LACROSSE SOLUTIONS

LACBWR Site Restoration Project Work Control Procedure

Final Status Survey Data Assessment

Procedure No. LC-FS-PR-008

Revision No. 1

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Summary of Changes:

1.) Minor formatting changes that did not affect the technical content of this procedure.

2.) Revised for consistency with Revision 1 of the License Termination Plan, request for additional information related to the License Termination Plan for the Zion Nuclear Power Station, Units 1 and 2. (TAC Numbers L53045 and L53046) and additional NRC commitments.

3.) Incorporated information applicable to Structure data assessment.

4.) Incorporated Base Case and Operational DCGLs per LC-FS-TSD-002.

5.) Specify additional requirements for resurvey if remediation is performed post-FSS in response to condition report ES-LCR-CR-2017-0073.

1. PURPOSE AND SCOPE

1.1. Purpose

This procedure provides guidance to interpret survey results using the Data Quality Assessment (DQA) process during the assessment phase of Final Status Survey (FSS) at the La Crosse Station Restoration Project (LCSRP). FSS is conducted on above grade and below grade structures (basements), soil (including excavations), and buried piping to demonstrate that residual radionuclide concentrations are equal to or below established Derived Concentration Guideline Levels (DCGL).

1.2. Scope

This procedure implements the requirements of applicable U.S. Nuclear Regulatory Commission (NRC) regulations and guidance documents; specifically, NUREG-1757, Volume 2, Revision 1**,** "*Consolidated Decommissioning Guidance – Characterization, Survey, and Determination of Radiological Criteria"* (Reference 2.1), NUREG-1575, "*Multi-Agency Radiation Survey and Site Investigation Manual"* (MARSSIM, Reference 2.2) and Chapter 5 of the LCSRP "*License Termination Plan*" (LTP, Reference 2.3).

This procedure applies to all persons involved with the receipt, management, storage and conversion of data collected in support of FSS. The data to be received and processed includes direct download data from instrumentation, counting instrument reports, instrument control and calibration databases, field survey records and other manual entry data. Data processing includes converting measurement data into reporting units, validating instrument applicability and sensitivity, calculating relevant statistical quantities, and verification that all Data Quality Objectives (DQOs) have been met. Following data validation, processing, reduction and evaluation, a Release Record will be generated in accordance with procedure LC-FS-PR-009, *"Final Status Survey Data Reporting"* (Reference 2.4).

2. REFERENCES

2.1. NUREG-1757, "Consolidated NMSS Decommissioning Guidance - Survey, and Determination of Radiological Criteria" Volume 2, Revision 1 – September 2002

2.2. NUREG-1575, "Multi-Agency Radiation Survey and Site Investigation Manual" (MARSSIM) – August 2000

2.3. "La Crosse Station Restoration Project License Termination Plan" – December 2014

2.4. LC-FS-PR-009, "Final Status Survey Data Reporting"

2.5. LC-QA-PN-001, "Final Status Survey Quality Assurance Project Plan"

2.6. LC-FS-PR-006, "Survey Unit Classification"

2.7. LC-FS-PR-010, "Isolation and Control for Final Status Survey"

2.8. LC-FS-PR-009, "Final Status Survey Data Reporting"

2.9. LC-AD-PR-004, "Corrective Action Program"

2.10. LaCrosse*Solutions* Technical Support Document RS-TD-313196-001, "Radionuclides of Concern During LACBWR Decommissioning"

2.11. LC-FS-PR-002, "Final Status Survey Package Development"

2.12. LC-FS-PR-015, "Final Status Surveys for Structures"

2.13. LC-FS-TSD-002, "Operational Derived Concentration Guideline Levels for Final Status Survey"

3. GENERAL

3.1. Responsibilities

3.1.1 Radiation Protection (RP)/ FSS Manager – is responsible for:

- Providing overall technical support for the review, validation and interpretation of FSS results and analysis.
- Reviewing and approving the conclusions reached for the survey unit from the assessment of the survey data.
- Ensuring the conclusions from FSS are appropriately documented and technically defensible.

