Characterization Survey Plan

Revision 3

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- ☐ Non-Proprietary
- ☒ Proprietary
- ☐ Restricted Information
- ☐ Safeguards Information
- ☐ Sensitive Security Information

- ☐ New
- ☐ Title Change
- ☒ Revision
- ☐ Rewrite
- ☐ Cancellation

Effective Date: ______________________

RECORD OF REVISIONS

Revision	Revision Title Description and Reason for Change
0	Initial issue. New FCS License Termination (LT) plan/procedure.
1	2.2: updated records procedure references 3.1: added definitions for survey package and sample plan 3.2: updated responsibilities and added LT/FSS Instrumentation Specialist 4.2.1: added note allowing for grouping of like survey units Table 4-2: corrected name of Storage Shed Figure 4-5 added, which shows structure survey units 4.3: provided note regarding need to have NRC agreement on ROCs 4.4.4: added discussion of limited characterization in the note 4.5.1.E: added clarification about reclassification 4.5.5.D.6: added discussion of hollow bit volumetric concrete collection
2	Table 4-2: added 9000 series of survey units (Miscellaneous SSC) and clarified the classifications of survey units 8400, 8500, and 8600 Figure 4-5: corrected survey unit 5300 to Class 2 and survey units 4700 and 4800 to Class 3 on map, corrected the placements of survey units 5500 and 5600 4.2.7: added additional guidance on activities that will not require this procedure to be revised 2.2: updated records procedure reference
3	2.1.4 and Table 4-8: Removed reference to Regulatory Guide 4.8, as this Regulatory Guide was withdrawn by the NRC

Table of Contents

1 PURPOSE AND SCOPE

1.1 Purpose

This document provides guidance and direction to personnel responsible for planning, designing, implementing, and assessing characterization survey activities. The Characterization Survey Plan will work in conjunction with the License Termination Plan (LTP), implementing procedures, and survey unit specific survey instructions (sample plans) developed to safely and effectively acquire any requisite characterization data.

Characterization data acquired through the execution of this plan is used to meet three primary objectives:

- Ensure that the Final Status Survey (FSS) provides the expected results.
- Ensure that the radiological conditions and assumptions to be used in the LTP to derive site-specific unrestricted release criteria for the Fort Calhoun Station (FCS) Decommissioning Project are valid.
- Support the evaluation of remediation alternatives and technologies.

The term “Final Status Survey” is from 10 CFR 50.82(9) (ii) (D) and is used in the LTP to specify the compliance surveys to be performed by the License Termination (LT)/FSS Group. These surveys are conducted in accordance with NUREG-1575, “Multi-Agency Radiation Survey and Site Investigation Manual” (MARSSIM) (Reference 2.1.1) on soil, buried piping, structures (including penetrations and embedded piping) and groundwater to demonstrate that residual radionuclide concentrations are equal to or below site-specific Derived Concentration Guideline Levels (DCGL).

1.2 Scope

Characterization incorporates the results of investigations and surveys conducted to quantify the extent and nature of contamination at the FCS site. The results of site characterization surveys and analyses will continue to be used to identify areas of the site that require remediation, as well as to plan remediation methodologies, develop waste classification and volumes, and estimate costs.

Initial characterization surveys are performed site-wide on land, structures and systems. The characterization survey should be focused on areas that will remain at the time of license termination (e.g., land, buried piping, building basements, etc.) to enable better planning for FSS and to verify initial classifications. The initial characterization survey may also be focused on structures and components that will be removed as part of the decommissioning process in order to better plan for the remediation, removal and disposal options.

During the site characterization, the surveys of many inaccessible or not readily accessible subsurface soils and structural surfaces may be deferred. This is referred to as “continuing characterization.” Examples of these areas include soils under structures, concrete, or asphalt coverings; areas restricted by high dose rates;

underlying concrete of the Containment, Spent Fuel Pool, and Transfer Canal; and interiors of embedded and/or buried pipe that may remain. Deferring characterization in these areas may be based on one or more of the following conditions:

- ALARA considerations (e.g., the area was either a high radiation or high contamination area and additional data would likely not change the survey area or area classification of the location or surrounding areas).
- Safety considerations (e.g., difficulty of access to the upper reaches of the Containment Building due to height, close proximity to nuclear fuel, etc.).
- Historical data shows that the area could be classified without further characterization.
- Access for characterization would require significant deconstruction of adjacent systems, structures or other obstacles where the removal could result in an unsafe condition, interfere with continued operation of systems, or interfere with ongoing decommissioning activities.
- The ability to use engineering judgment in assigning the survey unit or area a classification based on physical relationship to surrounding areas and the likelihood of the survey unit to have radiological conditions represented by the conditions in these adjacent areas.

As access is gained to these areas, additional characterization data should be collected, evaluated, and stored with previous radiological survey data in a survey history file for the survey unit. This data should supplement existing data to update both the types of radionuclides present and the variability in the radionuclide mix for both gamma-emitting and Hard-to-Detect (HTD) radionuclides. As decommissioning progresses, data from operational events caused by equipment failures or personnel errors, which may affect the radiological status of a survey unit, should also be captured, evaluated, and when appropriate, stored in the survey history file. This additional characterization data should be used in validating the classification of a survey unit and in planning for FSS.

Characterization surveys are designed and executed using the guidance provided in MARSSIM and NUREG-1757, "Consolidated NMSS Decommissioning Guidance - Characterization, Survey, and Determination of Radiological Criteria" Volume 2, Revision 1 (Reference 2.1.2). In addition, surveys are designed and executed in accordance with FCSD-RA-LT-100, "Quality Assurance Project Plan for License Termination Plan Development, Site Characterization, and Final Status Survey Projects at Fort Calhoun Station" (QAPP) (Reference 2.2.1), which describes policy, organization, functional activities, the DQO process, and measures necessary to achieve quality data. The information obtained from performing characterization provides guidance for decontamination and remediation planning. Materials contaminated with radioactive material at concentrations greater than the unrestricted release criteria will continue to be removed and properly packaged for shipment and disposal.

The characterization survey process incorporates survey data from previous site characterizations, historical information from the FCS Historical Site Assessment (HSA), as well as static measurements, scan measurements and/or sampling and analyses performed to adequately present the current radiological condition of each survey unit.

Radiological characterization provides reliable information for the quantity and type of radionuclides, their distribution, and their physical state. The primary purpose for collecting this information is to fulfill the requirement that a complete radiological characterization of the site be performed, enabling the LT/FSS Group to develop necessary design information. This information may also provide decommissioning planning personnel insight in evaluating the following concerns:

- Operating techniques, decontamination processes, dismantling procedures (i.e., hands on, semi-remote, or fully remote working), and the tools required.
- The protection for workers, the general public, and the environment.
- Resulting costs.
- Validation and verification of the full nature and extent of the final suite of dose-significant Radionuclides of Concern (ROC), including HTD radionuclides specified in the LTP.
- Identification of any additional structures that may be candidates for removal from site as clean waste.
- Determine or verify the lateral/vertical extent of radioactive contamination in basement concrete and sub-slab soils.
- Determine or verify the lateral/vertical extent of radioactive contamination in surface soil and subsurface soil.
- Obtaining additional data to provide guidance to decontamination personnel for waste management planning and decontamination/remediation activities planning.

If contamination from hazardous material other than radioactive material is identified during the performance of characterization, the FCS Environmental Group will be notified. The evaluation and determination of the need for further surveys, sampling, and analyses to identify and quantify non-radiological contaminants that may be present at FCS will be performed by the FCS Environmental Group.

2 REFERENCES

2.1 Regulatory Requirements

2.1.1 NUREG-1575, “Multi-Agency Radiation Survey and Site Investigation Manual”

2.1.2 NUREG-1757, “Consolidated Decommissioning Guidance - Characterization, Survey, and Determination of Radiological Criteria” Volume 2, Revision 1

2.1.3 International Standard ISO 7503-1, Part 1, “Evaluation of Surface Contamination, Beta-Emitters (maximum beta energy greater than 0.15 MeV) and Alpha-Emitters"

2.2 Procedures

2.2.1 FCSD-RA-LT-100, "Quality Assurance Project Plan for License Termination Plan Development, Site Characterization, and Final Status Survey Projects at Fort Calhoun Station”

2.2.2 FCSD-RA-LT-307, “Unconditional Release Surveys”

2.2.3 FC-18-002, “Potential Radionuclides of Concern During the Decommissioning of Fort Calhoun Station”

2.2.4 OPPD Safety Manual

2.2.5 FCSD-RA-LT-201, “Characterization Sample Plan Development”

2.2.6 EPND-RM-100, “Record Management Program”

2.2.7 EPND-RM-101, “Records Creation, Index, and Transmittal Process”

2.2.8 FC-SRRS, “SRRS Process”

3 GENERAL

3.1 Definitions

3.1.1 Action Levels: A derived media-specific, radionuclide-specific concentration or gross activity level of radioactivity that triggers a response, such as further investigation or remediation, if exceeded.

3.1.2 Biased Measurements: Measurements performed at locations selected using professional judgment based on unusual appearance, location relative to known contamination areas, high potential for residual radioactivity or other general supplemental information.

3.1.3 Data Quality Assessment (DQA): The scientific and statistical evaluation of data to determine if the data are of the right type, quantity, and quality to support their intended use.

3.1.4 Data Quality Objectives (DQO): Qualitative and quantitative statements derived from the DQO process that clarify technical and quality objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions.

3.1.5 Derived Concentration Guideline Level (DCGL): A derived, radionuclide-specific activity concentration within a survey unit corresponding to the release criterion. DCGLs are derived from activity/dose relationships through various exposure pathway scenarios.

3.1.6 Final Status Survey (FSS): Surveys conducted on structures, soil, buried piping and groundwater to demonstrate that residual radionuclide concentrations are equal to or below site-specific DCGLs.

3.1.7 Impacted Area: An area with a possibility of containing residual radioactivity from licensed activities in excess of natural background or fallout levels.

3.1.8 Mean: The average value obtained when the sum of individual values is divided by the number of values.

3.1.9 Measurement: For the purpose of characterization, it is used interchangeably to mean: 1) the act of using a detector to determine the level or quantity of radioactivity on a surface or in a sample of material from a media being evaluated, or 2) the quantity obtained by the act of measuring.

3.1.10 Median: The center of the data set when data points are ranked in order from smallest to largest.

3.1.11 Minimum Detectable Concentration (MDC): The minimum detectable concentration is the a priori activity level that a specific instrument and technique can be expected to detect 95% of the time. When stating the detection capability of an instrument, this value should be used. The MDC is the Detection Limit (L_D), multiplied by an appropriate conversion factor to give units of activity concentration.

3.1.12 Non-impacted Area: Area where there is no reasonable possibility (extremely low probability) of residual contamination from licensed activities.

3.1.13 Outlier: A measurement that is unusually large or small relative to the sample population and therefore is suspected of misrepresenting the population from which it was collected.

3.1.14 Range: The measure of difference between the largest and smallest values in a data set.

3.1.15 Reference Area: Geographical area from which representative reference measurements are performed for comparison with measurements performed in a specific survey unit at remediation site. A site radiological reference area (background area) is defined as an area that has similar physical and radiological characteristics as the site area being remediated, but which has not been contaminated by site activities.

3.1.16 Sample Plan: Sample plans are usually prepared for each survey unit independently and contain, at a minimum, survey instructions, the number and location of survey measurements and samples, survey maps, instrumentation requirements, and safety requirements as necessary.

