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April 4, 2003

Docket 50-62

United States Nuclear Regulatory Commission
Mail Stop O12-G13
One White Flint North
11555 Rockville Pike
Rockville, Maryland 20852-2783

Attention: Mr. Daniel E. Hughes, Project Manager
Operating Reactor Improvements Program

Subject: Transmittal of Master Final Status Survey Plan, UVA-FS-002, Revision 0, March 2003

References: 1. Amendment No. 26 to Amended Facility Operating License No. R-66 for the University of Virginia Research Reactor
2. Docket 50-62

Dear Mr. Hughes,

We are pleased to transmit the "Master Final Status Survey Plan," Revision 0, March 2003, prepared for the University of Virginia by CH2M HILL and its subcontractor, Safety and Ecology Corporation. The referenced Amendment approves the decommissioning plan for the University of Virginia Research Reactor. Following the decommissioning, a Final Status Survey (FSS) of the facility will be performed to demonstrate that the radiological conditions satisfy NRC-approved criteria for use without radiological restrictions and termination of License No. R-66. The enclosed plan describes the methodologies for conducting and evaluating that Final Status Survey. The enclosed plan is being submitted for NRC review in conformance the referenced amendment.

Because the medium, dimensions, contamination potential (i.e. classification), and contaminant mix may differ for each area undergoing FSS, all factors influencing a specific survey design are typically not available until immediately before an area is turned over for FSS. Therefore, designs for specific surveys, including determination of specific guidelines, sampling/measurement methods, survey unit identification and classification, and data evaluation techniques, will be developed at the time of survey in accordance with the guidance presented in the Master Plan. Each design will be documented as an Addendum

A020

to the Master FSS Plan. The University will provide NCR with information copies of Addenda as they are finalized.

If you have any questions regarding this transmittal, please contact me at (434) 982-5446.

Sincerely,

Robert Mulder
Reactor Director
University of Virginia

Enclosure: Master Final Status Survey Plan, UVA-FS-002, Revision 0, March 2003

c: Ralph Allen, Chair Reactor Decommissioning Committee
Stephen Holmes, NRC

MASTER

Master Final Status Survey Plan

UVA-FS-002

Revision 0

Prepared for
University of Virginia
Reactor Facility Decommissioning Project

Prepared by

CH2MHILL

151 Lafayette Drive, Suite 110
Oak Ridge, TN 37830

With assistance from

Safety and Ecology Corporation
2800 Solway Road
Knoxville, TN 37931

March 2003

Information Copy

Master Final Status Survey Plan

Prepared for the
University of Virginia
Reactor Facility Decommissioning Project

UVA-FS-002

Revision 0

March 2003

Client Approvals:

_______________________ April 3, 2003

OEHS Date

_______________________ April 1, 2003

Technical Director Date

CH2MHILL

151 Lafayette Drive, Suite 110
Oak Ridge, TN 37830

Master Final Status Survey Plan

for the
University of Virginia
Research Reactor Facility

UVA-FS-002

Revision 0

Prepared for
University of Virginia
Reactor Facility Decommissioning Project

March 2003

[signature]	3/24/03
Certified Health Physicist	Date
[signature]	3/24/2003
ES&H & QA Director	Date
Patrick L. Erwin	3/26/2003
Project Engineer	Date
Mark Lundly	3/26/03
Project Manager	Date

CH2MHILL

Contents

TABLES

FIGURES

APPENDICES

Acronyms

ALARA	As Low As Reasonably Achievable
AEC/DOE	Atomic Energy Commission/Department of Energy
CAVALIER	Cooperatively Assembled Virginia Low Intensity Educational Reactor
cm	centimeter
cm^2	square centimeters
DCGL	Derived Concentration Guideline Level
dpm	disintegrations per minute
DQO	Data Quality Objective
FSS	Final Status Survey
g	gram
km	kilometer
LBGR	Lower Bound of the Gray Region
m	meter
m^2	square meters
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
NRC	Nuclear Regulatory Commission
N or n	number of data points
pCi	picocurie
QA	Quality Assurance
QC	Quality Control
RCS	Radiological Control Supervisor
S+	Sign test statistic
SEC	Safety and Ecology Corporation
UVAR	University of Virginia Reactor
W_R	Wilcoxon Rank Sum test statistic
WRS	Wilcoxon Rank Sum

1. Introduction

The University of Virginia operated a light-water cooled, moderated, and shielded pool-type nuclear research reactor at its Department of Mechanical, Aerospace, and Nuclear Engineering beginning in June 1960. Reactor uses included radiation research, activation analysis, isotope production, neutron radiography, radiation damage studies, and training of Nuclear Engineering students. The reactor was initially commissioned to operate at a maximum power of 1 Megawatt (MW) thermal; it was upgraded to a power level of 2 MW in January 1971. Aluminum clad high-enriched uranium fuel was initially used; the reactor was converted to low-enriched uranium fuel in early 1994. The reactor operated under NRC License No. R-66.

In June 1998 the reactor was permanently shutdown, and the fuel was removed and shipped offsite between the shutdown date and mid 1999. Beginning in July 1999 GTS Duratek performed a radiological characterization of the reactor and the facility housing the reactor, collectively referred to as the UVAR facility; results of that characterization are presented in a March 2000 Characterization Survey Report (Ref. 1.). The University of Virginia submitted a Decommissioning Plan for the UVAR facility to the NRC in February 2000 (Ref. 2.).

Beginning in March 2002, the University of Virginia contracted with CH2M HILL to conduct the decommissioning of the UVAR. Other contractors teamed with CH2M HILL to accomplish this effort are Waste Management Group, Inc. (WMG), Safety and Ecology Corporation (SEC), Bartlett Nuclear, Inc., and Parallax, Inc. (see Section 4). This team conducted additional characterizations, as required; surveyed and released or disposed of materials, depending on radiological conditions; and performed decontamination of components, where appropriate. Following the removal or decontamination of surfaces and materials, a Final Status Survey of the facility will be performed to demonstrate that the radiological conditions satisfy NRC-approved criteria for use without radiological restrictions and termination of License No. R-66. This document describes the methodologies for conducting and evaluating that Final Status Survey of the UVAR facility.

The University of Virginia Reactor Facility also housed the smaller 100-Watt CAVALIER reactor (License No. R-123), located on the ground floor in Room G007. The approval authorizing the Decommissioning Plan for the UVAR facility also required that the CAVALIER facility would first be decommissioned to satisfy Regulatory Guide 1.86, "Termination of Operating Licenses for Nuclear Reactors," and would then be integrated into the UVAR site. A thorough characterization survey of the CAVALIER facility has been conducted. Results were evaluated relative to the NRC-authorized radiological criteria, Regulatory Guide 1.86 and the Decommissioning Plan for termination of the CAVALIER License. This evaluation indicates that the CAVALIER facility satisfies requirements for termination of the license and a report has been prepared for submission to the NRC. Once the CAVALIER License is terminated, that facility becomes integrated into the UVAR site for FSS under this Plan.

2. Facility Description

The 2045 m^2 UVAR facility is located on Old Reservoir Road on the Northern Grounds of the University of Virginia in Charlottesville, Virginia (Figure 2-1). The UVA Research Reactor and the decommissioned former CAVALIER facility, as well as offices for former faculty, students of the former Department of Nuclear Engineering, and the reactor staff, are housed in the facility. The UVAR facility is sited approximately 0.6 kilometers (km) west of the city limits of Charlottesville in Albermarle County Virginia. To the north, east, and south of the facility (no closer than 0.5 km) there are city residential districts. The only access to the Facility is by way of Old Reservoir Road. The land and facilities are the property of the University of Virginia, which is responsible for facility oversight and support. Figures 2-2 and 2-3 are plans of the UVAR facility and environs.

Figures 2-4 through 2-6 show the three levels of the UVAR facility. The Reactor Confinement Room (Rm 131), which housed the former UVA Research Reactor, is located on the upper floor (first floor). This room contained the 9.8 m long by 3.7 m wide by 8.2 m deep reactor pool, associated operating equipment and systems, the operating controls, and some research/experimental equipment. This room is circular and has an elevated (~10 m) ceiling. In addition, the Instrument Shop (Rm 128, Shipping Area (Rm 127), and multiple offices and other support facilities for staff and students are located on this building level.

On the Mezzanine level were located the Demineralizer (Rm M021), Mechanical Room (Rm M020), HP Laboratory (Rm M019), several partially contaminated laboratories (Rms M005 [Tc-99 contamination] and M008 [Ni-63 contamination]), and multiple offices and other support facilities for staff and students. A crawl space (MCS) is accessed from the stairwell on the Mezzanine level.

The ground floor contained the Heat Exchanger (Rm G024), Rabbit Room (Rm G005), Beamport/Experimental area (Rm G020), Hot Cell (Rms G025, G026, and G027), Counting Room (Rm G004), Woodworking and Machine Shop (Rm G008), Source Storage (Rms G022, G018, and G007A), the former CAVALIER facility (Rm G007), and miscellaneous support facilities and areas.

There was a cooling tower located on the roof of the 1st level, adjacent to the Reactor Confinement room; this facility provided cooling for the reactor secondary system water.

The UVAR facility building is situated on a 9500 m^2 fenced parcel of land. This land area included 2 sets of underground tanks for collection of potentially contaminated facility liquid wastes, a pond used for collection and holdup of facility discharges with no or low potential for containing radioactive contamination, a water tank for fuel transfer at ground level at the front of the building, underground storm and sanitary sewer drainage systems, and miscellaneous larger materials and equipment with little or no potential for being radiologically impacted.

