are sufficiently low to support confident $DCGL_{emc}$ decisions. How the sample was formed from its area is irrelevant from the perspective of laboratory detection limits – it could either have been a discrete grab sample taken from the center of the specified area, or a composite sample formed from soil increments systematically distributed across the area. In either case, the assumption is that the soil sample result is an estimate of the actual average activity concentration associated with the area it was collected, and the only requirement is that the detection limit for the sample be well below the relevant $DCGL_{emc}$.

For any particular radionuclide, the $DCGL_w$ represents an activity concentration that must be met, on average, across individual final status survey units. For the $DCGL_w$, whether any individual sample result is above or below the standard is irrelevant; the average activity concentration across samples is the point of comparison. The average activity concentration across a survey unit is evaluated using results from samples systematically distributed across the surface of the survey unit. The final status survey evaluation process typically involves two steps: computing an average activity concentration based on sample results and comparing this directly to the $DCGL_w$ requirement, and then, if the computed average is less than the $DCGL_w$ requirement, performing a statistical test to confirm that it can be stated with the required statistical confidence that the computed average is, indeed, less than the $DCGL_w$ requirement.

In the case of radionuclides (as opposed to chemical results), these calculations are typically performed using reported results, regardless of whether results were flagged as non-detects, consistent with MARSSIM's recommendation. This is done under the assumption that reported results for individual samples are non-biased estimators of actual activity concentrations, and so any measurement error that might be associated with individual samples will "average out" as averages are calculated for sets of systematic samples collected from a survey unit. The statistical evaluation (either Sign or WRS test) accounts for these errors, and in fact the presence of measurement error is one reason why statistical tests are used as part of the $DCGL_w$ evaluation process. Both the Sign and WRS are non-parametric statistical tests; one of the reasons that MARSSIM recommends non-parametric statistical tests is because their performance is relatively immune to non-detected sample results.

Similar to the $DCGL_{emc}$ evaluation, whether individual systematic samples are discrete grab samples collected from individual locations or an equal number of composite samples formed from soil increments collected from the areas around each systematic location does not impact the analytical laboratory detection limit requirements for those samples, nor does it affect how the sample results are ultimately used to demonstrate $DCGL_w$ compliance.

A.4 Conclusions

The generic MARSSIM final status survey process relies on a combination of gross activity scans, biased sampling and systematic sampling to establish compliance with DCGL requirements. Gross activity scans typically demonstrate that $DCGL_{emc}$ exceedances are not present. For some WVDP Phase 1 areas, Sr-90 will likely be the primary contaminant of concern, and may be present without any other radionuclide that might be detectable by scans. Consequently scanning will likely not be effective to demonstrate Sr-90 $DCGL_{emc}$ compliance in some areas. Research and field experience has demonstrated that discrete grab soil samples alone are not always capable of reliably identifying $DCGL_{emc}$ exceedances. The use of sample compositing techniques can significantly improve the confidence that $DCGL_{emc}$ problems do not exist within final status survey units. Sample compositing techniques can also reduce Type II error rates associated with $DCGL_w$ compliance evaluation. For these two reasons, the Phase 1 FSSP proposes to use composite sampling techniques to improve the overall performance of the Phase 1 final status survey process. The proposed composite soil sampling protocols will produce data sets that are consistent with MARSSIM requirements.

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