3.1.2 FSS Supervisor – is responsible for:

- Ensuring the survey data taken for FSS is authentic and of sufficient quality.
- Ensuring all required surveys have been performed and documented in accordance with the FSS Sample Plan for the survey unit.
- The evaluation of FSS data & results using the DQA process.

3.1.3 Graphics/GPS Specialist – is responsible for:

- Preparing survey maps, layout diagrams, composite view drawings and other graphics as necessary to support FSS data analysis.

3.1.4 Final Status Survey (FSS) Technician(s) – are responsible for:

- Obtaining and documenting survey measurements and samples in accordance with the FSS Sample Plans and all applicable procedures.

3.2. Definitions

3.2.1 ***A priori*** – The probability assigned to a parameter or to an event in advance of any empirical evidence, often subjectively or on the assumption of the principal of indifference.

3.2.2 **Area Factor (AF)** – The factor by which an individual measurement within a specific area can exceed the DCGL, while maintaining compliance with the release criterion. Use of Area Factors only applies to open land survey units.

3.2.3 **Biased Measurements** – Also referred to as judgmental measurements, biased measurements are performed at locations selected using professional judgment based on unusual appearance, location relative to known contamination areas, high potential for residual radioactivity, general supplemental information, etc.

3.2.4 **Data Quality Assessment (DQA)** – The scientific and statistical evaluation of data to determine if the data are of the right type, quantity, and quality for the intended use.

3.2.5 **Data Quality Objectives (DQO)** – Qualitative and quantitative statements derived from the DQO process that clarify study 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.

3.2.6 **Derived Concentration Guideline Level (DCGL)** – A derived, radionuclide specific activity concentration within a survey unit corresponding to the release criterion (referred to as Base Case DCGLs). DCGLs are derived from activity/dose relationships through various exposure pathway scenarios. To ensure that the summation of dose from each source term is 25 mrem/yr. or less after all FSS is completed, the Base Case DCGLs are reduced based on an expected, or *a priori*, fraction of the 25 mrem/yr. dose limit from each source term. These reduced DCGLs are called Operational DCGLs. The Operational DCGL is then used as the DCGL for the FSS design of the survey unit (calculation of surrogate DCGLs, investigations levels, etc.).

3.2.7 **Elevated Measurement Comparison (EMC)** – At LACBWR, the $DCGL_{EMC}$ only applies to open land (soil) survey units. The $DCGL_{EMC}$ is a comparison of measured values against the $DCGL_W$ modified to account for small areas where residual radioactivity levels exceed the $DCGL_W$. The $DCGL_{EMC}$ is the acceptable level of residual radioactivity over a small but defined area which meets the site release criterion.

3.2.8 **Final Status Survey (FSS)** – FSS conducted on soil, buried piping, basement concrete, penetrations, embedded piping and groundwater to demonstrate that residual radionuclide concentrations are equal to or below site-specific DCGLs.

3.2.9 **Frequency Plot** – A bar chart of the number of data points within a certain range of values. The frequency plot may reveal any obvious departures from symmetry, such as skewness or bimodality (two peaks), in the data distributions for survey units or background reference areas.

3.2.10 **Histogram** – A graphical representation of the distribution of numerical data. It is an estimate of the probability distribution of a continuous variable (quantitative variable).

3.2.11 **Investigation Level** – A derived media-specific, radionuclide-specific concentration or activity level of radioactivity that: 1) is based on the release criterion, and 2) triggers a response, such as further investigation or cleanup, if exceeded.

3.2.12 **Mean** – The average value of the data set, obtained when the sum of the individual measurements is divided by the number of measurements.

3.2.13 **Median** – The center of the data set when data points are ranked in order from smallest to largest. The median is the center data point if the data set contains an odd number of values or the average of the two center data points if the data set contains an even number of values.