The UVAR building is of concrete block construction with brick veneer. Floors are concrete slab. Internal walls are block and drywall.

In preparation for implementing the Final Status Survey, impacted reactor and support systems and components were removed and disposed of as radioactive waste or surveyed and released for use without radiological restrictions, and contaminated facility surfaces and materials were removed or decontaminated.

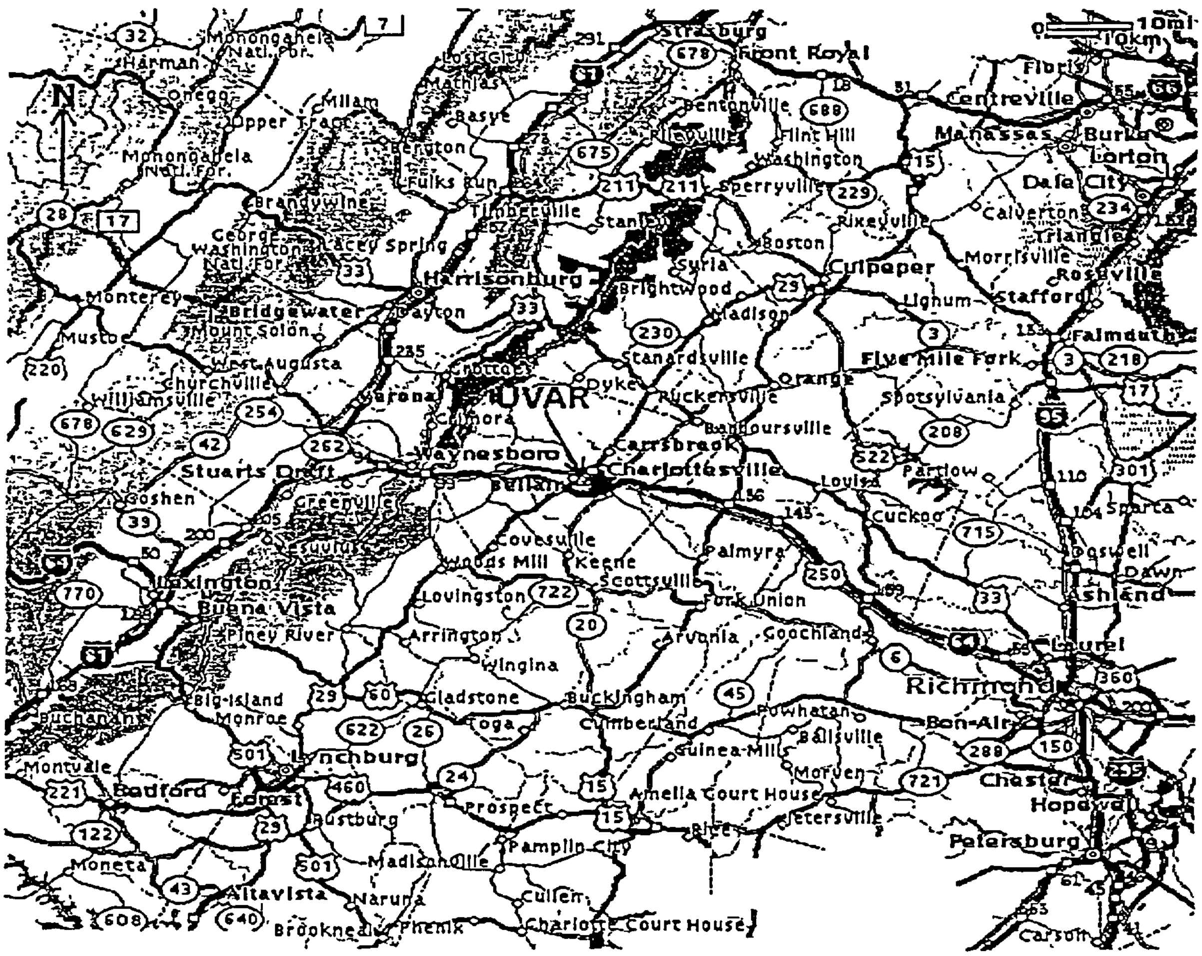


Figure 2-1 Map of Charlottesville Area Surrounding the UVAR Site

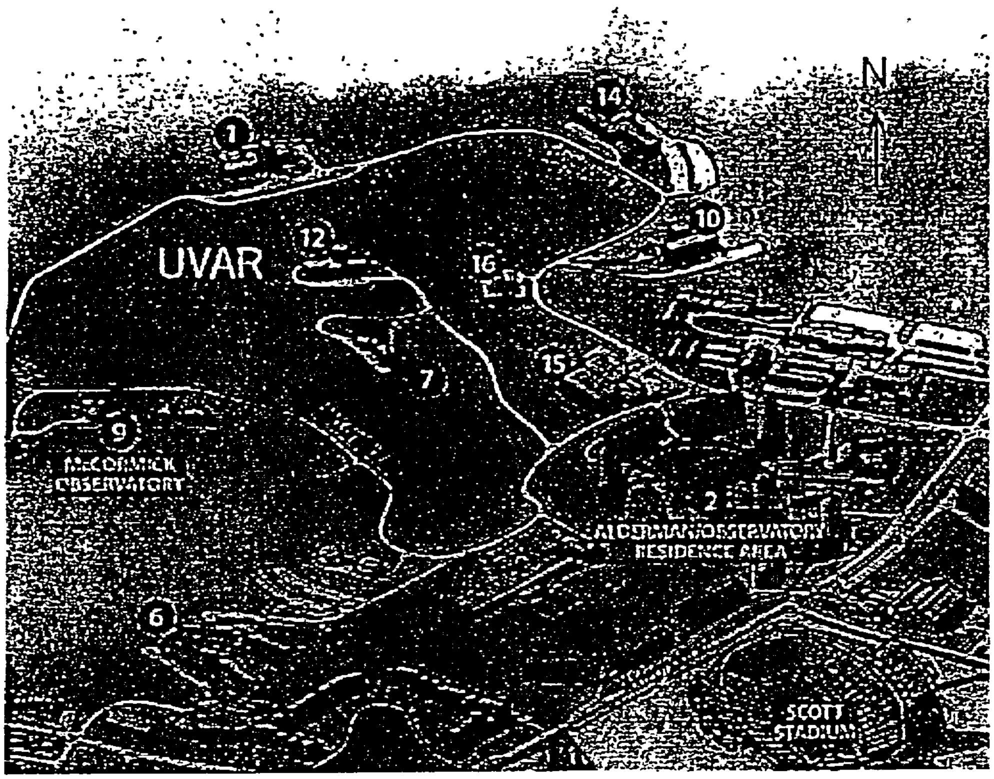
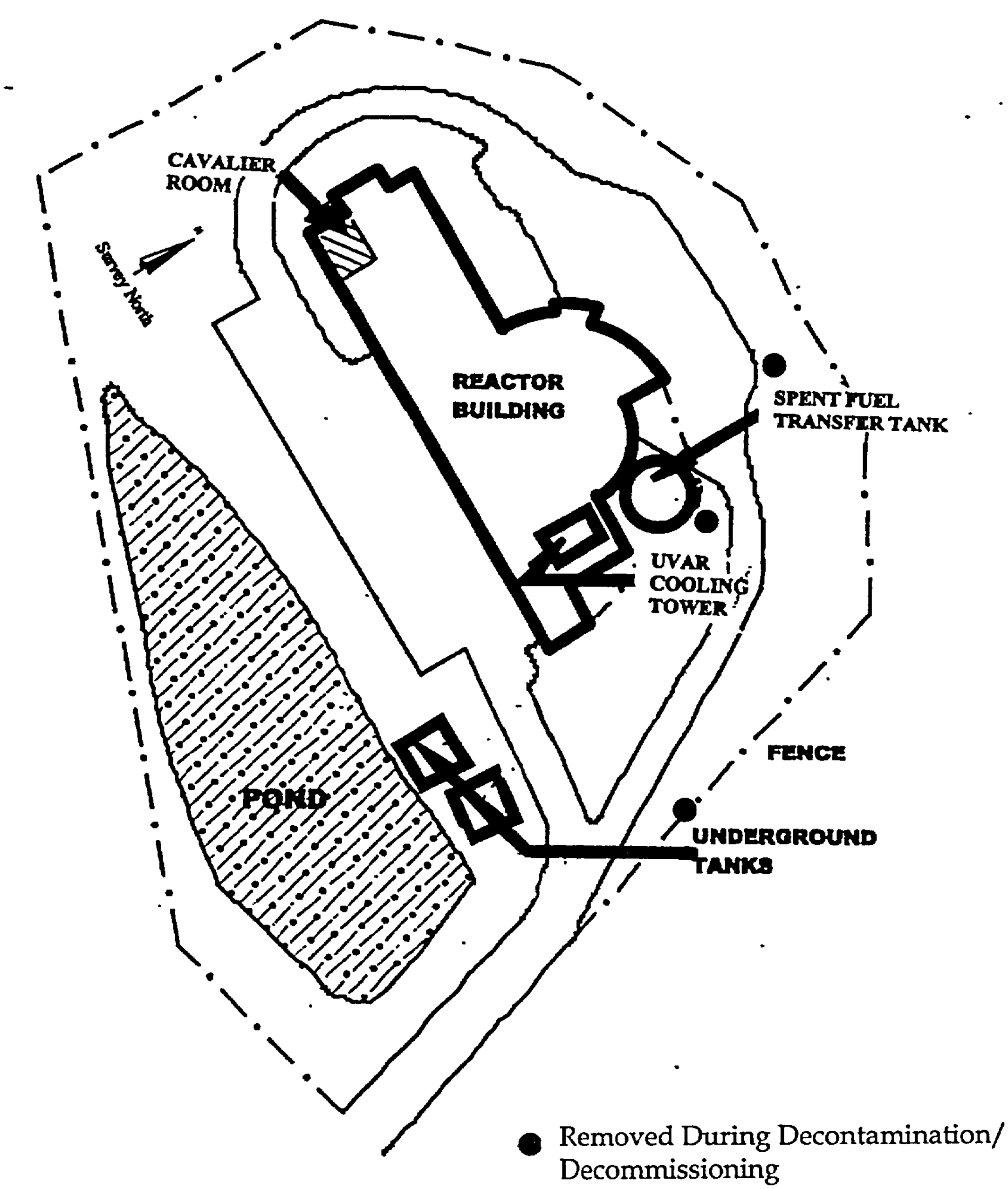