3.1.17 Survey Area: Survey areas are established based on logical physical boundaries and site landmarks for the purpose of documenting and conveying radiological information, and in order to facilitate the scheduling, management and reporting of characterization data. The survey areas may be sub-divided into one or more survey units.

3.1.18 Survey Package: Survey packages are prepared for each survey unit independently. A survey package is a collection of sample plans, files or other historical data and will contain all the quality records and other documents relevant to the FSS of a survey unit, including any characterization sample plans/results, radiological assessment or remedial action support survey sample plans/results and the FSS sample plans/results including the survey unit release records.

3.1.19 Survey Unit: A contiguous (usually) unit within a survey area of similar use history and the same classification of contamination potential.

3.1.20 Unity Rule: A rule applied when more than one radionuclide is present at a concentration that is distinguishable from background and where a single concentration comparison does not apply. In this case, the mixture of radionuclides is compared against default concentrations by applying the unity rule. This is accomplished by determining: the fraction between the concentration of each radionuclide in the mixture, and the concentration for that radionuclide in an appropriate listing of default values. The Sum of Fractions (SOF) for all radionuclides in the mixture should not exceed one (1).

3.2 Acronyms

ALARA	As Low As Reasonably Achievable
AMCG	Average Member of the Critical Group
LT/FSS	License Termination/Final Status Survey
DQA	Data Quality Assessment
DQO	Data Quality Objectives
DCGL	Derived Concentration Guideline Level
FCS	Fort Calhoun Station
FOV	Field of View
FSS	Final Status Survey
GPS	Global Positioning System
HASP	Health and Safety Plan
HTD	Hard-to-Detect
HSA	Historical Site Assessment
ISFSI	Independent Spent Fuel Storage Installation
ISOCS	In Situ Object Counting System
JHA	Job Hazard Analysis
L_D	Detection Limit
LTP	License Termination Plan
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MW	Megawatts
MDC	Minimum Detectable Concentration

NAD	North American Datum
NaI	Sodium Iodide
NIST	National Institute of Standards and Technology
NRC	Nuclear Regulatory Commission
OPPD	Omaha Public Power District
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RA	Radiological Assessment
RASS	Remedial Action Support Survey
RE	Radiological Engineer
RRA	Radiological Restricted Area
ROC	Radionuclides of Concern
RWP	Radiation Work Permit
SFP	Spent Fuel Pool
SOF	Sum of Fractions
TEDE	Total Effective Dose Equivalent
THA	Task Hazard Assessment
TSD	Technical Support Document
VSP	Visual Sample Plan
WGS	World Geodetic System

3.3 Responsibilities

3.3.1 LT/FSS Project Organization

The duties and responsibilities of the various positions within the LT/FSS Group as they pertain to the implementation of this Characterization Survey Plan are described below. Responsibilities for each position described may be assigned to a designee, as appropriate.

3.3.2 LT/FSS Manager

The LT/FSS Manager has overall responsibility for the implementation of this Characterization Survey Plan, as well as approving survey methodology, performance, and evaluation and analysis of resulting data. The LT/FSS Manager is also responsible for the control of samples and the review and approval of all characterization sample plans prior to implementation in the field, as well as the review and approval of all characterization survey reports. The LT/FSS Manager is also responsible for the schedule and budget for characterization activities.

3.3.3 LT/FSS Radiological Engineer (RE)

Radiological Engineers are responsible for the technical direction, development, and implementation of each characterization survey. As part of the survey development, REs are responsible for approving the survey techniques and instrumentation, sampling locations and reference areas, and determining whether the acquired data supports the survey objectives.

3.3.4 LT/FSS Specialist

LT/FSS Specialists are responsible for the development of all characterization sample plans, including the development of DQOs for survey design, performing data review, verification and validation and supporting the preparation of data tables. LT/FSS Specialists are also responsible for the development of characterization survey reports.

3.3.5 LT/FSS Supervisor

The LT/FSS Supervisor is responsible for the control and implementation of characterization sample plans and to ensure that all survey objectives are achieved. The LT/FSS Supervisor is responsible for ensuring all necessary personnel, instrumentation, and other equipment is available to support survey activities.

3.3.6 LT/FSS Instrumentation Specialist

The LT/FSS Instrumentation Specialist is responsible for maintaining the program for the calibration, set-up and repair of the on-site radiological instrumentation and analytical equipment used to support obtaining characterization measurements. The LT/FSS Instrumentation Specialist also provides direction and support for project sampling activities, including sample collection, preparation, handling, storage, and shipment, and ensuring that all requisite instrument Quality Control (QC) and MDC criteria are met.

3.3.7 Laboratory Technician

The Laboratory Technicians perform radiological sample analysis of volumetric material and swipe samples obtained for characterization. They also operate radiological laboratory instrumentation in accordance with approved procedures and manufacturers' recommendations and ensure that all requisite instrument QC and MDC criteria are met.

3.3.8 LT/FSS Technician (Radiation Protection Technician)

LT/FSS Technicians are responsible for collecting samples and obtaining and documenting survey measurements in accordance with the characterization sample plan instructions and approved procedures.

3.4 Precautions, Limitations, and Prerequisites

3.4.1 Precautions
None

3.4.2 Limitations
None

3.4.3 Prerequisites

None

3.5 Records

3.5.1 None

4 REQUIREMENTS AND GUIDANCE

4.1 Site Description

The FCS site is located on the west bank of the Missouri River at river mile 646.0 on 660.46 acres, approximately 19.4 miles north of Omaha, Nebraska. OPPD has a perpetual easement on 582.18 acres of land primarily on the east bank of the river directly opposite the plant buildings, approximately 475 acres of which is located in Iowa. About 85% of the site is on relatively level ground located in the alluvial plain of the river. On the western part of the site the ground rises sharply about 60 feet to a higher, level area which is bounded on the west by United States (U.S.) Highway 75, formerly U.S. Highway 73. In July of 2018, OPPD requested approval from the U.S. Nuclear Regulatory Commission (NRC) to remove a portion of land on the northwest portion of the owner-controlled area (totaling approximately 120 acres) from the Part 50 License. This partial site release was approved in September, 2018. In November of 2018, OPPD submitted a request for partial site release of the 475-acre property in Iowa that was subject to a perpetual easement, and the NRC approved the release in January of 2019.

FCS Unit 1 was a Combustion Engineering 2-loop pressurized water reactor (PWR) rated at 479 megawatts (MW) electrical. The station is comprised of a Combustion Engineering pressurized water reactor with supporting facilities. The primary coolant system consisted of two heat transfer loops. Each loop contained one steam generator and two reactor coolant pumps with associated piping and valves. In addition, the primary coolant system included a pressurizer, pressurizer relief tank, interconnecting piping, and the instrumentation necessary for operational control. All major components of the primary coolant system are located within the containment building.

Plant construction began in 1966. The first fuel assembly was loaded into the reactor between May and June, 1973. The NRC issued an operating license on August 9, 1973 (NRC License No. DPR-40, Docket No. 50285). The plant officially went online on September 1, 1973, with commercial operation starting 25 days later. On June 24, 2016, and updated on August 25, 2016, FCS submitted the Certifications of Permanent Cessation of Power Operations in accordance with 10 CFR Part 50.82(a)(i). The plant went offline on October 24, 2016.

4.2 Initial Survey Units and Initial Classification

Provide a description of the impacted and non-impacted survey units on site including their respective classifications, including as appropriate:

- The size of the Licensed Site boundary,

- The size and location of the Protected Area (PA), or similar,
- The size of non-impacted land areas, the structures or systems that reside within them, and a list of survey units,
- The size of impacted land areas, the structures or systems that reside within them, a list of survey units, and the initial classification of each (Class 1, 2 or 3), based on the operational history.

i	**NOTE** The suggested survey unit sizes from Table 4-1 are recommendations for survey units that will undergo FSS. Based on the specific DQOs for characterization surveys (e.g., verification of classification, establishing baseline radiological data), survey units may be grouped by similar geography and classification to perform characterization, with the approval of the LT/FSS Manager. In this instance, the number of measurements or samples required to meet the DQOs is at the discretion of the LT/FSS Specialist or LT/FSS RE; however, population sizes should be increased, as appropriate, based on professional judgment.	**i**

4.2.1 For the characterization surveys of open land areas and structures, survey unit size was determined based upon the guidance provided in MARSSIM, Section 4.6, which provides the following suggested physical area sizes for survey units:

Table 4-1 Suggested Area Size for Survey Units that will undergo FSS

Classification	Suggested Area
Class 1 Land Areas Class 1 Structures	up to 2,000 m^2 up to 100 m^2 floor area
Class 2 Land Areas Class 2 Structures	2,000 m^2 to 10,000 m^2 100 m^2 to 1,000 m^2
Class 3 Land Areas Class 3 Structures	No Limit No Limit
Non-Impacted Land Areas Non-Impacted Structures	No Limit No Limit

4.2.2 Survey units may be increased up to 10% in size to account for the impact of physical conditions.

4.2.3 For structure survey units that will not undergo FSS, the size limits in Table 4-1 are not applicable.

4.2.4 For the characterization surveys of structures, the survey units are comprised of the following scenarios, or combinations of scenarios, as determined by the LT/FSS Specialist or LT/FSS RE:

A. Floors
B. Interior Walls below 2 meters
C. Interior Walls above 2 meters
D. Ceiling
E. Exterior Walls below 2 meters
F. Exterior Walls above 2 meters
G. Roof
H. System (piping/component) external surfaces below 2 meters
I. System (piping/component) external surfaces above 2 meters

i	**NOTE** A characterization survey will typically not be performed on system internals with known contamination and where the system is earmarked for removal as radioactive waste. For systems that reside in non-impacted structures, or within structures earmarked for unconditional release from site as clean material, a characterization survey will also typically not be performed; rather, these systems will be subject to unconditional release surveys performed in accordance with FCSD-RA-LT-307, "Unconditional Release Surveys" (Reference 2.2.2).	i

4.2.4 For the characterization surveys of the internal surfaces of systems (e.g., buried piping, embedded piping, components), survey units may be established as an entire system or as a component of the land area or structure that the system traverses.

4.2.5 Although it is expected that the classification of existing areas and conceptual survey units will require little modification, the characterization process is iterative. When additional characterization data is obtained during the decommissioning process, the DQO process will be used to verify that the initial classification is appropriate, which will guide reclassification of the survey unit and/or guide the design of subsequent surveys, if necessary.

4.2.6 Initial survey area numbers, survey unit numbers and survey unit classifications are presented in Table 4-2. Note, the bold type in Table 4-2 represents survey units that are earmarked to remain at the time of license termination and will be subject to FSS. The locations and boundaries of the survey units are provided in Figures 4-1, 4-2, 4-3, 4-4, and 4-5.

4.2.7 Throughout the decommissioning process, these survey units may be altered by changing the boundaries, adjusting the survey unit areas, or breaking the survey unit into one or multiple smaller survey units. A master copy of the survey units is maintained by the LT/FSS Manager. As changes are made to the physical boundaries of survey units, as survey units are added, and as survey unit classifications change due to the results of characterization, Remedial Action Support Surveys (RASS) and Radiological Assessments (RA), the master copy is updated by the LT/FSS Manager until final classification for FSS is performed. This Characterization Survey Plan will not be revised to reflect these changes.