3.2.14 **Minimum Detectable Concentration (MDC)** – The Minimum Detectable Concentration (MDC) is defined as 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. The critical level, (L_C), is the lower bound on the 95% detection interval defined for L_D and is the level at which there is a 5% chance of calling a background value "greater than background." This is the value used when actually counting samples or making direct radiation measurements. Any response above this level should be considered as above background (i.e., a net positive result). This will ensure 95% detection capability for L_D. The MDC is dependent upon the counting time, geometry, sample size, detector efficiency and background count rate.

3.2.15 **Nonparametric Statistical Test** – A test based on relatively few assumptions about the exact form of the underlying probability distributions of the measurements. As a consequence, nonparametric statistical tests are valid for a fairly broad class of distributions. The Sign Test is an example of a nonparametric test.

3.2.16 **Outlier** – A measurement that is unusually large or small relative to the rest and therefore is suspected of misrepresenting the population from which it was collected.

3.2.17 **Posting Plot** – A map of the survey unit with the data values entered at the measurement locations. The posting plot can reveal spatial non-homogeneities in the survey unit such as patches of elevated residual radioactivity or groupings of measurements that exceed the $DCGL_W$.

3.2.18 **Quantile Plot** – A plot used to diagnose asymmetry in a data set. A quantile plot is constructed by ranking the data from smallest to largest. Each data value is plotted against the percentage of the data set with that value or less.

3.2.19 **Range** – The measure of the difference between the largest and smallest values in the data set.

3.2.20 **Sign Test** – A nonparametric statistical test used to demonstrate compliance with the site release criterion when the radionuclide of interest is not present in background or constitutes a small fraction of the $DCGL_W$.

3.2.21 **Standard Deviation** – The measure of the variability around the mean of the data set.

3.2.22 **Structure** (for the purposes of this procedure) – Above grade and below grade (basements) portions of buildings that will remain on site at the time of license termination.

3.2.23 **Sum-of-Fractions** – The Sum-of-Fractions (SOF) or "unity rule" is applied in FSS survey planning, data evaluation and statistical tests since multiple radionuclide-specific measurements may be performed or the concentrations inferred based on known relationships. The application of the unity rule serves to normalize the data to allow for an accurate comparison of the various data measurements to the release criteria. When the unity rule is applied, the DCGL (used for non-parametric statistical tests) becomes one (1).

3.3. Acronyms

α	Type I Error Probability
β	Type II Error Probability
σ	Standard Deviation (sigma)
AAF	Area Adjustment Factor
AF	Area Factor
LT	License Termination
CoC	Chain-of-Custody
DCGL	Derived Concentration Guideline Level
DQA	Data Quality Assessment
DQO	Data Quality Objectives

EMC	Elevated Measurement Comparison
FOV	Field of View
FSS	Final Status Survey
HTD	Hard-to-Detect
ISOCS	*In-Situ* Object Counting System
LCSRP	LaCrosse Station Restoration Project
LTP	License Termination Plan
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	Minimum Detectable Concentration
NIST	National Institute of Standards and Technology
NRC	US Nuclear Regulatory Commission
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
ROC	Radionuclides-of-Concern
SOF	Sum-of-Fractions
TSD	Technical Support Document

3.4. Precautions, Limitations, and Prerequisites

3.4.1 Precautions

a. Documents and databases containing FSS data are Quality Assurance (QA) records when complete. Positive control of this data shall be maintained in accordance with section 2.5.2 of LC-QA-PN-001 *"Final Status Survey Quality Assurance Project Plan"* (Reference 2.5).

b. When documenting survey information, all personnel shall ensure that all QA records are of good quality and legible. Legibility is determined to be readable and reproducible.

c. Direct access to FSS data shall be limited to personnel authorized by the RP/ FSS Manager.

d. The required areal coverage for a Class 1 basement survey unit is 100%. Sufficient measurements must be taken in Class 1 FSS units to ensure that 100% of the surface area is surveyed (e.g. ISOCS FOV will be overlapped to ensure that there are no un-surveyed corners and gaps). If 100% areal coverage cannot be achieved in a Class 1 basement survey unit, then notify the RP/FSS Manager.