Figure 2-2 Northern Grounds of the University of Virginia

Location 12:	Reactor Facility
Location 1:	Aerospace Research Laboratory
Location 2:	Alderman Observatory Residence Area
Location 6:	Hereford Residential College
Location 7:	High Energy Physics Laboratory
Location 9:	McCormick Observatory
Location 10:	National Radio Astronomy Observatory
Location 14:	Shelbourne Hall
Location 15:	Slaughter Recreation Facility
Location 16:	Special Materials Handling Facility

Figure 2-3 University of Virginia Reactor Facility



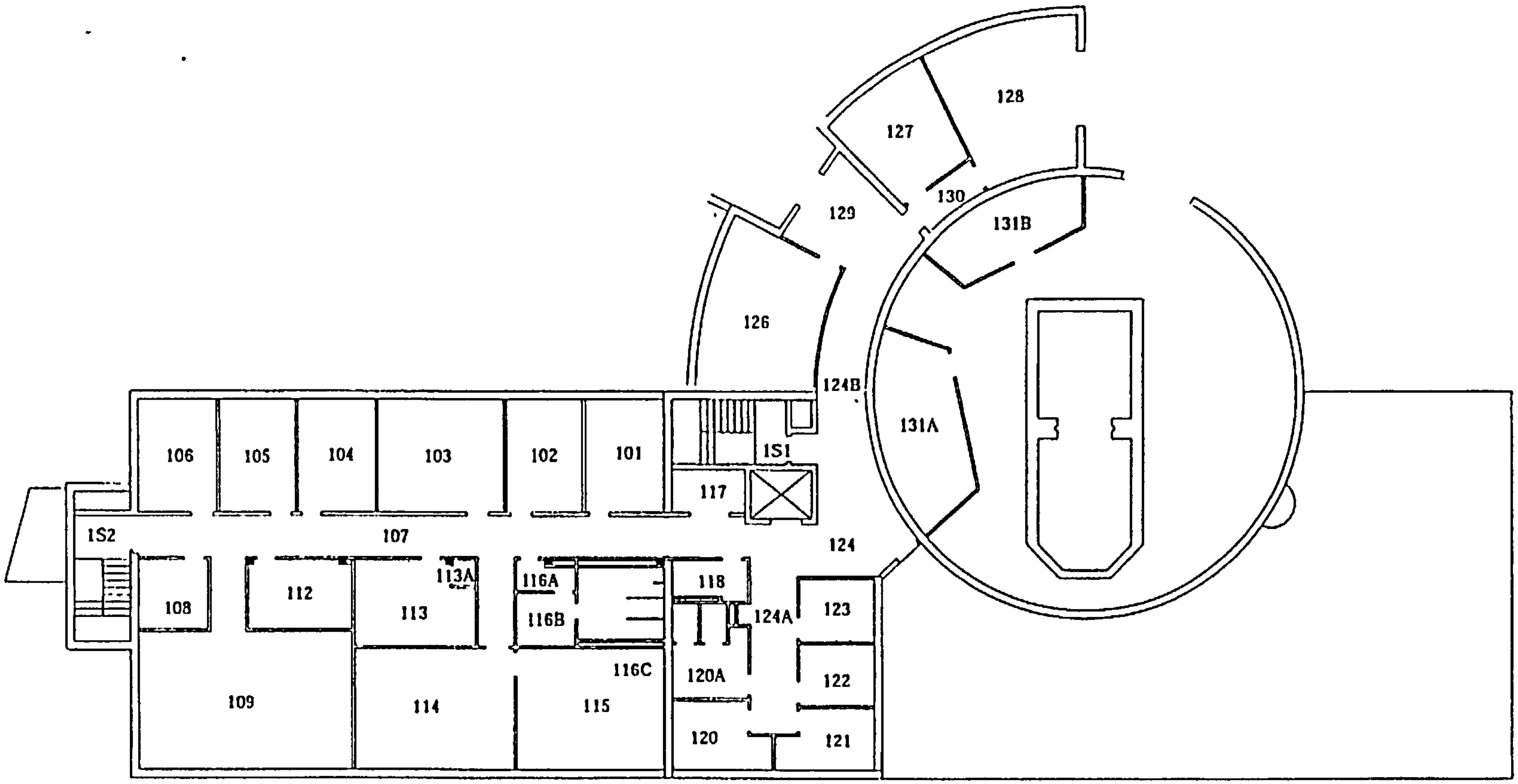


Figure 2-4 UVA Reactor First Floor Plan View

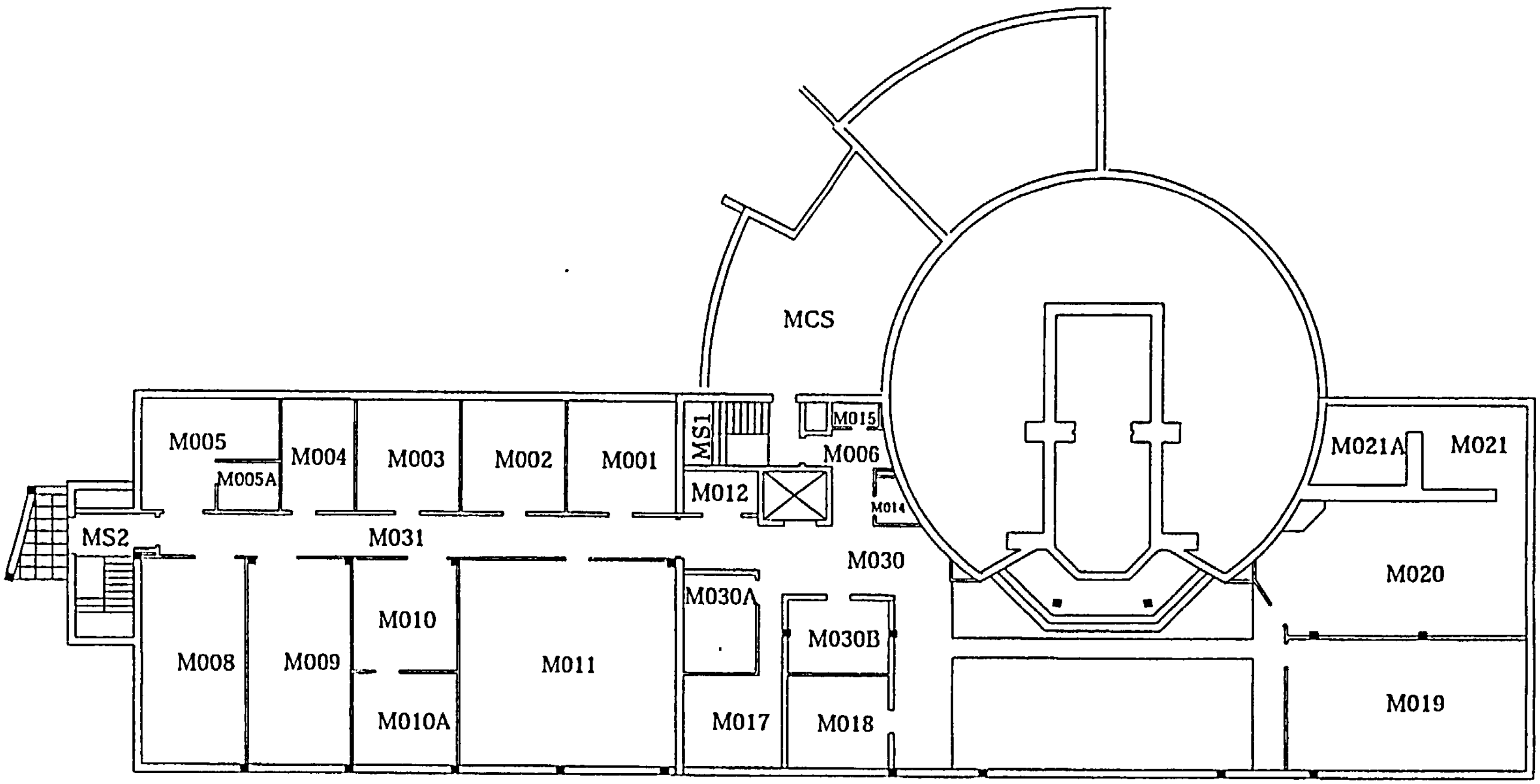


Figure 2-5 UVA Reactor Mezzanine Floor Plan View

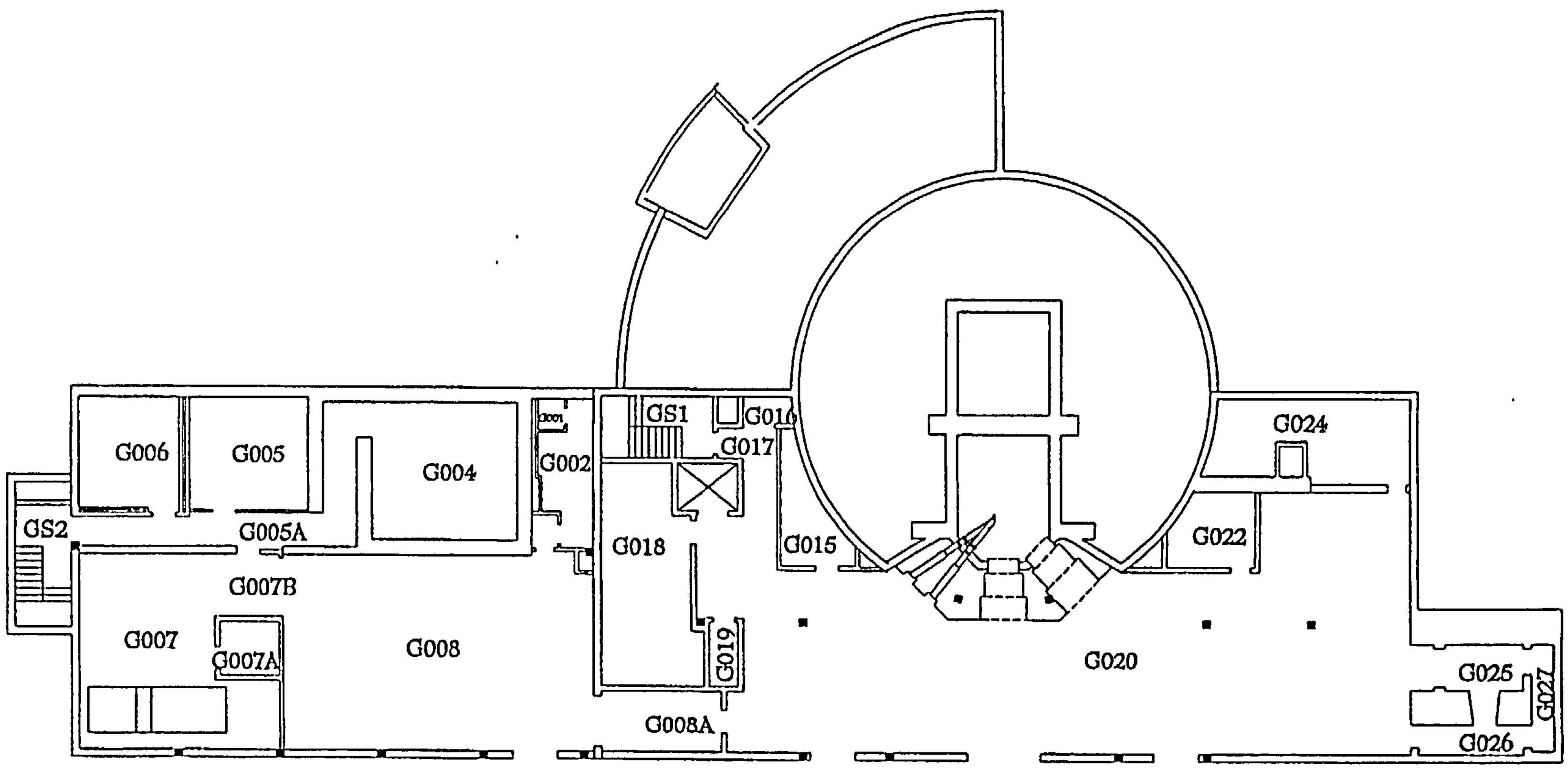


Figure 2-6 UVA Reactor Ground Floor Plan View

3. Survey Objective

The objective of the Final Status Survey (FSS) is to demonstrate that the radiological conditions of the UVAR facility building and grounds satisfy the approved radiological guidelines for unrestricted release and termination of NRC License No. R-66.

4. Organization and Responsibilities

A multi-organization team, led by CH2M HILL, is assisting the University of Virginia in this decommissioning project. Other team members include Safety and Ecology Corporation, Bartlett Nuclear Inc., WMG, Inc., and Parallax, Inc. This Section describes the organizational structure for FSS survey activities.

4.1 Project Manager

The Project Manager, Lark Lundberg, manages the day-to-day planning, organizing, scheduling, directing, coordinating, and controlling of project resources and budget and is the primary point of contact with the University of Virginia regarding project-related matters. The Project Manager monitors project status and performance to ensure implementation of the required technical, environmental, safety, health, radiation protection, quality assurance, and safeguards elements of the project.

4.2 Project Engineer

The Project Engineer, Patrick Ervin, assists the Certified Health Physicist and Radiological Control Supervisor in development of survey work packages, plans, and procedures; coordinates with the Radiological Control Supervisor to schedule and implement survey work activities; and assists the Project Manager in providing technical oversight of survey activities. The Project Engineer reviews and approves Final Status Survey Plans.

4.3 Environmental Safety and Health Manager

The Environmental Safety and Health Manager (ESHM), Mike Anderson, reports to the Project Manager and is responsible for oversight of all site radiological controls and radiation protection activities, as well as implementation of all industrial safety and industrial hygiene, and environmental monitoring requirements. The ESHM evaluates potential health and safety concerns, prepares hazard assessments for the activities, and assists in training personnel in the safe performance of these activities. The ESHM reviews and approves Final Status Survey Plans.

4.4 Certified Health Physicist/Characterization and Final Survey Supervisor

The Certified Health Physicist/ Characterization and Final Survey Supervisor, Jim Berger, assists the Project Engineer and Radiological Control Supervisor in development of survey work packages, plans, and procedures; provides oversight of the Radiological Control Supervisor to assure project requirements are satisfied and that radiological surveys are implemented in accordance with applicable work packages, plans, and procedures; and provides technical expertise in selection of survey methodologies and evaluation and interpretation of survey findings. He is responsible for technical adequacy of survey results and approves the final status survey report. He also provides assistance in resolution of NRC issues related to FSS.

4.5 Radiological Control Supervisor