Table 4-2 Initial Survey Units

Survey Unit ID No.	Survey Unit Description	Initial Classification	Survey Unit Area (m^2)
1000	Unit 1 Containment Building (CB)		
1100	CB 977’ Elevation – Under Vessel Area	1	NA
1200	CB 995’/996’ Elevation G/A	1	NA
1201	CB 995’ Elevation – ‘A’ S/G Enclosure	1	NA
1202	CB 995’ Elevation – ‘B’ S/G Enclosure	1	NA
1203	CB 996’ Elevation – Reactor Cavity	1	NA
1204	CB 996’ Elevation – Fuel Transfer Canal	1	NA
1300	CB 1013’ Elevation G/A	1	NA
1400	CB 1045’ Elevation G/A	1	NA
1500	CB 1060’ Elevation G/A	1	NA
1600	CB Exterior Surfaces	-	-
1601	CB Roof	2	NA
1602	CB Exterior Walls	3	NA
2000	Auxiliary Building (AB)		
2100	AB 971’ Elevation G/A	1	NA
2200	AB 989’ Elevation G/A	1	NA
2201	AB 994’ Elevation – Spent Fuel Pool	1	NA
2300	AB 1007’ Elevation G/A	1	NA
2400	AB 1011’ Elevation G/A	1	NA
2500	AB 1013’ Elevation G/A	1	NA
2600	AB 1025’ Elevation G/A	1	NA
2700	AB 1036’ Elevation G/A	1	NA
2800	AB 1039’ Elevation G/A	1	NA
2900	AB Exterior Surfaces	-	-
2901	AB Roof	2	NA
2902	AB Exterior Walls	3	NA
3000	Turbine Building (TB)		
3100	TB 990’ Elevation G/A	3	NA
3200	TB 1000’ Elevation G/A	3	NA
3300	TB 1011’ Elevation G/A	3	NA
3400	TB 1036’ Elevation G/A	3	NA

Table 4-2 Initial Survey Units (continued)

Survey Unit ID No.	Survey Unit Description	Initial Classification	Survey Unit Area (m^2)
4000	Balance of Plant (BOP) Buildings Inside Restricted Area (RA)		
4100	Radwaste Processing Building	1	NA
4200	Intake Building	3	NA
4300	Security Building	3	NA
4400	Security Access Facility (SAF)	3	NA
4500	Service Building	3	NA
4600	Maintenance Shop	3	NA
4700	Technical Support Center (TSC)	3	NA
4800	Chemistry and Radiation Protection Facility	3	NA
4900	New Warehouse	3	NA
5000	Balance of Plant (BOP) Buildings Outside Restricted Area (RA)		
5100	Administrative Office Building	3	NA
5200	Training Center	3	NA
5300	Mausoleum (OSGSF)	2	NA
5400	FLEX Building	3	NA
5500	New Maintenance Storage Shed	3	NA
5600	Chemical Pump House	3	NA
5700	Storage Shed	3	NA
5800	Sanitary Lift Stations	3	NA
6000	Buried Pipe		
6100	Sanitary System	3	NA
6200	Storm Drain System	3	NA
6300	Fire Protection	3	NA
7000	Land Areas Inside Protected Area		
7100	Northwest Land Areas I/S PA Fence	-	9,429
7101		1	1,994
7102		1	1,994
7103		1	1,994
7104		1	1,570
7105		1	1,877

Table 4-2 Initial Survey Units (continued)

Survey Unit ID No.	Survey Unit Description	Initial Classification	Survey Unit Area (m^2)
7000	Land Areas Inside Protected Area (continued)		
7200	Southwest Land Area I/S PA Fence	-	8,906
7201		1	1,655
7202		1	1,725
7203		1	1,634
7204		1	1,946
7205		1	1,946
7300	Southeast Land Area I/S PA Fence	-	6,686
7301		1	558
7302		1	2,031
7303		1	2,044
7304		1	2,053
7400	Northeast Land Area I/S PA Fence	-	11,847
7401		1	1,995
7402		1	1,874
7403		1	1,995
7404		1	1,995
7405		1	1,995
7406		1	1,993
7500	Primary Plant Land Area	-	14,201
7501		1	2,033
7502		1	2,032
7503		1	2,038
7504		1	2,032
7505		1	2,034
7506		1	2,034
7507		1	1,998
8000	Owner Controlled Area Outside the Protected Area		
8100	North Owner Controlled Areas	-	761,648
8101		3	99,210
8102		3	74,685

Table 4-2 Initial Survey Units (continued)

Survey Unit ID No.	Survey Unit Description	Initial Classification	Survey Unit Area (m^2)
8000	Owner Controlled Area Outside the Protected Area (continued)		
8103		3	58,497
8104		3	99,971
8105		3	99,994
8106		3	99,788
8107		3	53,489
8108		3	77,748
8109		3	98,266
8110		3	105,611
8200	West Owner Controlled Area	-	470,118
8201		3	30,726
8202		3	54,169
8203		3	99,184
8204		3	91,521
8205		3	90,907
8206		3	75,745
8207		3	27,866
8300	South Owner Controlled Area	-	765,085
8301		3	42,609
8302		3	51,214
8303		3	56,518
8304		3	97,649
8305		3	98,059
8306		3	99,150
8307		3	90,659
8308		3	62,535
8309		3	72,638
8310		3	94,054
8400	Waste Haul Path Buffer Zone	-	61,133
8401		2*	10,809
8402		2*	10,297

Table 4-2 Initial Survey Units (continued)

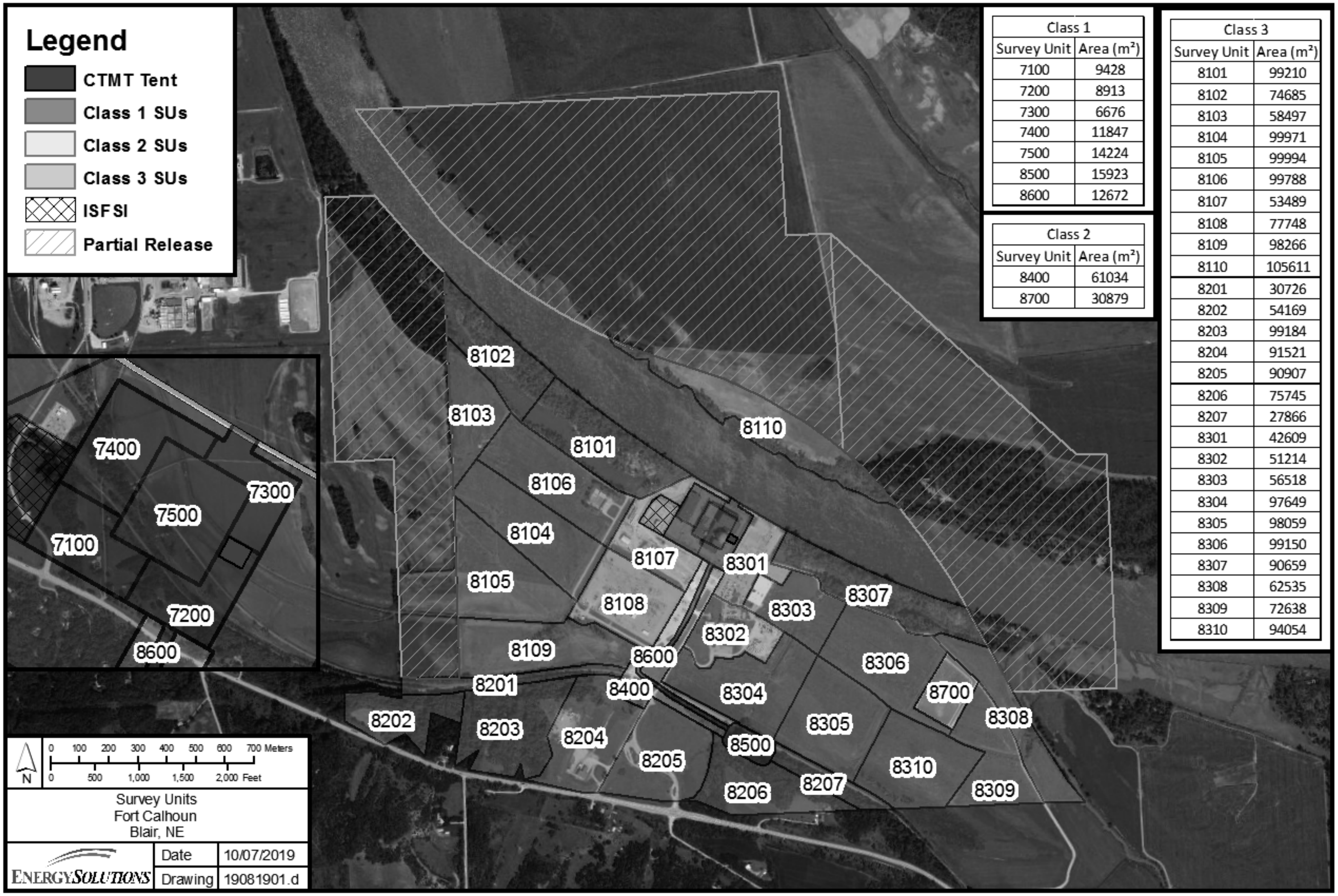
Survey Unit ID No.	Survey Unit Description	Initial Classification	Survey Unit Area (m^2)
8000	Owner Controlled Area Outside the Protected Area (continued)		
8403		2*	10,488
8404		2*	10,670
8405		2*	10,833
8406		2*	8,036
8500	Waste Loadout Containment Structure	-	20,189
8501		1*	2,024
8502		1*	2,005
8503		1*	2,001
8504		1*	2,085
8505		1*	2,006
8506		1*	2,002
8507		1*	1,994
8508		1*	1,805
8600	Waste Haul Path	-	12,672
8601		1*	1,997
8602		1*	2,016
8603		1*	1,998
8604		1*	2,002
8605		1*	1,996
8606		1*	2,000
8607		1*	663
8700	Sewage Lagoon	-	30,879
8701		2	10,281
8702		2	10,322
8703		2	10,276
9000	Miscellaneous SSC		
9001	Blast and Ballistic Rated Enclosures (BBREs)	3	NA
9002	RO Unit	3	NA
9003	Firing Range	3	NA

Table 4-2 Initial Survey Units (continued)

Survey Unit ID No.	Survey Unit Description	Initial Classification	Survey Unit Area (m^2)
9000	Miscellaneous SSC (continued)		
9004	Hazardous Materials Storage Building	3	NA
9005	Access Road Security Guardhouse	3	NA

* The survey unit classifications listed in this table and denoted in Figures 4-3 and 4-4 for the Waste Haul Buffer Zone (8400), Waste Loadout Containment Structure (8500), and the Waste Haul Path (8600) are intended as future classifications for FSS. Surveys conducted before the Waste Haul Path and Waste Loadout Containment Structure are constructed may treat these survey units as Class 3. Additionally, the sizes and locations of survey units 8400, 8500, and 8600 are approximate, as future D&D planning may relocate them.