e. For laboratory analysis, MDCs less than 10% of the Operational DCGL are preferable while MDCs up to 50% of the Operational DCGL are acceptable. The MDC for measurements obtained using field instruments will be 50 percent of the applicable Operational DCGL. Instruments used for scan measurements in Class 1 surface soil areas are required to be capable of detecting radioactive material at the $DCGL_{EMC}$.

f. When assessing FSS results, the analysis of the structures must be below the Base Case DCGLs that are used to demonstrate compliance with the 25 mrem/yr. unrestricted release criterion. Default screening values from NUREG-1757, Appendix H, Table 1, are applied to above grade structures that will remain at the time of license termination. The survey plans for structures were designed based upon use of the Sign Test for data analysis.

g. Remediation, Reclassification, and Resurvey

i. Re-classification of a survey unit from a less restrictive classification to a more restrictive classification shall be performed in accordance with procedure LC-FS-PR-006, *"Survey Unit Classification"* (Reference 2.6).

ii. A survey unit may not be reclassified to a lesser classification (e.g. from a Class 1 to a Class 2 or from a Class 2 to a Class 3) without RP/ FSS Manager approval.

iii. The decision to separate out and reclassify a new survey unit due to the presence of elevated residual radioactivity with the remainder of the original survey unit retaining its original classification should consider the following;

A. The assumptions made as to how the original survey unit was classified.

B. The postulated cause of the elevated residual radioactivity.

C. The possibility for other similar areas within the original survey unit having gone undetected.

D. The extent of the elevated residual radioactivity (and corresponding remediation) relative to the total area of the original survey unit.

3.4.2 Limitations

a. All attachments described in this procedure may be generated electronically. If electronic attachments are used, the physical layout of the attachment may be modified provided the intent described in this procedure is not changed.

b. Data accepted as the FSS of record shall be reviewed to verify they are authentic, appropriately documented, and technically defensible.

NOTE
Prior to issuing the order to backfill an excavation or sub-grade basement, at a minimum the RP/FSS Manager shall verify that the requirements of 3.4.2.c have been met, AND obtain concurrence from the NRC Project Manager that the survey unit is suitable for backfill.

c. Survey data may be accepted as FSS data provided the following requirements are met:

i. Methodology, techniques, and quality controls required for the FSS have been applied and achieved.

ii. No further remediation will be performed in the survey unit or, if remediation is performed, then the remediation that occurs will be localized in nature, all resultant contamination material will be controlled, and the area impacted by the remediation activity will be re-scanned and re-sampled (see Attachment 16).

iii. Isolation and control measures have been implemented and maintained in accordance with procedure LC-FS-PR-010, *"Isolation and Control for Final Status Survey"* (Reference 2.7).

d. Use of Graphics for Data Evaluation

i. A frequency plot is useful where anomalies in the data are encountered or where the data distribution is otherwise suspected to depart from symmetry.

ii. A posting plot and histogram can be useful as part of an investigation survey where one or more direct measurements or volumetric samples exceed the DCGL.

iii. Other graphical data representation tools may be used, as appropriate, to examine the general shape of the data distribution or to identify spatial patterns, relationships, or potential anomalies in the data that might go unnoticed using purely numerical methods.

e. In order to close a FSS sample plan, a survey unit release record will be prepared for each survey unit within the survey area in accordance with procedure LC-FS-PR-009, "Data Reporting" (Reference 2.8).

3.4.3 Prerequisites

a. Computer based programs developed to assist in calculating FSS data (i.e. Excel spreadsheets) shall be tested to verify and validate that the calculations are correct before they are used.

b. Any field copies of data collection forms generated in support of FSS implementation shall be filed with the applicable survey package.

c. Soil samples and concrete cores will be collected at 10% of the systematic sample locations during FSS to confirm the HTD to surrogate radionuclide ratios.

i. Only HTD radionuclides included as ROC (Sr-90) will be analyzed in the FSS confirmatory samples.

ii. For soil samples or concrete cores with positive results for both a HTD ROC and the corresponding surrogate radionuclide (Cs-137 or Co-60), the HTD to surrogate ratio will be calculated.