The Radiological Control Supervisor (RCS), Frank Myers, develops survey work packages, plans, and procedures; develops Radiation Work Permit (RWP) and ALARA plans for surveys; determines that prerequisites for survey activities are satisfied; determines the level of survey coverage for various applications; selects appropriate survey instrumentation; oversees the performance of the surveys; evaluates survey results; and documents conclusions of survey evaluation.

4.6 Radiation Control Technicians

Radiation Control Technicians (RCTs) conduct survey activities in accordance with hazard assessment, RWP, and ALARA requirements and approved plans and operating procedures. RCTs analyze smears, convert data (as required), and document survey findings.

4.7 Quality Assurance Specialist

The Quality Assurance Specialist (Parallax, Inc.) provides periodic performance audits, inspections, and surveillances to assure the requirements of the Quality Assurance Project Plan and quality procedures are satisfied and that work plans and procedures being followed.

4.8 UVAR Technical Director

The UVAR Technical Director (Robert Mulder) is the University's representative for technical oversight of this decommissioning project. He will review and approve FSS plans and reports for technical adequacy in satisfying project and regulatory requirements.

5. Radiological Contaminants and Criteria

The GTS Duratek initial characterization survey and continuing characterization by the CH2M HILL team showed that radiological contamination was generally low level and was limited to a small portion of the structure and grounds. Depending on the mechanism of contamination and the medium, radionuclides and their relative ratios varied. The overall predominant radionuclide was Co-60; smaller activities of fission and activation products, namely Cs-137, C-14, Fe-55, and Eu-152 were identified in some media. Ni-63 and Tc-99 contaminants were present on facility surfaces from research projects in labs M008 and M005, respectively. Low levels of uranium and thorium decay series nuclides were identified in the pond sediments and some backfill material; however, these are of natural origin, rather than from licensed reactor operations.

The Decommissioning Plan established the criteria for residual radioactive material contamination on UVAR facility surfaces and in facility soil. UVAR facility criteria, also referred to as derived concentration guideline levels (DCGLs) are selected from the tables of NRC default screening values (refer to NUREG-1757, Ref. 3). The screening values for total surface contamination are listed in Table 3-1; guideline levels for removable activity are 10% of the values in that table. Screening values for contaminants in soil are listed in Table 5-2. These screening criteria are based on assuring that estimated doses to facility occupants and the public during future facility use do not exceed annual doses exceeding 25 mrem; default screening criteria are based on conservative exposure scenario and pathway parameters and are generally regarded as providing a high level of confidence that the annual dose limits will not be exceeded.

Aside from the contamination in labs M005 and M008, multiple radionuclides constituted the contamination on most UVAR surfaces and in facility soils and sediments. Review of historic data and analyses of characterization samples indicated different radionuclide mixtures associated with the following facility media and surfaces:

- Reactor pool surfaces
- Reactor Confinement Room surfaces
- Reactor coolant processing system surfaces
- Soil around the reactor pool
- Pond sediment
- Soil and components associated with liquid waste tanks

Additional radionuclide mixes were identified during this project. When such situations were encountered, representative samples were collected and analyzed for specific contents (gamma spectrometry and hard-to-detect analyses) and results were used to develop application-specific DCGLs.