Figure 4-1 Survey Unit Layout – Owner Controlled Areas



Class 1

Survey Unit	Area (m²)
7100	9428
7200	8913
7300	6676
7400	11847
7500	14224
8500	15923
8600	12672

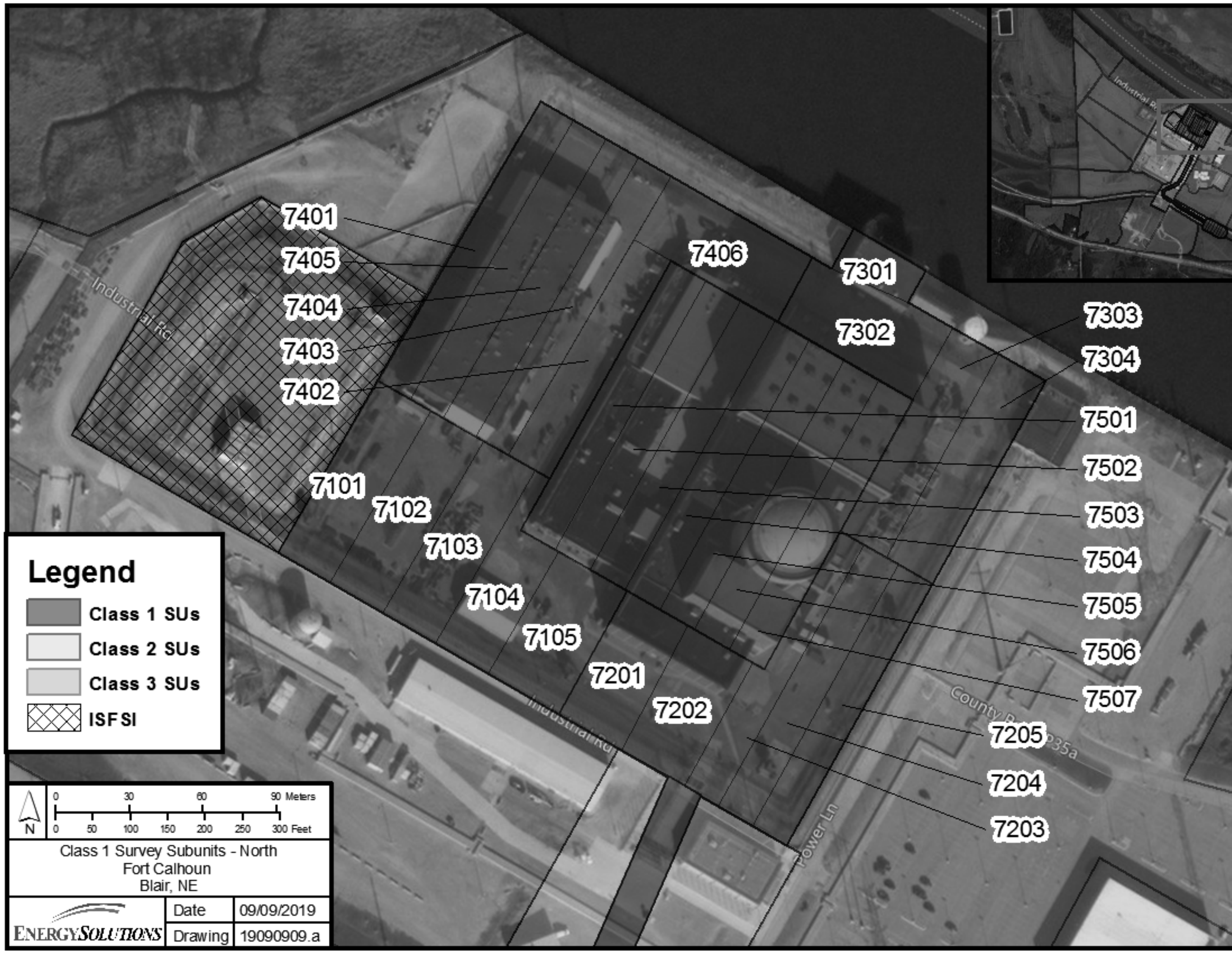
Class 2

Survey Unit	Area (m²)
8400	61034
8700	30879

Class 3

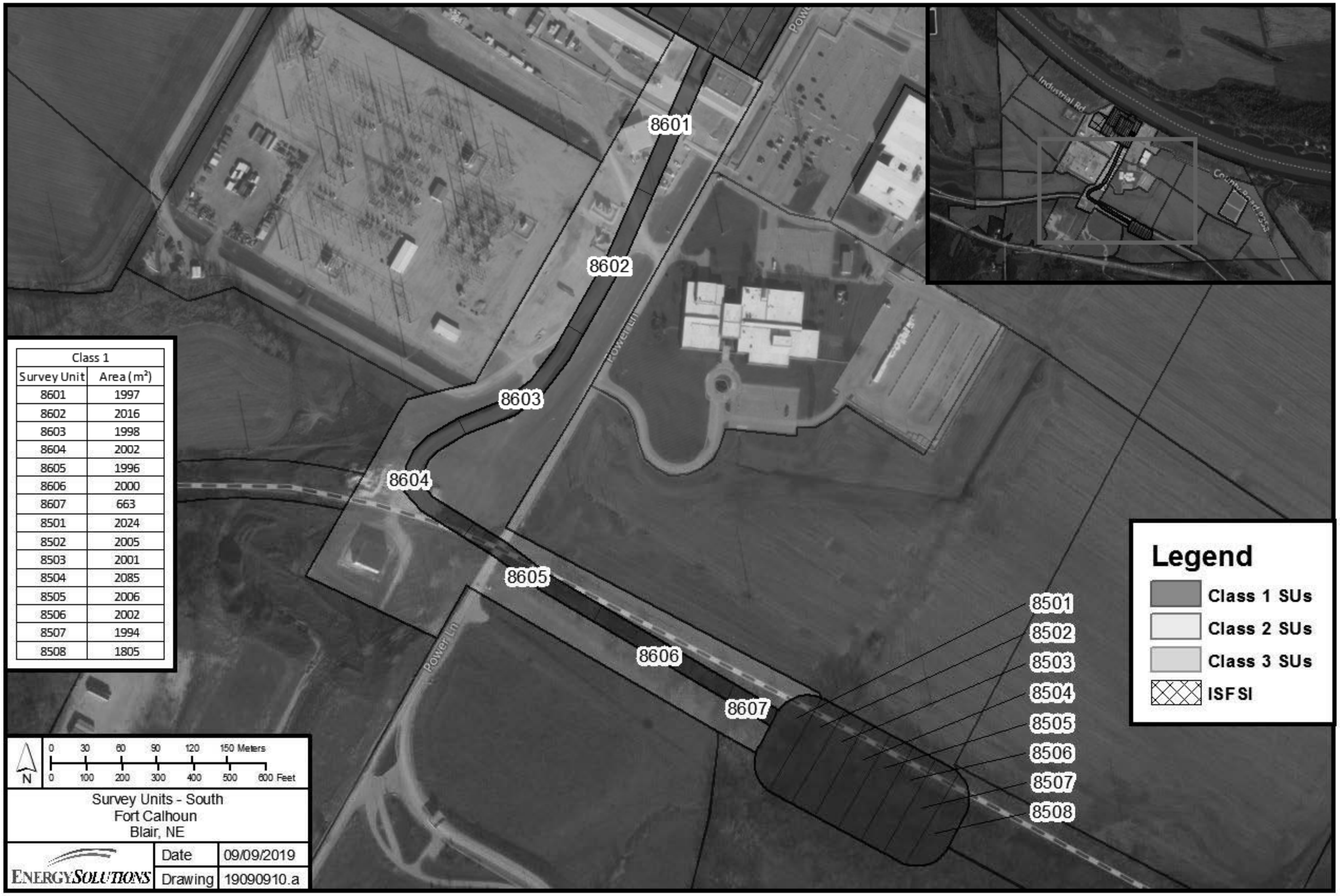
Survey Unit	Area (m²)
8101	99210
8102	74685
8103	58497
8104	99971
8105	99994
8106	99788
8107	53489
8108	77748
8109	98266
8110	105611
8201	30726
8202	54169
8203	99184
8204	91521
8205	90907
8206	75745
8207	27866
8301	42609
8302	51214
8303	56518
8304	97649
8305	98059
8306	99150
8307	90659
8308	62535
8309	72638
8310	94054

Figure 4-2 Survey Unit Layout – Protected Area



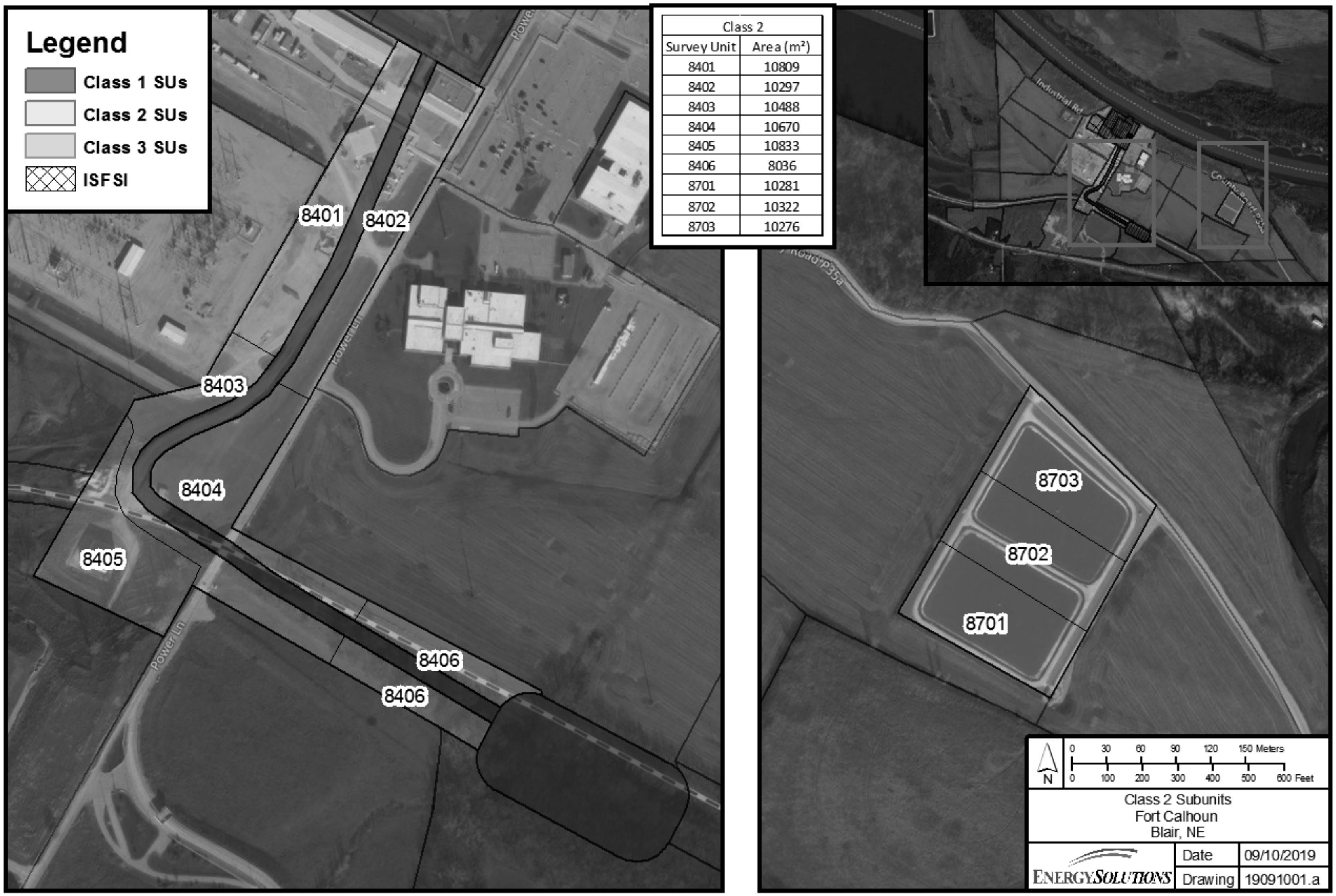
Class 1	
Survey Unit	Area (m²)
7401	1995
7402	1874
7403	1995
7404	1995
7405	1995
7406	1993
7101	1994
7104	1570
7105	1877
7102	1994
7103	1994
7201	1655
7202	1725
7203	1634
7204	1946
7205	1946
7301	558
7302	2031
7303	2044
7304	2053
7501	2033
7502	2032
7503	2038
7504	2032
7505	2034
7506	2034
7507	1998