iii. The maximum ratio from characterization (see Attachment 4) will be used for the surrogate calculation unless the survey information from the soil sample(s) (positive results for both a HTD ROC and the corresponding surrogate radionuclide) supports the use of a surrogate ratio that is specific to the area. In these cases, the area-specific ratios will be determined by the actual survey data in lieu of the maximum ratios. The area-specific ratios used and the survey data serving as the basis for the ratios will be documented in the Sample Plan and the Release Record.

d. If levels of residual radioactivity in an individual measurement/sample(s) exceed a Sum-of-Fractions (SOF) of 0.1 (using Operational DCGLs), then the measurement/sample(s) will be analyzed for HTD ROC (Sr-90).

e. In Class 1 open land survey units, a subsurface soil sample shall be taken at 10% of the systematic surface soil sample locations in the survey unit with the location(s) selected at random.

f. When assessing grade-level land area FSS results, if the analysis of a surface soil sample, or the results of a surface gamma scan indicates the potential presence of residual radioactivity at a concentration of 75% of the Operational DCGL for soil, then additional biased subsurface soil sample(s) shall be taken to the appropriate depth within the area of concern as part of the investigation.

3.5. Records

3.5.1 Attachment 1, “Final Status Survey Data Quality Objectives Review Checklist”

3.5.2 Attachment 2, “FSS Preliminary Survey Data Summary”

3.5.3 Attachment 11, “Sign Statistical Test”

3.5.4 Attachment 13, “Final Status Survey Investigation”

3.5.5 Attachment 15, “Corrective Actions for Final Status Survey Failure”

4. PROCEDURE

4.1. Data Validation

4.1.1 Ensure that the survey area and survey unit for which the data is relevant is clearly marked on the data report.

4.1.2 Perform a validation of the survey data to ensure the data results are authentic, realistic and valid. Assess each specific sample or measurement result individually. Data validation includes the following;

a. Verify that the unique sample identification number for each sample or measurement is consistent between the sample analysis report, the Chain-of-Custody (CoC) form, the FSS Sample Plan and/or the survey instructions.

b. Verify that the recorded sample date & time for each sample or measurement is consistent with the CoC form (if applicable) and the survey record or download data.

c. Verify that the data is complete and that there are no missing results or supporting data, including but not limited to MDC, uncertainty, background, Field-of-View (FOV), geometry or methods of analysis.

d. Verify that the MDC of the instrument used for analysis was adequate to detect all ROC or gross activity at the target MDC values specified in the FSS Sample Plan for that survey unit.

NOTE

When performing an FSS in an excavation, the individual performing data validation shall be cognizant of data anomalies that may be indicative of a source term at a greater depth than the excavation. For example, if all scan readings are in the 10k cpm to 13k cpm range but an area shows 20k cpm, although the 20k cpm may be below the investigation levels, the anomalous reading may warrant an investigation to verify there is no source term at a greater depth.

e. Verify the absence of anomalies in the sample or measurement results, or in the supporting data, including but not limited to MDC, uncertainty, deviation from established procedure or analysis flags.

f. For data collected with a data logging instrument, verify the data has been downloaded with a unique file name.

4.1.3 For the assessment of FSS, present survey data results in units appropriate for comparison to the DCGL (pCi/m^2 for basement structures, pCi/g for soil and $dpm/100cm^2$ for above grade structures and buried pipe). As applicable, convert the units for the reported data to the DCGL units by correcting for survey instrument background, efficiency, geometry, detector area, and/or measurement size.

4.1.4 Indicate the analysis or measurement results have been validated by signing and dating on the cover of the analysis or survey report.

4.1.5 Once analysis or measurement results have been validated, place the documentation in the survey unit package for FSS data evaluation.