Table 5-1 Acceptable License Termination Screening Values of Common Radionuclides for Structure Surfaces

Radionuclide	Symbol	Acceptable Screening Levels[a] for Unrestricted Release (dpm/100 cm^2)[b]
Hydrogen-3 (Tritium)	^{3}H	1.2E+08
Carbon-14	^{14}C	3.7E+06
Sodium-22	^{22}Na	9.5E+06
Sulfur-35	^{35}S	1.3E+07
Chlorine-36	^{36}Cl	5.0E+05
Manganese-54	^{54}Mn	3.2E+04
Iron-55	^{55}Fe	4.5E+06
Cobalt-60	^{60}Co	7.1E+03
Nickel-63	^{63}Ni	1.8E+06
Strontium-90	^{90}Sr	8.7E+03
Technetium-99	^{99}Tc	1.3E+06
Iodine-129	^{129}I	3.5E+04
Cesium-137	^{137}Cs	2.8E+04
Iridium-192	^{192}Ir	7.4E+04

Notes:

a Screening levels are based on the assumption that the fraction of removable surface contamination is equal to 0.1. For cases when the fraction of removable contamination is undetermined or higher than 0.1, users may assume for screening purposes that 100 percent of the surface contamination is removable, and therefore the screening levels should be decreased by a factor of 10. Users may calculate site-specific levels using available data on the fraction of removable contamination and DandD version 2.

b Units are disintegrations per minute (dpm) per 100 square centimeters (dpm/100 cm^2). One dpm is equivalent to 0.0167 becquerel (Bq). Therefore, to convert to units of Bq/m^2, multiply each value by 1.67. The screening values represent surface concentrations of individual radionuclides that would be deemed in compliance with the 0.25 mSv/y (25 mrem/y) unrestricted release dose limit in 10 CFR 20.1402. For radionuclides in a mixture, the "sum of fractions" rule applies (see Part 20, Appendix B, Note 4).

Table 5-2 Acceptable License Termination Screening Values of Common Radionuclides for Surface Soil

Radionuclide	Symbol	Surface Soil Screening Values[b]
Hydrogen-3	^{3}H	1.1E+02
Carbon-14	^{14}C	1.2E+01
Sodium-22	^{22}Na	4.3E+00
Sulfur-35	^{35}S	2.7E+02
Chlorine-36	^{36}Cl	3.6E-01
Calcium-45	^{45}Ca	5.7E+01
Scandium-46	^{46}Sc	1.5E+01
Manganese-54	^{54}Mn	1.5E+01
Iron-55	^{55}Fe	1.0E+04
Cobalt-57	^{57}Co	1.5E+02
Cobalt-60	^{60}Co	3.8E+00
Nickel-59	^{59}Ni	5.5E+03
Nickel-63	^{63}Ni	2.1E+03
Strontium-90	^{90}Sr	1.7E+00
Niobium-94	^{94}Nb	5.8E+00
Technetium-99	^{99}Tc	1.9E+01
Iodine-129	^{129}I	5.0E-01
Cesium-134	^{134}Cs	5.7E+00
Cesium-137	^{137}Cs	1.1E+01
Europium-152	^{152}Eu	8.7E+00
Europium-154	^{154}Eu	8.0E+00
Iridium-192	^{192}Ir	4.1E+01
Lead-210	^{210}Pb	9.0E-01
Radium-226	^{226}Ra	7.0E-01
Radium-226+C[c]	$^{226}Ra+C$	6.0E-01
Actinium-227	^{227}Ac	5.0E-01
Actinium-227+C	$^{227}Ac+C$	5.0E-01
Thorium-228	^{228}Th	4.7E+00

Radionuclide	Symbol	Surface Soil Screening Values[b]
Thorium-228+C[c]	$^{228}Th+C$	4.7E+00
Thorium-230	^{230}Th	1.8E+00
Thorium-230+C	$^{230}Th+C$	6.0E-01
Thorium-232	^{232}Th	1.1E+00
Thorium-232+C	$^{232}Th+C$	1.1E+00
Protactinium-231	^{231}Pa	3.0E-01
Protactinium-231+C	$^{231}Pa+C$	3.0E-01
Uranium-234	^{234}U	1.3E+01
Uranium-235	^{235}U	8.0E+00
Uranium-235+C	$^{235}U+C$	2.9E-01
Uranium-238	^{238}U	1.4E+01
Uranium-238+C	$^{238}U+C$	5.0E-01
Plutonium-238	^{238}Pu	2.5E+00
Plutonium-239	^{239}Pu	2.3E+00
Plutonium-241	^{241}Pu	7.2E+01
Americium-241	^{241}Am	2.1E+00
Curium-242	^{242}Cm	1.6E+02
Curium-243	^{243}Cm	3.2E+00

Notes:

a These values represent surficial surface soil concentrations of individual radionuclides that would be deemed in compliance with the 25 mrem/y (0.25 mSv/y) unrestricted release dose limit in 10 CFR 20.1402. For radionuclides in a mixture, the "sum of fractions" rule applies; see Part 20, Appendix B, Note 4.

b Screening values are in units of (pCi/g) equivalent to 25 mrem/y (0.25 mSv/y). To convert from pCi/g to units of becquerel per kilogram (Bq/kg), divide each value by 0.027. These values were derived using DandD screening methodology (NUREG/CR-5512, Volume 3). They were derived based on selection of the 90th percentile of the output dose distribution *for each specific radionuclide* (or radionuclide with the specific decay chain). Behavioral parameters were set at "Standard Man" or at the mean of the distribution for an average human.

c "Plus Chain (+C)" indicates a value for a radionuclide with its decay progeny present in equilibrium. The values are concentrations of the parent radionuclide but account for contributions from the complete chain of progeny in equilibrium with the parent radionuclide (NREG/CR-5512 Volumes 1, 2, and 3).

Specific guidelines for different surfaces and media depend on the nature of the surface or medium and the radionuclide mix. For soil and sediment contamination, concentrations of specific significant contaminants in FSS samples will be determined to demonstrate satisfying the unity rule; gross beta measurements will be used to demonstrate compliance with surface activity guidelines, with the gross beta DCGL based on measurements of surrogate contaminants with known relationships to the total contamination mix. Appendix A describes the approach for determining and implementing area-specific guidelines for FSS.

The criteria described in this section are net (above background) concentrations and activity levels of radionuclides; appropriate adjustments for instrument background levels and naturally occurring radionuclide concentrations in various local media will be made to FSS data before comparing data to the respective criteria.

Use of default screening values as decommissioning guidelines does not allow for areas of elevated activity. Therefore, there are no area factors for small areas of contamination, and all surface activity levels and radionuclide concentrations in soil must satisfy those guideline levels. In addition, because of use of the conservative default screening values, further evaluations and actions, relative to demonstrating the final conditions satisfy ALARA, are not required.

6. General Survey Approach

This survey plan was prepared in accordance with the guidelines and recommendations presented in the *"Multi-Agency Radiation Survey and Site Investigation Manual"* (MARSSIM), NUREG-1575, (Ref 4). Guidance provided in NUREG-1757, *"Consolidated NMSS Decommissioning Guidance"*(Ref. 3), is also followed in the design, implementation, and evaluation of this final status survey. The process emphasizes the use of Data Quality Objectives and Data Quality Assessment, along with a quality assurance/quality control program. The graded approach concept is followed to assure that survey efforts are maximized in those areas having the greatest potential for residual contamination or the highest potential for adverse impacts of residual contamination.

Final Status Surveys will be performed by trained radiological control technicians, who are following standard, written procedures and using properly calibrated instruments, sensitive to the potential contaminants. Appendix B contains a listing of the procedures applicable to this FSS.

The medium, dimensions, contamination potential (i.e., classification), and contaminant mix may differ for each area undergoing FSS; all factors influencing a specific survey design are typically not available until immediately before an area is turned over for FSS. Therefore, designs for specific surveys, including determination of specific guidelines, sampling/measurement methods, survey unit identification and classification, and data evaluation techniques, will be developed at the time of survey in accordance with the guidance presented in this Master Plan. Each design will be documented as an Addendum to the Master FSS Plan.

7. Survey Plan and Procedures

7.1 Data Quality Objectives

The objective of the FSS is to demonstrate that the radiological conditions of the facility satisfy the decommissioning criteria (see Section 5.0) established in the NRC-approved Decommissioning Plan. The Data Quality Objectives (DQOs) permit demonstration at the 95% confidence level that these criteria are met. Decision errors are 5% for both Type I and Type II errors. Such a Type I (alpha) decision error provides a confidence level of 95% that the statistical tests do not incorrectly determine that a surveyed area satisfies criteria when, in fact, it does not. The Type II (beta) decision error provides a confidence level of 95% that the statistical tests do not incorrectly determine that a surveyed area does not satisfy criteria when, in fact, it does. Measurement sensitivities ≤ 25% of $DCGL_W$'s enable quantification of contaminants at or below the guideline values at the 95% confidence level.

Data quality indicators for precision, accuracy, representativeness, completeness, and comparability, are as follows:

- Precision is determined by comparison of replicate values from field measurements and sample analyses; the objective is a relative percent difference of 20% or less at 50% of the guideline value.
- Accuracy is the degree of agreement with the true or known value; the objective for this parameter is +/- 20% at 50% of the guideline value.
- Representativeness and comparability do not have numeric values. Performance is assured through selection and proper implementation of sampling and measurement techniques.
- Completeness refers to the portion of the data that meets acceptance criteria and is thus acceptable for statistical testing; the objective for this survey is 90%.

7.2 Classification of Areas by Contamination Potential

For the purposes of guiding the degree and nature of FSS coverage, MARSSIM first classifies areas as *impacted*, i.e., areas that may have residual radioactivity from licensed activities, or *non-impacted*, i.e., areas that are considered unlikely to have residual radioactivity from licensed activities. Non-impacted areas do not require further evaluation. For impacted areas MARSSIM identifies three classifications of areas, according to contamination potential.