Figure 4-3 Survey Unit Layout – Waste Haul Path and Waste Load Out Containment Structure



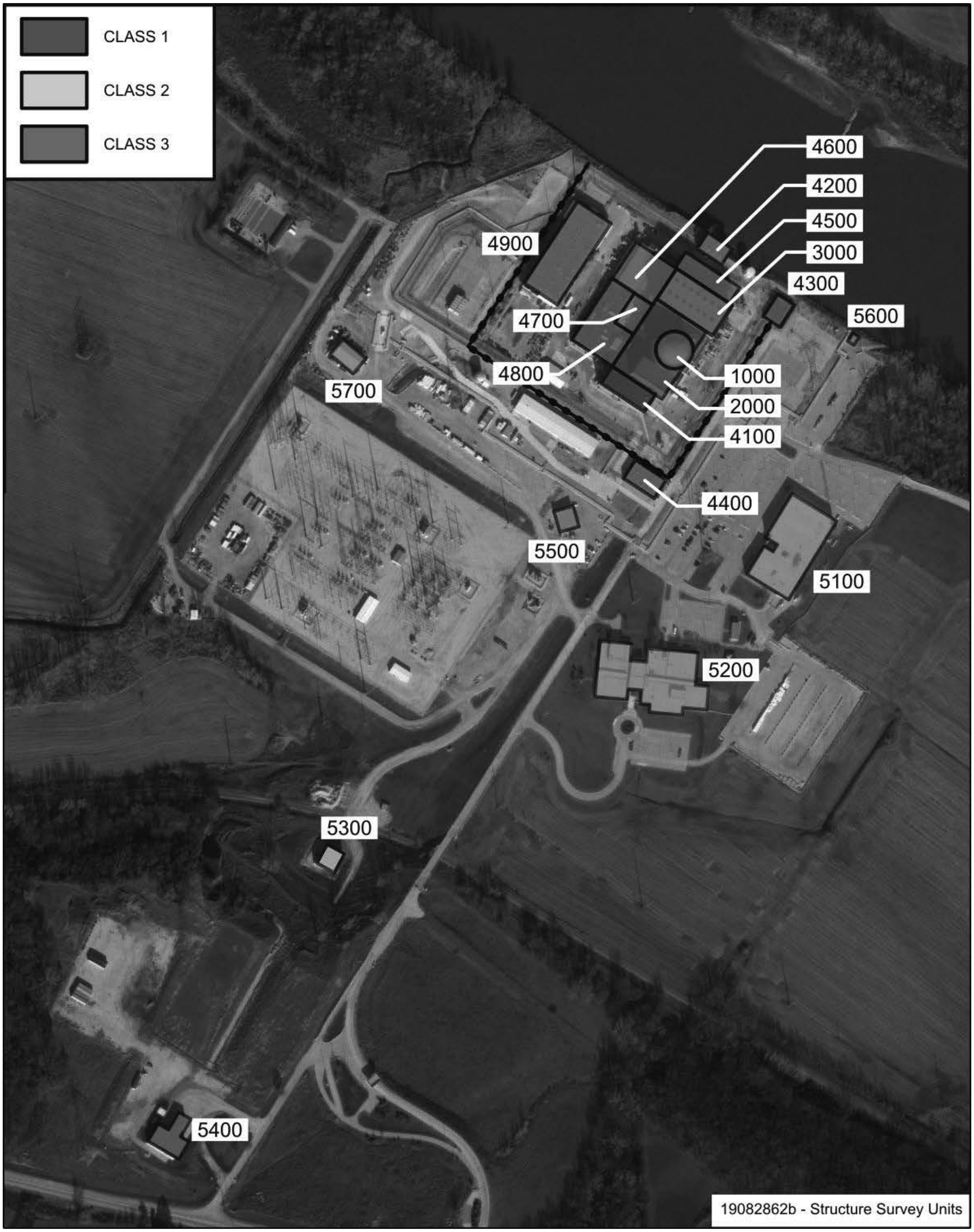
Class 1	
Survey Unit	Area (m²)
8601	1997
8602	2016
8603	1998
8604	2002
8605	1996
8606	2000
8607	663
8501	2024
8502	2005
8503	2001
8504	2085
8505	2006
8506	2002
8507	1994
8508	1805

Figure 4-4 Class 2 Survey Units



Class 2	
Survey Unit	Area (m²)
8401	10809
8402	10297
8403	10488
8404	10670
8405	10833
8406	8036
8701	10281
8702	10322
8703	10276

Figure 4-5 Structure Survey Units



4.3 Radionuclides of Concern

i	**NOTE** Prior to commencing site radiological characterization, the initial suite of ROC should be agreed to by the NRC. Failure to gain agreement prior to characterization could lead to re-analyses of characterization data at a later date (for missing ROC) which could lead to delays in LTP and DCGLs development.	i

4.3.1 Calculations and Position Paper (CPP) FC-18-002, "Potential Radionuclides of Concern During the Decommissioning of Fort Calhoun Station" (Reference 2.2.3) was prepared and approved in March, 2018. The purpose of the CPP was to establish the basis for an initial suite of potential ROCs for the decommissioning of FCS. Industry guidance was reviewed as well as the analytical results from the sampling of various media from past plant operations. Based on the elimination of some of the theoretical neutron activation products, noble gases, and radionuclides with a half-life less than two years, an initial suite of potential ROC for the decommissioning of FCS was prepared. These radionuclides are listed in Table 4-3.

Table 4-3 Initial Suite of Radionuclides for the Decommissioning of Fort Calhoun Station

Radionuclide	Half-Life (years)
H-3	12.3
Fe-55	2.73
Co-60	5.27
Ni-63	100.1
Sr-90	28.74
Cs-134	2.07

Radionuclide	Half-Life (years)
Cs-137	30.04
Pu-238	87.7
Pu-239/240	24,110
Pu-241	14.4
Am-241	432.2
Cm-243/244	29.1

4.4 Action Levels

4.4.1 The overall objective for the decommissioning of FCS is to sufficiently remediate all remaining structures, piping, and soil to a condition that corresponds to a calculated dose to the an average member of the critical group (AMCG) of less than 25 mrem/yr Total Effective Dose Equivalent (TEDE) from residual radioactivity distinguishable from background from all applicable pathways plus ALARA. The remaining structures, systems, and land may then be released for unrestricted use. This is the decommissioning rule in accordance with 10 CFR 20.1402.

4.4.2 The DCGLs that will be used to demonstrate compliance with the 25 mrem/yr unrestricted release criterion will be established in the LTP. Site-specific DCGLs are calculated by analysis of various pathways (e.g., direct radiation, inhalation, ingestion, etc.), media (e.g., concrete, soils, and groundwater) and scenarios through which exposures could occur. As site-specific DCGLs have not yet been established for the FCS decommissioning, alternate action levels must be selected for characterization. In lieu of site-specific DCGLs, the default screening values from NUREG-1757, Appendix H, Table H.1 and Table H.2 will be used for radiological site characterization, as appropriate.

As stated in the guidance, the models, scenarios, and parameters used to develop the screening values were intended to be conservative. The lack of information about a site warrants the use of conservative models and default conditions to ensure that the derived dose is not underestimated. Subsequently, use of screening values as action levels during characterization will provide reasonable assurance that the survey unit is conservatively classified.

4.4.3 The values in Table 4-4 represent surface soil concentrations of individual radionuclides that would be deemed in compliance with the 25 mrem/yr unrestricted release dose limit. If multiple ROC are present, then the dose contribution from each ROC is accounted for using a Sum of Fractions (SOF) calculation to ensure that the total dose from all ROC does not exceed the action level. If the analysis of characterization samples indicates the presence of any unlisted radionuclides from licensed activities at a concentration greater than MDC, then the LT/FSS Manager will be notified, and a determination will be made as to revising the initial suite of radionuclides.

Table 4-4 Interim Surface Soil Screening Values for Characterization

Radionuclide	Screening Value (pCi/g)
H-3	1.1 E+02
Fe-55	1.0 E+04
Co-60	3.8 E+00
Ni-63	2.1 E+03
Sr-90	1.7 E+00
Cs-134	5.7 E+00

Radionuclide	Screening Value (pCi/g)
Cs-137	1.1 E+01
Pu-238	2.5 E+00
Pu-239/240	2.3 E+00
Pu-241	7.2 E+01
Am-241	2.1 E+00
Cm-243/244	3.2 E+00

4.4.4 Radiological characterization of structures will provide the necessary data to derive defensible radionuclide distributions, which would then allow for the derivation of an adjusted gross DCGL for static measurements for FSS. However, as a gross screening level that will be used during characterization to evaluate the correct classification of a survey unit, the nuclide-specific screening value of 7,100 dpm/100 cm^2 total gross beta-gamma surface activity for Co-60 from Table H.1 from NUREG-1757, Appendix H, will be used. Use of the Co-60 screening value is appropriate and conservative as it is anticipated that the radionuclide distribution for surface contamination will be principally Co-60 and Cs-137, and the more conservative approach is to assume a distribution of 100% Co-60 as the screening value for Cs-137 is significantly greater.

i	**NOTE** Non-impacted structures, and/or structures earmarked for unconditional release from site as clean material, will not typically be included in the scope of radiological characterization. Rather, these structures will be subject to unconditional release surveys performed in accordance with FCSD-RA-LT-307, "Unconditional Release Surveys." A limited characterization may be performed at the judgment of the LT/FSS Manager.	i

4.4.5 For non-impacted structures, or structures with a low potential for residual contamination above established background values that are earmarked for unconditional release from site as clean material, action levels are typically based on the MDCR of the instrument used plus ambient background. Any detectable activity of plant-related radionuclides greater than the established background threshold value in a structure classified as non-impacted, or a structure earmarked for unconditional release from site as clean material, is cause to reclassify the structure (or portion of a structure) as impacted or unsuitable for unconditional release from site as clean material.

4.4.6 For buried piping, action levels were established by calculating the surface activity on the interior of the pipe that would produce NUREG-1757 Table H.2 soil screening value concentrations after excavation and mixing in a 15 cm (6") surface soil layer. The calculation was based on 1,500 linear feet of 15" diameter storm drain piping. Like structures, the gross screening level that will be used during characterization to evaluate the correct classification of a buried pipe survey unit, the nuclide-specific screening value of 6,590 dpm/100 cm^2 total gross beta-gamma surface activity for Co-60 will be used. Again, the more conservative approach is to assume a distribution of 100% Co-60 as the screening value for Cs-137 is significantly greater.

4.5 Description of Planned Characterization Activities

The radiological characterization process consists of four principal elements:

- Planning
- Designing
- Implementation
- Data Assessment

The DQO and Data Quality Assessment (DQA) processes are applied to these four principal elements. DQOs allow for systematic planning and are specifically designed to address problems that require a decision to be made and provide alternate actions. The DQA process is an evaluation method used during the assessment phase to ensure the validity of survey results and demonstrate achievement of the sampling plan objectives.

Survey planning includes a review of the HSA, any previous operational or radiological characterization survey results, and any other pertinent information specific to the survey unit that will be characterized.

Before the characterization process can proceed to the implementation phase, the survey unit must be prepared. Survey unit preparation for characterization mostly pertains to housekeeping and the establishment of a reference grid system as necessary to allow for the reproducibility of sample and/or static measurement locations.

Survey implementation is the process of carrying out the survey plan for a given survey unit. This consists of performing the appropriate scan measurements, static measurements, and collection and analysis of samples.

Quality assurance and control measures will be employed in accordance with the QAPP to ensure that subsequent decisions are made on the basis of data of acceptable quality. Quality assurance and control measures are applied to ensure:

- DQOs are properly defined and derived.
- The plan is correctly implemented as prescribed.
- Data and samples are collected by individuals with the proper training using approved procedures.
- Instruments are properly calibrated and source checked.
- Collected data are validated, recorded, and stored in accordance with approved procedures.
- Documents are properly maintained.
- Corrective actions are prescribed, implemented, and followed up on.

The DQA approach is applied to characterization survey results to ensure that the population of the data is complete and valid, and that the objectives of the survey have been met. The data quality assessment verifies that:

- The measurements were obtained using approved methods.
- The quality requirements for the methods were met.
- The appropriate corrections were made to the gross measurements and the data are expressed in proper reporting units.
- The measurements required by the survey design and any investigations have been included.
- The classification and associated survey unit design remain appropriate based on a preliminary review of the data.

4.5.1 Overall Characterization Data Quality Objectives

The DQO process will be incorporated as an integral component of the planning and survey design steps of the radiological characterization. Complex characterization survey designs that have a higher level of risk associated with an incorrect decision require significantly more effort than a survey plan used to simply verify known conditions. The DQO process entails a series of planning steps found to be effective in establishing criteria for data quality and developing survey plans. DQOs allow for systematic planning and are specifically designed to address problems that require a decision to be made and alternate actions to be provided. Furthermore, the DQO process is iterative, which allows for the incorporation of new knowledge and the modification of the output of previous steps to act as input to subsequent steps. The seven steps of the DQO process are outlined in the following sections.

A. State the Problem

The first step of the planning process consists of defining the problem. This step provides a clear description of the problem and a conceptual model of the hazard to be investigated. In all cases, the problem associated with radiological characterization is to "perform characterization inspections and surveys of sufficient quality and quantity to determine the nature, extent and range of radioactive contamination in the survey unit."

B. Identify the Decision

For radiological characterization, the most important step in the DQO process is decision identification. This step consists of developing a decision statement or, in most cases, several decision statements, based on a principal study question (i.e., the stated problem) and determining alternative actions that may be taken based on the answers. For characterization, the possible decisions and the objectives are one and the same. For each survey unit, each of the characterization objectives must be assessed as to their applicability to the end state of each specific survey unit. These objectives include, but are not limited to:

- Providing a basis for classifications (Class 2 or 3).
- Providing a basis for identification and distribution of ROC.
- Providing a basis for surrogate relationships for HTD ROC.
- Providing a basis for the lateral extent of remediation of surface soils.
- Providing a basis for the lateral and vertical extent of remediation of subsurface soils.
- Evaluating the variability of existing radioactivity to support FSS survey design.
- Evaluating neutron activation of concrete that is intended for use as fill.
- Evaluating residual radioactivity of concrete that is intended for use as fill.
- Evaluating if unrestricted release as non-radioactive is a viable disposition path for certain materials.
- Providing sufficient radiological data to determine waste streams.
- Providing sufficient data to guide remediation planning and the selection of the appropriate decontamination technology.

C. Identify Inputs to the Decision

This step in the DQO process identifies the types and quantity of information necessary to address the different decisions, which are identified in the previous steps. The information required depends on the type of media under consideration (e.g., soil, water, concrete) and the adequacy of existing data. If a decision can be made based on the existing data, then the source(s) will be documented and evaluated to ensure reasonable confidence that the data are acceptable. If new data are needed, then the type of measurement (e.g., scan, static measurement and sampling) will be determined in the next step.

The following types of information can be utilized to determine the necessary inputs:

- Historical incidents or accidents involving radioactive materials (HSA).
- Evidence of previous radioactive material storage or the burial of radioactive material (HSA).
- Anticipated ROC (HSA and LTP).
- Initial survey unit classification and basis for classification.
- Action levels.

- Instrumentation and sensitivity (MDC).
- Analytical requirements.
- QC sample requirements.

D. Define the Study Boundaries

This step of the DQO process includes identification of the target population of interest, the spatial and temporal features of the population pertinent to the decision, a time frame for collecting the data, practical constraints, and the scale of decision making. Sampling methods, sample quantities, sample matrices, types of analyses, and analytic and measurement process performance criteria, including detection limits, are established to ensure adequate sensitivity relative to the decision and/or action level.

For characterization, the target population is the set of samples or static measurements that constitute the area of interest (i.e., the survey unit). The medium of interest is the type of materials that will be sampled or surveyed (e.g., soil, water, concrete, and steel). The spatial boundaries include the entire area of interest, including soil depth, area dimensions, contained water bodies, and natural boundaries, as needed. Temporal boundaries include those activities impacted by time-related events such as weather conditions, seasons (i.e., more daylight available in the summer), operation of equipment under different environmental conditions, resource loading, and work schedule.

E. Develop a Decision Rule

This step of the DQO process develops the binary statement that defines a logical process for choosing among alternative actions. The decision rule is a clear statement using the “If..., then...” format; it includes action level conditions and the statistical parameter of interest (e.g., mean of data). Decision statements can become complex, depending on the objectives of the survey and the radiological character of the affected area.

For example, the decision rule could be based on if the radioactivity concentrations of residual radioactivity exceed the established action level values. Subsequently, the decision rule could be established as follows:

- For a Class 3 open land survey unit, if the SOF is less than 0.5, then the basis for the initial classification is verified as valid. If the SOF is greater than or equal to 0.5 but less than unity (1), then the survey unit will be reclassified as a Class 2 open land survey unit.
- For a Class 2 open land survey unit, if the SOF is less than unity (1), then the basis for the initial classification is verified as valid.

- If the SOF is greater than or equal to unity (1), then the survey unit will be reclassified as a Class 1 open land survey unit.

F. Specify Limits on Decision Errors

This step of the DQO process incorporates hypothesis testing and probabilistic sampling distributions to control decision errors during data analysis. Hypothesis testing is a process, based on the scientific method, that compares a baseline condition to an alternate condition. The baseline condition is technically known as the null hypothesis. Hypothesis testing rests on the premise that the null hypothesis is true and that sufficient evidence must be provided for to reject it in favor of the alternate hypothesis.

While the MARSSIM guidance for acquiring FSS data is based on non-parametric statistics, site characterization surveys are more of an exploratory nature verses the verification phase of the FSS. Therefore, decision errors are more subjective during the characterization process, and the use of descriptive statistics is more appropriate.

Characterization data requires statistical quality to support decision making and to provide input to FSS design. Subsequently, the decision errors should be established to ensure that the type, quantity, and quality of data used in decision making are appropriate for the intended application.

G. Optimize the Design for Obtaining Data

The first six steps of the DQO process develop the performance goals of the survey. This final step in the DQO process leads to the development of an adequate survey design. For characterization, this step incorporates the data acquired and the analytical results to further refine inputs into the decision.

For example, scan measurements may indicate the presence of an area of elevated activity in an open land survey unit. That will prompt the acquisition of additional investigative soil samples to act as additional inputs into the decision regarding the lateral and vertical extent of soil contamination. This data will be evaluated and used to refine the scope of field activities to optimize implementation of the characterization design and ensure the DQOs are met.

4.5.2 Survey Unit Preparation for Continuing Characterization

Preparation for characterization will be performed in all survey units as deemed appropriate. Prior to performing characterization surveys, the survey units should be cleared of all loose equipment and materials to the extent possible. Appropriate staging or mechanical devices shall be used in accordance with the OPPD Safety Manual (Reference 2.2.4) and applicable site-specific safety procedures to safely access structural surfaces greater than

6 feet above a normal walking surface, to access confined spaces, or to access system internals.

Prior to performing characterization surveys in open land survey units, it may be necessary to clear the area of debris and/or vegetation to the extent possible, to eliminate physical obstructions. In this case, the vegetation should be cut as close to the ground surface as possible. All physical hazards in the survey unit should be either identified and removed or marked, as appropriate.

An excavation permit may be required for intrusive sampling. Typically, sampling to depths equal to or greater than 12" (30 cm) requires an excavation permit.

In order to facilitate the selection of systematic survey locations, a reference coordinate or grid should be established. Reference grids provide a mechanism for identifying the location of a scan area, static measurement or sample and ensuring that the location can be reproduced. Random or judgmental survey locations should also be pre-marked as needed to provide reproducibility.

For structural survey units that will be subjected to FSS, the reference coordinate system may consist of a grid of intersecting lines which reference a fixed site location. The lines will be arranged in a perpendicular pattern, dividing the survey unit into grid squares depending upon its classification. Typically, Class 1 structural survey units may be gridded in 1-meter by 1-meter grids. Class 2 structural survey units may be gridded in 10-meter by 10-meter grids. Class 3 survey units are typically not gridded.

For open land survey units, reference coordinates may be acquired using a Global Positioning System (GPS) coupled with a standard topographical grid coordinate system such as the North American Datum (NAD) or World Geodetic System (WGS).

4.5.3 Survey Packages and Sample Plans

Survey packages and sample plans will be prepared by, or under the direct supervision of, an LT/FSS Specialist. A survey package will be developed for each survey unit designated in Table 4-2 in accordance with FCSD-RA-LT-201, "Characterization Sample Plan Development" (Reference 2.2.5). A folder designated as the survey package should be utilized to keep sample plans and survey results for all characterization, RA, RASS, and FSS. The folder shall be controlled in accordance with EPND-RM-100, "Record Management Program" (Reference 2.2.6), EPND-RM-101, "Records Creation, Index, and Transmittal Process" (Reference 2.2.7), and FC-SRRS, "SRRS Process" (Reference 2.2.8) as well as other relevant requirements in Section 4.2 of the QAPP.

Multiple sample plans may be generated for a survey unit when performing characterization in phases. Sample plans contain survey instructions that describe the number, type, and location of static measurements and material samples with the type of analyses to be performed. Direction will also be provided for selection of instruments, count times, instrument modes, survey methods, required documentation, action levels, investigation actions, background requirements, and other appropriate instructions. In conjunction with the survey instructions, survey data forms, indicating desired measurements, are prepared to assist in survey documentation. The survey package will become the primary method of controlling and tracking survey results.

A sample plan should contain sections for the following types of information:

- Detailed description of the survey unit
- Photographs, maps, and/or drawings of the survey unit
- A summary of the operational history from the HSA pertinent to the survey unit and summary data from any previous radiological surveys if available
- The specific DQOs for the characterization surveys performed in the survey unit
- Types and number of survey measurements and/or samples prescribed for the survey
- Specific survey instructions
- Sample designation codes and locations,
- Quality assurance measures in accordance with the QAPP,
- Any additional pertinent information such as support from others, health and safety information, necessary Work Orders (e.g., for coring, drilling, excavation activities, as required), and/or permits (e.g., Excavation Permit, Radiation Work Permit, etc.)