- Class 1 Areas: Impacted areas that, prior to remediation, are expected to have concentrations of residual radioactivity that exceed the guideline value.
- Class 2 Areas: Impacted areas that, prior to remediation, are not expected to have concentrations of residual radioactivity that exceed the guideline value.
- Class 3 Areas: Impacted areas that have a low probability of containing residual activity. Typically levels will not exceed 25-35% of the guideline value.

Facility history (including the Historic Site Assessment) and radiological monitoring conducted during characterization and remedial activities are the bases for classification.

7.3 Identification of Survey Units

Impacted areas are divided into survey units for implementing the FSS. A survey unit is a portion of a facility with common contaminants and contamination potential. A survey unit consists of contiguous surfaces or areas. Table 7-1 lists the survey unit areas suggested by MARSSIM for application at the UVAR facility, areas of survey units will follow these suggested maximum sizes.

Table 7-2 contains a list of facility areas by classification and a projected number of survey units within those areas. Classifications and survey unit boundaries may change, based on results as the FSS progresses if classifications or boundaries change, the survey for affected areas, as described in the applicable FSS Addendum, will be redesigned and the survey and data evaluation repeated.

Table 7-1 MARSSIM – Recommended Survey Unit Areas

Class	Recommended Survey Unit Area	
	Structures	Land
1	up to 100 m^2	up to 2000 m^2
2	100 to 1000 m^2	2000 to 10,000 m^2
3	no limit	no limit

Impacted structure surfaces of ≤ 10 m^2 and impacted land surfaces of ≤ 100 m^2 will not be designated as survey units. Instead, a minimum of 4 measurements (or samples) will be obtained from such areas, based on judgment, and compared individually with the $DCGL_W$.

7.4 Demonstrating Compliance with Guidelines

MARSSIM recommends the use of non-parametric statistical tests for demonstrating that radiological conditions satisfy the established project guideline levels. One of the recommended tests is the Wilcoxon Rank Sum (WRS) test; this WRS test may be used when a specific radionuclide of concern is present in background at a concentration greater than 10% of the guideline level and when the measurement is not radionuclide specific, e.g., for direct measurements of total surface activity. The other recommended test is the Sign test; this test is used when the radionuclide of concern is not present in background at a significant fraction (i.e., <10%) of the guideline level. The Sign test is also used when evaluating data based on the Unity Rule (Sum of Ratios) and may be used for surface activity data representing multiple surface media. Both of these tests are applicable to UVAR facility FSS. The selection of a specific test method will be designated at the time of area FSS design and documented in individual FSS Addenda. MARSSIM Section 8 and

Table 7-2 UVAR Survey Areas and Classifications

Room or Area	Surface	Class	Approximate Surface Area (m^2)	No. of Survey Units	Remarks
131 Reactor Room	Floor	1	130	2	
131 Reactor Room	Lower Walls	1	100	1	
Reactor Pool	Floor and Walls	1	150	2	
M005/005A	Floor and Lower Walls	1	45	1	
M008	Floor and Lower Walls	1	60	1	
M019	Floor and Lower Walls	1	80	1	
M020	Floor and Lower Walls	1	85	1	
M021/021A	Floor, Walls, and Ceiling	1	100	1	
Bio Shield Surfaces	Wall	1	100	1	
G005	Floor, Walls, and Ceiling	1	85	1	
G007/G007A	Floor, Pit and Lower Walls	1	100	1	
G018	Floor, Walls, and Ceiling	1	110	1	
G020	Floor and Lower Walls	1	300	3	
G022	Floor, Walls, and Ceiling	1	60	1	
G024	Floor, Walls, and Ceiling	1	100	1	
G025/G026/G027	Floor, Walls, and Ceiling	1	70	1	
Pond	Sediments	1	1600	1	
Waste tank area	Soil	1	350	1	
Outside Drains	Basins and piping	1	N/A	1	Sanitary, storm, and surface
Reactor Stack		1	N/A	1	Ductwork, stacks, blowers
Other Vent systems		1	N/A	2	Ductwork, stacks, blowers
Reactor Piping/Drain Systems	Piping Interior	1	N/A	7	Coolant piping, drain systems

Table 7-2 UVAR Survey Areas and Classifications (continued)

Room or Area	Surface	Class	Approximate Surface Area (m^2)	No. of Survey Units	Remarks
131 Reactor Room	Upper Walls and Ceiling	2	420	1	
127/128/130	Floor, Walls, and Ceiling	2	180	1	
107/124/124A/124B	Floor and Lower Walls	2	250	1	
M005/005A	Upper Walls and Ceiling	2	30	1	
M008	Upper Walls and Ceiling	2	40	1	
M019	Upper Walls and Ceiling	2	60	1	
M020	Upper Walls and Ceiling	2	65	1	
M006/M014/M015/M030/M031	Floor and Lower Walls	2	250	1	Includes catwalk over G020
MCS (crawl space)	Floor, Walls, and Ceiling	2	100	1	Possible soil samples also
G004/G005A	Floor and Lower Walls	2	100	1	
G006	Floor and Lower Walls	2	70	1	
G007B/G008/G008A/G016/G017/G019	Floor and Lower Walls	2	150	1	
Stairwell 1	Floor and Lower Walls	2	300	1	
Stairwell 2	Floor and Lower Walls	2	300	1	
Reactor Room Roof	all	2	140	1	
Building Roof	all	2	700	1	
Outside Paved Surfaces	all	2	2000	2	Rear Loading Area/Remainder
Soil Area NE of Reactor	soil	2	800	1	
Remainder of structure	Floors, walls, and Ceiling	3	4500	3	
Remainder of Property	Soil	3	4000	1	

NUREG-1505 (Ref. 5) contains details on data assessment/interpretation and selection and application of these statistical tests. Also refer to Section 8 of this Plan.

The Null Hypothesis (H_o) for each survey unit is that residual activity exceeds the guideline levels. Rejection of the Null Hypothesis by the statistical test therefore concludes that the residual activity does not exceed guidelines and the survey unit satisfies requirements for unrestricted release.

7.5 Background Reference Areas and Materials

In addition to the instrumentation background response, many construction materials and environmental media (e.g., soil/sediment) contain naturally occurring levels of radioactive materials, which contribute to a survey measurement. Background contributions must therefore be determined, if 1) the residual contamination includes a radionuclide that occurs in background or 2) measurements are not radionuclide-specific. Multiple reference areas and materials are anticipated to be required for the UVAR FSS. For applications involving the WRS test, reference areas must be of the same material as the survey unit being evaluated, but without a history of potential contamination by licensed operations; the number of reference data points must be the same (+/- 20%) as the number of data points required from the survey unit. A set of reference measurements must be obtained for each instrument being used for survey unit evaluation. For applications involving the Sign test, sufficient background determinations should be made for each media or surface material and with each instrument to provide an average background level that is accurate to within +/- 20%; this usually requires 8 to 10 measurements, which are then evaluated using the procedure described in draft NUREG/CR-5849 (Ref. 6) and additional data points obtained, as necessary. Reference area and background requirements will be identified in individual FSS Addenda.

7.6 Instrumentation

Table 7-3 lists principal instrumentation to be used for survey activities described in this Plan, along with nominal operating parameters and estimated detection sensitivities. As survey conditions and situations require, instruments that are the functional equivalent of those listed in Table 7-3 and additional, special-application instruments may be used for FSS. Individual FSS addenda will document any such instrument additions and substitutions. Because radionuclides present as contaminants emit (with few exceptions) beta particles with maximum energy greater than 0.300 MeV, detector efficiencies for measuring surface activity are generally determined using Tc-99 (maximum beta energy of approximately 0.292 MeV). For situations where contaminants emit beta particles of lower energy, e.g., facilities contaminated with Ni-63, detector efficiencies are specifically determined for those contaminants. Effects of surface conditions on measurements are integrated into the overall instrument response through use of a "source efficiency" factor, in accordance with the guidance in ISO-7503-1 (Ref. 7) and NUREG-1507 (Ref. 8). Default source efficiency factors, of 0.5 for beta-emitters > 0.4 MeV E_{max} and 0.25 for beta-emitters between 0.150 MeV and 0.400 MeV E_{max} (per ISO-7503-1) are generally applicable to UVAR contaminants and surface conditions. However, if contaminants and/or conditions are not consistent with use of these default values specific source efficiency factors will be determined and documented in the FSS Addendum.

Detection sensitivities are estimated, using the guidance in NUREG-1575 (MARSSIM) and NUREG-1507. Instrumentation and survey techniques are chosen with the objective of achieving detection sensitivities of ≤ 25% of the criteria for structure surfaces, for both scanning and direct measurement. This assures identification of areas of elevated activity, having a size and activity level that could adversely impact the average for the survey units.

All instruments have current calibrations using NIST-traceable standards. Operational and background checks will be performed at the beginning of each day of FSS activity and whenever there is reason to question instrument performance. Defective instruments will be removed from service and data obtained with that instrument since its previous acceptable performance, will not be accepted.