When a sample plan is ready for implementation, a separate LT/FSS Specialist or LT/FSS RE will perform a peer review of the plan, including a review of the survey design, instructions, and calculations. The peer review will also ensure that appropriate instruments, survey methods, and sample locations have been properly identified. When the peer review is complete, sample plans will be reviewed and approved by the LT/FSS Manager or designee prior to implementation.

4.5.4 Survey Unit Walk-down

Sample plan development will begin with the performance of a walk-down of the survey unit. During the walk-down, details regarding the physical survey area will be compiled, such as the surfaces in the unit (e.g., wall, floor, ceiling, surface soil, etc.) and metric dimensions in meters. Data from available operational surveys will be reviewed and utilized, as appropriate.

The pre-survey walk-down will identify potential industrial safety hazards specific to the survey unit. This inspection is intended to identify general safety hazards, as well as significant industrial safety hazards, that may or may not impact the performance of the survey. Significant health and safety concerns include the potential industrial hazards commonly found at a construction site, such as exposed electrical circuitry, excavations, enclosed work spaces, hazardous atmospheres, insects, venomous snakes, poisonous plants, and animals, unstable surfaces, heat and cold, sharp objects or surfaces, falling objects, tripping hazards, and working at heights.

Each hazard identified will be evaluated to determine if the hazard can be eliminated, avoided, or minimized, as well as to determine if the need for additional outside support/expertise is necessary to complete further evaluation. If, at any time during the inspection or the subsequent survey, a serious hazard is identified that requires immediate action (i.e., cannot be immediately eliminated, avoided, or minimized), the area will be isolated until an acceptable remedy has been implemented.

4.5.5 Survey Design

Characterization surveys will be designed and performed in accordance with all applicable approved procedures and this characterization survey plan. Survey design will incorporate a graded approach based upon the DQOs for the survey unit.

There are three approaches that can be used for survey design: judgmental (biased), systematic, or random sampling. Judgmental survey designs use known information or process knowledge to select locations for static measurements and/or samples. Systematic survey design, usually only utilized for FSS, selects static measurement and/or sample locations by using a systematic sampling design (typically a square or triangular grid) with a random start. Random survey design selects static measurements and/or sample locations randomly. The decision of whether to perform survey design using a judgmental, systematic, or random approach should be addressed by the DQO process. A judgmental approach would be warranted when the characterization effort is designed to delineate the extent of an area that requires remediation. Alternatively, a systematic or random approach would be warranted if the characterization effort is designed to verify the basis for classification. Most characterization surveys will utilize a combination of random and judgmental approaches to survey design.

A. Number of Static Measurements and/or Samples

1. The number of measurements and/or samples that will be taken in each survey unit will be determined by assessing the population size necessary to satisfy the DQOs.

2. For the characterization of Class 1 survey units, the number of static measurements and/or samples will be of sufficient quantity to satisfy the DQO decision in the professional judgment of the responsible LT/FSS Specialist or LT/FSS RE.
3. For the characterization of Class 2 survey units, the minimum number of systematic or random static measurements and/or samples that should be taken in the survey unit should be commensurate with the probability of the presence of residual radioactive contamination in the survey unit. The sample size selected should be sufficiently robust to provide a statistically defensible mean and assessment of variability.
4. For Class 3 survey units, the primary characterization DQO is to establish the basis for the Class 3 or non-impacted classification. Consequently, the population of random measurements and/or samples should be sufficiently robust so that the basis for the classification will present a high degree of confidence that no licensee-generated radioactive material resides in these areas. Since the recommended survey unit size for a Class 3 is unlimited, additional measurements and/or samples above the minimum population calculated may be necessary to address this DQO.
5. Table 4-5 provides recommended judgmental and random measurement and/or sample population sizes. These are recommended sample population sizes; the actual number of judgmental and random measurements and/or samples that may be taken in a survey unit is at the discretion of the responsible LT/FSS Specialist or LT/FSS RE.

Table 4-5 Recommended Sample Population Size

Survey Unit Classification	Population Type	Recommended Population Size
Class 1	Judgmental	8
	Random	Not Required
Class 2	Judgmental	30
	Random	15
Class 3	Judgmental	13
	Random	14

B. Determination of Measurement or Sample Locations

1. For impacted survey units, the location of measurements and/or samples to be taken in each survey unit (or group of survey units with similar geography and classification) will be determined by the responsible LT/FSS Specialist or LT/FSS RE. For judgmental measurement and/or sample locations, consideration should be given to locations that exhibit measurable radioactivity (identified during the scan survey), depressions, discolored areas, cracks, low point gravity drain points, actual and potential spill locations, or areas where the ground has been disturbed. Historical information found in the HSA can aid in judgmental location selection.
2. For Class 1 survey units, the location of measurements and/or samples should be biased to suspect areas. For Class 2 and 3 survey units, the location of measurements and/or samples should be chosen at random and augmented with biased measurements/samples, as necessary. Sample locations should be determined by generating random pairs of coordinates that correspond to specific locations within a survey unit. This can be accomplished through the use of a random number generator or through the use of computer software such as Visual Sample Plan (VSP).
3. A combination of photographs, maps, and drawings should be developed for each sample plan depicting each survey unit. The survey unit maps should be annotated with the grid reference system and the location of the characterization survey measurement locations. The sample locations and/or the reference grid should be superimposed onto the map to provide an (x, y) coordinate for each location.

C. Scan Coverage

Survey units are scanned in accordance with their classification. The area to be scanned in each survey unit will be determined by the professional judgment of the responsible LT/FSS Specialist during the survey design process. The following is a list of recommended scan coverage guidelines that may be used.

Table 4-6 Recommended Scan Coverage

Survey Unit Classification	Recommended Characterization Scan Coverage
Class 1	No scanning required unless compelled by a specific survey objective.
Class 2	50% to 100%, concentrating on areas with an increased probability of exhibiting elevated activity (such as Class 1 boundaries, vehicle transit routes, etc.).

Class 3	5% to 50%, with emphasis on areas that were used for plant activities during operation and areas downwind or downstream of known effluent release points.

D. Types of Measurements or Samples

The characterization survey of building or piping surfaces may consist of surface scans (beta and gamma), *in situ* gamma spectroscopy measurements using the Canberra In Situ Object Counting System (ISOCS) or similar, static beta measurements, material samples, and smears. The characterization survey of any concrete and/or asphalt-paved open land area may consist of surface scans (beta and gamma), static beta measurements, and volumetric samples. The characterization survey of the open land areas will consist of gamma scans and the sampling of surface and subsurface soil, sediment, and surface water for isotopic analysis. The following is a description of the different types of measurements and samples that may be utilized.

1. Static Measurements

   Static measurements are performed to detect direct levels of total surface contamination on structural surfaces of the buildings or on concrete or asphalt paved areas. These measurements are typically performed using ~126 cm^2 scintillation or gas-flow proportional detectors. Smaller detectors may be used as accessibility requires.

   Static measurements are conducted by placing the detector on or very near the surface to be counted and acquiring data over a pre-determined count time. A count time of one minute is typically used for surface measurements and generally provides detection levels well below the action level. (The count time may be varied provided the required detection level is achieved).

   Instrument count times will be adjusted, as appropriate, to achieve an acceptable MDC for static measurements.

2. Canberra ISOCS

   Static measurements may be taken using the ISOCS, primarily in building basements. Static measurements using the ISOCS detector are typically taken with the detector oriented perpendicular to the surface under assessment. In most cases, the exposed face of the detector may be positioned at a distance of one (1) to three (3) meters above the surface; however, some measurements may be taken at a closer distance to avoid obstructions. With the 90-degree collimation shield installed, an orientation at a height of three (3) meters from a surface corresponds to a nominal Field-of-View (FOV) of 28 m^2.

   Typically, the measurements acquired using ISOCS are taken with a geometry that evaluates activity to a specific depth over the geometric

FOV. Measurement count times are adjusted to achieve an acceptable MDC. Use of the ISOCS should be supported by a CPP and/or procedure.

3. Beta Surface Scans

   Scanning is performed in order to locate areas of residual activity above the investigation level. Beta scans are performed over accessible structural surfaces including, but not limited to, floors, walls, ceilings, roofs, asphalt, and concrete paved areas. Floor monitors using large area gas-flow proportional detectors (typically with 584 cm^2) may be used for floor and other larger accessible horizontal and vertical surfaces. Hand-held beta scintillation and/or gas-flow proportional detectors (typically 126 cm^2) may be used for surfaces not accessible by a floor monitor.

   Beta scanning will typically be performed with the detector position maintained within 1.27 cm (0.5 inch) of the surface and with a scanning speed of one detector active window per second. If surface conditions prevent scanning at the specified distance, the detection sensitivity for an alternate distance can be determined, and the scanning technique adjusted accordingly. Scanning speed is calculated *a priori* to assure the MDC for scanning is appropriate for the stated objective of the survey. Adjustments to scan speed and distance may be made when necessary.

   Whenever possible, technicians should monitor the audible response to identify locations of elevated activity that require further investigation and/or evaluation. All areas of elevated contamination should be identified for further investigation and potential decontamination.

4. Gamma Surface Scans

   Gamma scans are performed over land surfaces to identify locations of residual surface activity. Sodium iodide (NaI) gamma scintillation detectors (typically 2” x 2”) are typically used for these scans. Scanning may be performed by moving the detector in a serpentine pattern (using a 1-meter wide swath), while advancing at a rate not to exceed 0.5 m (20 in) per second. The distance between the detector and the surface should be maintained within two to three inches. Audible and visual signals should be monitored, and locations of elevated direct levels should be flagged for further investigation and/or sampling.

5. Removable Surface Contamination

   Smear surveys of removable beta and/or alpha contamination are performed to verify loose surface contamination is less than the action level. A smear for removable activity is usually taken at each static measurement location. A 100 cm^2 surface area will be wiped with a circular cloth or paper filter, using moderate pressure. Smears are then analyzed for the presence of gross beta and/or gross alpha activity, as appropriate. This is typically performed using a proportional counting system or equivalent.

6. Concrete Sampling

   Volumetric sampling of concrete, as opposed to static measurements, may be necessary if gross static measurements are not sufficient to address the survey unit specific DQOs. Core bore sampling of concrete typically involves the use of a diamond bit core drill. Sampling in asphalt covered surfaces may involve the use of an electric powered jackhammer. Alternative methods to obtain volumetric concrete samples (e.g., collecting samples via hollow drill bits and vacuum system) are also acceptable, especially when a large number of sample locations or high dose rates are involved.

   The material (asphalt or concrete) sample produced by the coring is typically sliced into ½-inch wide "pucks," which represent a certain depth into the surface. Static measurements are performed on the top and bottom of the pucks to determine contaminant intrusion depth and/or the activation of the concrete matrix. Concrete pucks can also be pulverized and analyzed for isotopic content. As an alternative to core boring, a patented procedure that uses a hollow drill bit may be used to obtain exact volumes of material at certain depths while utilizing a vacuum collection system. On asphalt, subsequent layers may be separated to reveal and measure contamination between the layers. For sampling using a specialized drill bit, material from each of the incremental depths at a location are captured in a separate container for each depth increment via use of a vacuum system.