Table 7-3 Instrumentation for UVAR Final Status Survey

Detector	Type	Make	Meter	Application	Estimated Sensitivity (dpm/100 cm², except as noted)	
					Scanning	Static Count (1 minute)
43-68	Gas Proportional	Ludlum	2221	Beta scan & measurement	1200	500
43-68	Gas Proportional	Ludlum	2221	Ni-63 Beta scan and measurement	5000	2000
43-37	Floor Monitor	Ludlum	2221	Beta scan	800	N/A
43-68	Gas Proportional	Ludlum	2221	Alpha measurement	200	70
Tennelec LB5100	Gas proportional	Tennelec	N/A	Alpha smear measurement	N/A	5
Tennelec LB5100	Gas proportional	Tennelec	N/A	Beta smear measurement	N/A	10
44-10	NaI	Ludlum	2221	Gamma scan	10 pCi/g	N/A
491-30	GM	Victoreen	2221	Beta scan & measurement of piping	3500	2300

7.7 Survey Reference Systems

A grid system is established on surfaces to provide a means for referencing measurement and sampling locations. On Class 1 and 2 structure surfaces, a 1-m interval grid will be established; a 5-m interval grid will be established on Class 3 structure surfaces; and a 10-m interval grid will be established for land area surfaces. Grid systems typically originate at the southwest corner of the survey unit, but specific survey unit characteristics may necessitate alternate grid origins. Grids are assigned alphanumeric indicators to enable survey location identification. Structure grids are referenced to building features; open land grids are referenced to the state or federal planar grid system. Maps and plot plans of survey areas will include the grid system identifications. Systems and surfaces of less than 20 m^2 will not be gridded, but survey locations will be referenced to prominent facility features.

7.8 Determining Data Requirements

Data needs for statistical tests are determined as follows:

1. Calculate the relative shift (Δ/σ)

   Δ/σ = DCGL - LBGR

   The DCGL is the gross or nuclide specific guideline (per Appendix A)
   The LBGR (the Lower Bound of the Gray Region) is initially selected as ½ of the DCGL as recommended by MARSSIM.
   σ should be determined empirically from actual survey data, however, for planning purposes, a value of 25% of the DCGL will be used.
   The resulting relative shift is 2, which is within the range of 1 to 3, recommended by MARSSIM.

2. Determine decision errors

   The DQOs for this project establish decision errors of 0.05 for both Type I and Type II errors.

3. Determine the number of data points required

   The number of data points required for statistical testing is obtained from MARSSIM Tables 5.3 (WRS test) and 5.5 (Sign test). For a relative shift of 2 and decision errors of 0.05, the number of data points for the WRS test is 13 and the number for the Sign test is 15. These numbers of data points include an additional 20% to allow for potential sample loss and QC.

The number of data points is determined in this manner for each survey unit undergoing FSS. The determination is documented in the FSS Addendum applicable to that survey unit.

7.9 Determining Data Point Locations

MARSSIM recommends a triangular measurement or sampling pattern to increase the probability of identifying small areas of residual activity. This type of triangular pattern is used for this FSS, except where dimensions and/or other factors related to a specific survey unit require use of an alternate pattern. The spacing (L) between data points on a triangular pattern is determined by:

$$L = [(\text{Survey Unit Area})/(0.866 \times \text{number of data points})]^{1/2}$$

To simplify the designation of data points while assuring a sufficient number of data points are obtained for statistical purposes, the value of L is rounded to the nearest whole meter. If the systematic pattern does not provide sufficient data points to satisfy the number determined in Section 7.8, additional data points will be identified, using a random-number technique.

7.10 Integrated Survey Strategy

Data collected for FSS of structure surfaces will consist of scans to identify locations of residual contamination; direct measurements of beta surface activity; and measurements of removable beta surface activity. FSS of open land (soil) areas will consist of scans to identify locations of residual contamination and samples of soil, analyzed for potential contaminants. Additional measurements and samples will be obtained, as necessary, to supplement the information from these typical survey activities. Survey techniques are described in more detail in this Section.

7.10.1 Beta Surface Scans

Beta scanning of structure surfaces will be performed to identify locations of residual surface activity. Gas-flow proportional detectors will be used for beta scans. Floor monitors with 580 cm^2 detectors will be used for floor and other larger accessible horizontal surfaces; hand-held 125 cm^2 detectors will be used for surfaces not assessable by the floor monitor. Scanning will be performed with the detector within 0.5 cm of the surface (if surface conditions prevent this distance, the detection sensitivity for an alternate distance will be determined and the scanning technique adjusted accordingly). Scanning speed will be no greater than 1 detector width per second. Audible signals will be monitored and locations of elevated direct levels identified for further investigation.

Minimum scan coverage will be 100% for Class 1 surfaces, 25% for Class 2 surfaces, and 10% for Class 3 surfaces. Coverage for Class 2 and Class 3 surfaces will be biased towards areas considered by professional judgment to have highest potential for contamination.

7.10.2 Gamma Surface Scans

Gamma scanning surfaces will be performed on structure and land surfaces to identify locations of residual surface activity. NaI gamma scintillation detectors (2" x 2") will be used for these scans. Scanning will be performed by moving the detector in a serpentine pattern, while advancing at a rate of approximately 0.5 m per second. The distance between the detector and the surface will be maintained within 5 cm of the surface. Audible signals will be monitored and locations of elevated direct levels identified for further investigation.

Minimum scan coverage will be 100% for Class 1 surfaces, 25% for Class 2 surfaces, and 10% for Class 3 surfaces. Coverage for Class 2 and Class 3 surfaces will be biased towards areas considered by professional judgment to have highest potential for contamination.

7.10.3 Surface Activity Measurements

Direct measurement of beta surface activity will be performed at designated locations (see Section 7.9) using a 125-cm^2-gas flow detector. Measurements will be conducted by integrating the count over a 1-minute period. Where adverse surface conditions may result in underestimating activity by direct measurements, surface samples will be obtained for laboratory analyses. Need for such sampling will be identified in FSS Addenda for specific survey units.

7.10.4 Removable Activity Measurements

A smear for removable activity will be performed at each direct surface activity measurement location. A 100 cm^2 surface area will be wiped with a 2" diameter cloth or paper filter, using moderate pressure.

7.10.5 Soil Sampling

Sample of surface (upper 15 cm) soil will be obtained from selected locations (Section 7.9) using a hand trowel or bucket auger. Approximately 500 to 1000 g of soil will be collected at each sampling location.

8. Data Evaluation and Interpretation

8.1 Sample Analysis

Smears for removable activity will be analyzed by the on-site laboratory for gross alpha and gross beta activity. Analyses of samples of soil and other volumetric media may include gamma spectrometry and/or wet chemistry analyses, depending on radionuclides anticipated. Individual FSS Addenda will describe analyses to be performed.

8.2 Data Conversion

Measurement data will be converted to units of dpm/100 cm^2 or pCi/g for comparison with guidelines and/or for statistical testing. Where appropriate for Sign tests, data will be adjusted for material and instrument background contributions; data for WRS tests will not be corrected for background, but, instead, will be compared with the data from a reference area.

8.3 Data Assessment

Data will be reviewed to assure that the type, quantity, and quality are consistent with the survey plan and design assumptions. Data standard deviations will be compared with the assumptions made in establishing the number of data points. Individual and average data values will be compared with guideline values and proper survey area classifications will be confirmed. Individual measurement data in excess of the guideline level for Class 2 areas and in excess of 25 % of the guideline for Class 3 areas will prompt investigation. Patterns, anomalies, and deviations from design assumption and Plan requirements will be identified. Need for investigation, reclassification, remediation, and/or resurvey will be determined; a resolution will be initiated and the data conversion and assessment process repeated for new data sets.

8.4 Determining Compliance with Guidelines

8.4.1 WRS Test

For a structure surface survey unit to be evaluated using the WRS test, individual survey unit net total activity measurements and the average of the total net activity measurements will be calculated, using the average reference area level; also, the difference between the highest survey unit and lowest reference area measurements will be calculated.

If the difference between the highest survey unit and lowest reference area measurements is less than the guideline level, the survey unit satisfies the criterion and no further evaluation will be necessary.

If the average net surface activity value is greater than the guideline, the survey unity does not satisfy the criterion, and further investigation, remediation, and/or resurvey is required.

If the average net surface activity value is less than the guideline value, but the difference between any survey unit and reference area activity measurement is greater than the guideline, data evaluation by the WRS test proceeds, as follows:

- List each of the survey unit measurements and reference area measurements; do not correct these data for background
- Add the guideline value to each reference area measurement (for surface activity add the calculated instrument response equivalent of the guide line to the reference area measurements); these are known as adjusted reference area measurements
- Rank all (survey unit and reference area) measurements in order of increasing size from 1 to N, where N is the total number of pooled measurements
- If several measurements have the same value, assign them the average ranking of the group of tied measurements.
- If there are "less-than" values, they are all assigned the average of the ranks from 1 to t, where t is the number of "less-than" values.
- Sum the ranks of the adjusted reference area measurements; this value is the test statistic, W_R.
- Compare the value of W_R to the critical value in MARSSIM Table I.4 for the appropriate sample size and decision level.

If W_R is greater than the critical value, the null hypothesis is rejected, and the survey unit meets the established criteria. If W_R is smaller than the critical value, the null hypothesis is accepted, and the survey unit does not meet the established criteria; investigation, remediation, reclassification, and/or resurvey should be performed as appropriate.

8.4.2 Sign Test

For an open land or structure surface survey unit to be evaluated using the Sign test, individual activity values and the average activity value will be calculated.

If all values for a survey unit are less than the guideline level, that survey unit satisfies the criterion and no further evaluation is necessary.

If the average activity value is greater than the guideline, the survey unit does not satisfy the criterion, and further investigation, remediation, and/or resurvey is required.

If the average activity value is less than the guideline level, but some individual values are greater than less than the guideline, data evaluation by the Sign test proceeds, as follows:

- List each of the survey unit measurements
- Subtract each measurement from the guideline level
- Discard all differences which are "0"; determine a revised sample size
- Count the number of positive differences; this value is the test statistic, S+
- Compare the value of S+ to the critical value in MARSSIM Table I.3 for the appropriate sample size and decision level.

If S+ is greater than the critical value, the null hypothesis is rejected, and the survey unit meets the established criteria. If S+ is smaller than the critical value, the null hypothesis is accepted, and the survey unit does not meet the established criteria; investigation, remediation, reclassification, and/or resurvey should be performed, as appropriate.

8.4.3 Unity Rule Sign Test

For an open land or structure surface survey unit to be evaluated using the Unity Rule Sign test, individual activity values and the ratios of the activity values to their respective guideline values will be calculated. For each data location add the ratios together to determine the *Sum of Ratios.*

If all Sum of Ratios values for the survey unit are less than 1, that survey unit satisfies the criterion and no further evaluation is necessary.

If the average Sum of Ratios value is greater than the guideline, the survey unit does not satisfy the criterion, and further investigation, remediation, and/or resurvey is required.

If the average Sum of Ratios value is less than 1, but some individual values are greater than 1, data evaluation by the Sign test proceeds, as follows:

- List each of the survey unit Sum of Ratios value.
- Subtract each value from 1.
- Discard all differences which are "0" determine a revised sample size.
- Count the number of positive differences; this value is the test statistic, S+.
- Compare the value of S+ to the critical value in MARSSIM Table I.3 for the appropriate sample size and decision level.

If S+ is greater than the critical value, the null hypothesis is rejected, and the survey unit meets the established criteria. If S+ is smaller than the critical value, the null hypothesis is accepted, and the survey unit does not meet the established criteria; investigation, remediation, reclassification, and/or resurvey should be performed, as appropriate.

9. Final Status Report

A report, describing the survey procedures and findings, will be prepared and provided to the University of Virginia for submission in support of license termination. Report format and content will be consistent with the recommendations presented in Chapter 9 of draft NUREG/CR-5849.

10. Works Cited

1. Characterization Survey Report for the University of Virginia Reactor Facility, GTS Duratek, March 2000.
2. University of Virginia Reactor Decommissioning Plan, GTS Duratek, February 2000.
3. Consolidated NMSS Decommissioning Guidance, NUREG-1757, September 2002.
4. Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), NUREG-1575, June 2001.
5. A Non-parametric Statistical Methodology for the Design and Analysis for Final Decommissioning Surveys, NUREG-1505.
6. Manual for Conduction Radiological Surveys in Support of License Termination, NUREG/CR-5849, June 1992.
7. Evaluation of Surface Contamination -Part 1: Beta Emitters (maximum beta energy greater than 0.15 MeV) and Alpha Emitters, ISO-7503-1, First Edition 1988-08-01.
8. Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions, NUREG-1507, December 1997.

APPENDIX A

Approach for Development of FSS Guidelines

Appendix A

Approach for Development of FSS Guidelines

Introduction

Application of dose-based UVAR facility guidelines for situations where multiple radionuclide contaminants are present requires consideration of the contribution of each radionuclide, relative to its specific guideline value. The particular radionuclides present at significant levels, the nature of the contamination (surface activity or volumetric), and the methods used to evaluate the radiological conditions (e.g., direct measurement of gross activity, radionuclide-specific analyses, or use of surrogate measurements) necessitate different approaches for developing appropriate guidelines for implementing the FSS. This document describes the methods for determining guidelines.

A. Determine the Mix of Radionuclide Contaminants

1. Tabulate the sample results (activity or concentration) for each of the analytes from nuclide-specific analyses. Consider non-detects (MDAs or MDCs) as actual levels. *(Note: Samples with low activity levels may result in MDA or MDC values which are a significant fraction of the total activity and will incorrectly overestimate the contributions from non-detectable radionuclides in the total contaminant mix. Therefore samples containing higher levels of the representative radionuclide mix of interest should be selected for this determination.)*

2. Adjust these results by eliminating radionuclides not associated with the licensed operation and by subtracting average natural background levels.

3. Calculate the total activity or concentration of adjusted levels in the sample and the individual fractional contribution of each radionuclide of interest.

4. Obtain the $DCGL_w$ guideline value equivalent to 25 mrem/y for each radionuclide from the appropriate (surface activity or soil) Table of NRC default screening values.

5. Divide the adjusted activity or concentration determined in step 2 by the respective guideline (step 4).

6. Add the values determined in step 5 and then normalize each of the individual contributions, based on a total of 1. The results provide the fractional contribution of each of the radionuclides present to the total dose from the mixture.

7. Repeat steps 1 – 6 for all samples from the survey area of interest. If there is justification to anticipate a consistent contaminant mix or the area of concern is being

treated as a single survey unit, a composite sample may be used for determining the representative radionuclide mix.

8. Determine the average and standard deviation of the fractional contributions from each radionuclide.

9. Eliminate radionuclides that may be considered insignificant contributors because, in total, they account for less than 10% of the dose for the mixture.

10. Recalculate the normalized activity contributions and dose contributions for the remaining significant radionuclides. The result is the radionuclide mix, which will be used for FSS purposes.

B. Establish the Gross Beta Surface Activity Guideline of a Mixture

1. Using the fractional contributions (f_1 to f_n) and respective surface activity DCGL for each radionuclide from step A.10, calculate the gross activity ($DCGL_{gross}$) as follows:

$$DCGL_{gross} = \frac{1}{\frac{f_1}{DCGL_1} + \frac{f_2}{DCGL_2} + \ldots + \frac{f_n}{DCGL_n}}$$

2. Adjust the $DCGL_{gross}$ to reflect the total activity fraction (R_1 to R_n) of detectable beta emitting radionuclides in the mix:

$$DCGL_{adjgross} = \frac{1}{\frac{1}{DCGL_{gross}} + \frac{R_1}{DCGL_1} + \frac{R_2}{DCGL_2} + \ldots + \frac{R_n}{DCGL_n}}$$

The resulting value is the adjusted gross beta activity applicable to FSS surface measurements for this contaminant mix.

C. Establish a Soil Guideline

1. For multiple contaminants in soil, the Unity Rule is applicable. This means that the sum of the ratios of concentrations present to their respective $DCGL_w$'s from the NRC Table of soil default screening values must be ≤ 1.

$$\frac{C_1}{DDCL_1} + \frac{C_2}{DCGL_2} + \ldots + \frac{C_n}{DCGL_n} \leq 1$$

Where

C_n = concentration of each individual radionuclide (1, 2, ...n)

$DCGL_n$ = guideline value for each individual radionuclide (1,2,..., n)

In other words, there is not a single soil guideline for the radionuclide mix, but, rather, a group of guidelines applicable to each radionuclide and a Unity Rule applicable to the sum of ratios.

2. An extension of the Unity Rule is to infer levels of certain contaminants from measurements of other contaminants; this is known as a "surrogate measurement" approach. Based on the established nuclide mix, one or more easily measured radionuclides that are representative of (surrogates for) the levels of other contaminants are identified. The level of a surrogate radionuclide, which would assure that the total from all contaminants represented by that surrogate will satisfy the Unity Rule, is calculated by multiplying the radionuclide $DCGL_w$ from the NRC screening value table by the dose contribution fraction of that surrogate radionuclide in the contaminant mix (from step A.10). The resulting value is the $DCGL_{SUR}$ applicable to the surrogate radionuclide. If there is more than one surrogate guideline value ($DCGL_{SUR}$) used for an evaluation, the Unity Rule is applied for the sum of ratios of each surrogate measurement to its respective $DCGL_{SUR}$.

APPENDIX B

List of Procedures

Applicable to UVAR Final Status Surveys

List of Procedures Applicable to UVAR Final Status Surveys

BJC-EH-4536	Portable Instrument Response and Operability Tests
SEC-IO-701	Radiological Measurement Instrumentation Quality Content Checks (forms only, used with procedure BJC-EH-4536)
SEC-IO-702	Calculating Detection Sensitivity
SEC-IO-703	Reference Grid System
SEC-IO-704	Surface Scanning
SEC-IO-705	Background Measurement and Baseline Sampling
SEC-IO-706	Direct Surface Activity Measurement
SEC-IO-707	Removable Surface Activity Measurement
SEC-IO-723	Operating Instructions for the Ludlum Model 2221
SEC-IO-726	Operating Instructions for the Ludlum 239-1F Floor Monitor
SEC-IO-727	Operation of the Tennelec LB5100W Automatic Counting System
SEC-IS-401	Instrumentation and Calibration
SEC-IS-402	Training of Instrumentation and Calibration Personnel
SEC-IS-403	Calibration of Ludlum Model 2221
SEC-IS-407	Calibration of Beta/Gamma Pancake Probes
SEC-IS-415	Calibration of High Energy Gamma Scintillation Probes
SEC-IS-417	Calibration of Gas Flow Proportional Probes
SEC-IS-426	Calibration of the Tennelec Low Background Counting System
SEC-EM-301	Waste Sampling
SEC-EM-302	Surface Water Sampling
SEC-EM-303	Groundwater Sampling
SEC-EM-304	Sediment Sampling
SEC-EM-305	Soil Sampling
SEC-EM-308	Laboratory Requests and Chain of Custody
SEC-EM-311	Sampling Information and Data Management
SEC-EM-312	Documentation and Logbooks
SEC-QA-001	Corporate Quality Management Program
SEC-QA-901	Audit Program
SEC-QA-908	Storage and Maintenance of Records
SEC-QA-909	Field Change Notice and Field Change Request