7. Material Sampling

   Samples of soil, sediment, and sludge will be obtained from designed judgmental, randomly selected, or systematic sample locations, as well as other biased locations in areas exhibiting elevated activity that were identified by scanning. Surface soil is usually defined as the top 15 cm (6 inch) layer of soil while subsurface soil is usually defined as soil below the top 15 cm layer in 1 meter increments. Surface soil can be collected using a split spoon sampling system or by using hand trowels, bucket augers, or other suitable sampling tools.

   Subsurface soil is typically sampled by direct push sampling systems (e.g., Geoprobe®) or by the excavation of test pits. Subsurface soil sampling is performed, as necessary, to address the DQOs for the survey unit.

   An adequate amount of material (may range from 0.5 liters up to two liters) will be collected at each location. Sample preparation may include the removal of extraneous material and the homogenization and drying of the soil for analysis. Separate containers will be used for each sample, and accountability for each container will be throughout the analysis process as specified in the QAPP. Samples will be split when required as specified in the QAPP.

4.5.6 Survey Implementation

When a sample plan has been approved, and prior to implementation, the responsible LT/FSS Specialist will conduct a pre-survey briefing with the LT/FSS Supervisor(s) and Technicians who will perform the survey. During the briefing, the survey instructions will be reviewed. Subsequently, Technicians will gather and stage all equipment and instruments required to perform the survey in accordance with the survey instructions.

Sample plan implementation may include the following:

- The set-up of the survey instrumentation.
- Checking source and background radiation before and after each shift to ensure proper operation.
- Performing preliminary inspections of the areas to identify additional specific survey requirements.
- Locating and marking static measurement and/or sample locations using the coordinates provided in the survey instructions.
- Taking survey measurements and the analysis of samples using appropriate calibrated instruments.
- Documentation of survey measurements and sample analysis data collected during the characterization and placed in the survey package.
- The review of the completed sample pans to ensure that all required surveys have been performed.
- The review of the survey results to identify any areas exceeding the specified action levels.

4.5.7 Survey Measurement Location Codes

To facilitate data queries and reporting, each characterization survey measurement and sample collected will be assigned a unique survey measurement location code. Table 4-7 presents an example of the sample and measurement unique identification designation system used to identify sample and measurement types and locations.

Table 4-7 Sample & Measurement Unique Identification Designation

1	2	3	4	5	-	6	-	7	8	-	9	10	11	12	-	13	14	15
					-		-			-					-			

1-4 Survey Unit Number
0000 through 9999

5 Survey Unit Division
A through T – allows for the survey unit to be divided into smaller survey units

Note: X denotes no division

6 Classification
1 = Class 1
2 = Class 2
3 = Class 3

7 Survey Type
B = Background
S = Scoping
C = Characterization
A = RA
R = RASS
F = FSS
U = URS
I = Investigation
V = Verification
Q = QC

8 Sample or Measurement Type
B = Background
R = Random
S = Systematic
J = Judgmental
I = Investigation
V = Verification
Q = QC

9 Surface Type
F = Floor
W = Wall
C = Ceiling
R = Roof
S = System
G = Ground
L = Water
P = Paved Road

10-11 Media/Measurement
SS = Surface Soil
SB = Subsurface Soil
SM = Sediment
WT = Water
LQ = Other Liquid
OL = Oil
CV = Volumetric Concrete
AV = Volumetric Asphalt
OV = Other Volumetric Solid
MT = Metal
PT = Paint
SW = Smear Sample
BD = Beta Direct
AD = Alpha Direct
GD = Gamma Static
BS = Beta Scan
GS = Gamma Scan

12 Split Sample/Increment Designation
A or B, or 1 through 9

Note: X denotes no split or increment

13-15 Sample or Measurement Number
001 through 999

4.5.8 Quality Assurance

This characterization plan was developed according to the essential elements of the QAPP. The QA/QC program elements applicable to characterization are as follows:

- Establishment/implementation of plans, procedures, and protocols for the field operations.
- Actions to ensure that the procedures are understood and followed by the implementing staff.
- Documentation of the data collected.

Details of the QA/QC elements specific to characterization are presented in the QAPP, as well as the procedures and sample plan instructions. The characterization operations and the associated data acquisition and recording will be guided and conducted in compliance with these QA/QC requirements. The specific QA/QC program components for the characterization are as follows:

- Personnel qualifications, experience, and training.
- Execution in accordance with approved procedures.
- Proper documentation of survey data and sample analyses.
- Selection of appropriate instruments to perform the surveys.
- Proper instrument calibration and daily functional checks.
- Management oversight of characterization activities relative to the adherence to procedures, protocols, and documentation requirements.

All characterization activities are conducted in accordance with this plan, the QAPP, all applicable implementing procedures, and approved sample plan instructions.

4.5.9 Instrumentation and Selection

Radiation detection and measurement instrumentation for characterization are selected to provide both reliable operation and adequate sensitivity to detect the ROC identified for the decommissioning of the FCS facility at levels sufficiently below the established action levels. Detector selection is based on detection sensitivity, operating characteristics, and expected performance in the field.

Commercially available portable and laboratory instruments and detectors are typically used to perform the three basic survey measurements: 1) surface scanning, 2) static measurements, and 3) analysis of material samples.

The instruments and detectors selected for static measurements and scanning should be capable of detecting the gross beta-gamma activity to a MDC of

50% of the applicable action levels. This is an administrative guideline only and not necessarily a limit.

An example of instrumentation and nominal MDC values that may be used during characterization are listed in Table 4-8.

Table 4-8 Example of Instrument Types and Nominal MDC

Detector Model[2]	Meter Model[2]	Application	Nominal Detection Sensitivity[1] MDCscan (dpm/100cm^2)	MDCstatic (dpm/100cm^2)
Ludlum 44-9	Ludlum 2350-1	β static & scan	2900	985
Ludlum 43-5	Ludlum 2350-1	α static & scan	150	75
Ludlum 43-68 β mode	Ludlum 2350-1	β static & scan	1050	330
Ludlum 43-68 α mode	Ludlum 2350-1	α static & scan	170	70
Ludlum 44-116	Ludlum 2350-1	β static & scan	1300	415
Ludlum 43-90	Ludlum 2350-1	α static & scan	130	55
Ludlum 44-10	Ludlum 2350-1	γ scan	3.5 pCi/g Co-60 6.5 pCi/g Cs-137	N/A
Ludlum 43-37	Ludlum 2350-1	β scan	1000	N/A
Tennelec LB5100 proportional counting system	N/A	α and/or β smear	N/A	18
HPGe Gamma Spectroscopy System 3	N/A	γ Analysis	N/A	~0.15 pCi/g for Co-60 and Cs-137

[1] Based on 1-minute count time; and default values for surface efficiencies,∈s, as specified in International Standard ISO 7503-1, Part 1, "Evaluation of Surface Contamination, Beta-Emitters (maximum beta energy greater than 0.15 MeV) and Alpha-Emitters" (Reference 2.1.3).
[2] Functional equivalent instrumentation may be used.

A. Instrument Calibration

All data loggers, associated detectors, and all other portable instrumentation that will be used for characterization are calibrated on an annual basis using National Institute of Standards and Technology (NIST) traceable sources and calibration equipment. The calibration of instruments used for characterization is addressed in Section 4.7 of the QAPP.

B. Instrument Use and Control

The receipt, inspection, issue, controls, and accountability of portable radiological instrumentation used for characterization is performed in accordance with the procedure that governs the issue, control, and accountability of characterization and FSS portable radiological instrumentation. The issue and control of instruments used for characterization is addressed in Section 4.6 of the QAPP.

4.6 Survey Documentation

Records of characterization surveys are maintained in the survey packages for each survey unit. The survey package could include the following records, depending upon the survey design and DQOs.

- Survey Unit Diagram or drawing which includes depictions of boundaries, landmarks, and measurement and/or sample locations.
- Photographs of the survey area, as necessary, to show special or unique conditions.
- Printout of laboratory analysis results reported in appropriate units.
- Hand-logged or downloaded data files with measurement results converted to appropriate units for all static surface contamination measurements.
- Alpha/beta smear counter logged results or data files with measurement results converted to appropriate units for all removable surface contamination measurements.

Digital cameras may be employed to provide a more permanent record of survey locations or conditions within a survey unit. When used, these photographic records should be linked to landmark and directional information to ensure reproducibility.

4.7 Data Validation

Characterization survey measurement and/or analysis results are reviewed by LT/FSS Specialists to ensure that the survey is complete, fully documented, and technically acceptable. Validation ensures that the data set is comprised of qualified measurement results collected in accordance with the survey design, which accurately reflects the radiological status of the survey unit. The review criterion for data acceptability includes the following items as a minimum.

- Compliance with survey instructions as specified in the sample plan.

- Showing that MDCs were appropriate for the instruments and techniques used to perform the survey.
- The instrument calibration was current and traceable to NIST standards.
- The field instruments were source checked with satisfactory results before and after use each day that the data was collected or, if unsatisfactory, data obtained with that instrument since its previous acceptable performance check was evaluated for acceptability.
- The survey methods used to collect data were proper for the types of radiation involved and for the media being surveyed.
- The data set is comprised of qualified measurement results collected in accordance with the survey design, which accurately reflects the radiological status of the survey unit.
- The data has been properly recorded.
- If the data review criteria are not met, then the LT/FSS Manager is informed. The discrepancy is then reviewed and the decision to accept or reject the data is documented in the survey package.

4.8 Data Evaluation and Review

Static beta-gamma and/or alpha measurements collected during the characterization surveys are compared against the action levels (Section 4.4). Material sample analysis results are also compared against the volumetric action level values. If multiple ROC are identified in concentrations greater than MDC, then the unity rule applies. In Class 3 survey units, individual survey results exceeding 50% of the action level are identified. Survey results that approach or exceed the action level are considered cause for additional investigation or possible reclassification. In addition, the mean activity and the standard deviation should be calculated for the survey population.

At the completion of the surveys conducted in each survey unit, measurement results are assessed and evaluated according to the DQOs. If the lateral extent of contaminated areas has not been determined by the measurements prescribed in the sample plan instructions, more measurements may be prescribed to delineate where surface contamination is no longer present. If the vertical extent of contaminated areas has not been determined, subsequent at depth samples will be prescribed to delineate where subsurface contamination is no longer present. The guidance provided in MARSSIM for survey, measurement, data analysis, and data evaluation according to the survey DQOs process is repeated during the data evaluation. Once all DQOs have been attained, the characterization is considered complete.

4.9 Health and Safety Considerations

The OPPD Safety Manual was developed to identify health and safety features to be used while performing characterization, deconstruction, and support activities at FCS. The OPPD Safety Manual and applicable procedures for job safety analysis meet the

MARSSIM Section 4.10, Health and Safety, recommendation for health and safety evaluation prior to commencement of work.

All sampling and surveys described in this plan are performed in accordance with the OPPD Safety Manual and applicable safety procedures. All sampling and surveys are also conducted safely, addressing hazards and applicable health and safety requirements as identified through Job Hazard Analysis (JHA), and pre-job briefings, as required. For entry and work in posted radiologically controlled areas, characterization activities are also conducted under an approved Radiation Work Permit (RWP). The characterization activities are described in sufficient detail to identify any applicable radiation protection and ALARA requirements.

5 ATTACHMENTS AND FORMS

None