4.1.6 If an analysis result, measurement or set of data cannot be validated (accepted), then notate the sample or measurement result in question. The reviewer shall place their initials next to the measurement or sample in question and notify the RP/FSS Manager.

a. The RP/FSS Manager or designee shall:

i. Consider initiating an investigation into the reason or cause in accordance with LC-AD-PR-004, "Corrective Action Program" (Reference 2.9).

ii. Assess the verified data for the survey unit in order to make a determination if the remaining data is sufficient to meet the DQOs for that survey unit.

iii. Direct the acquisition of additional measurements or samples as necessary if the remaining data is insufficient to continue FSS (see Attachment 16).

4.2. DQO Checklist

4.2.1 Initiate Attachment 1, "Final Status Survey Data Quality Objectives Review Checklist" when notified that all samples and measurements required by the FSS Sample Plan and survey instructions have been taken or acquired.

4.2.2 Using the checklist, review the FSS Sample Plan, the sample instructions, the Field Notes, survey records and/or data analyses reports to ensure that the DQOs used for the survey design are applicable and valid.

4.2.3 Ensure that the narrative presented in the FSS Sample Plan is consistent, that any deviations from the sample instructions are fully explained and all requisite information necessary to present the narrative is included in the FSS Sample Plan.

4.2.4 If the review identifies discrepancies, then document any corrective actions that were taken to resolve the discrepancy.

4.2.5 If discrepancies remain that are unresolved, then forward the documentation to the RP/FSS Manager for completion.

a. The RP/FSS Manager or designee shall;

i. Assess the data that has been impacted by the discrepancy to determine if the data remains valid.

ii. Assess the remaining data that has not been impacted by the discrepancy to make a determination if the remaining data is sufficient to meet the DQOs for that survey unit.

iii. Consider initiating an investigation into the reason or cause in accordance with LC-AD-PR-004, "Corrective Action Program" (Reference 2.9).

iv. Direct the acquisition of additional measurements or samples as necessary if the remaining data is insufficient to continue FSS.

4.3. Preliminary Data Review for FSS

NOTE

Appropriate units must be added to the header in Attachment 2, "FSS Preliminary Survey Data Summary" contingent upon the type of FSS performed (open land, basement surface, buried pipe, etc.). Preliminary data review can also be processed using alternate formats, pre-programmed computer databases, computer spreadsheets, electronic calculators and hand calculations provided that all requisite data is included.

4.3.1 Using Attachment 2, "FSS Preliminary Survey Data Summary" or an equivalent form, prepare a summary of the survey data that will be used for FSS for the survey unit, including scan survey results, any judgmental samples that were taken and any investigation measurements or samples that were taken as a result of elevated scan measurements.

4.3.2 On Attachment 2 or equivalent, list all samples or measurements taken to meet the systematic survey design from the FSS Sample Plan.

NOTE

The actual recorded value will be used as the recorded FSS result for measurement and/or sample values that are less than MDC. Negative values will be recorded as "zero". The recorded value for the highest percent abundance will be used for reported results for radionuclides with multiple gamma energies.

a. List the measured activity for each gamma-emitting ROC.

b. List all relevant information such as date, sample or measurement location (x and y axis), sample weight (if applicable) and measurement FOV (if applicable).

i. Ensure all measurements are reported in the correct units. Measurements taken on Basement surfaces are typically gross gamma measurements in units of pCi/m^2. Measurements in buried pipe are typically gross gamma measurements reported in units of $dpm/100cm^2$. Analytical data for soil samples are reported in units of pCi/g.

NOTE

The final ROC are Co-60, Cs-137, Eu-152 and Eu-154, which are gamma emitters and Sr-90, which is a HTD radionuclide. Attachment 3 presents the final suite of ROC for the decommissioning of LACBWR and the normalized mixture fractions based on the radionuclide distribution for all site structures. The mixture applies to all basement structures, pipe and soil.

ii. Document the measurement/sample concentrations of dose-significant gamma emitting ROC (Co-60, Cs-137, Eu-152 and Eu-154).

A. If reported as a gross gamma measurement, then derive concentration contribution from individual gamma emitting ROC (Co-60, Cs-137, Eu-152 and Eu-154) using applicable normalized gamma mixture from Attachment 3.

iii. When assessing FSS results, verify that no plant-derived gamma emitting radionuclides other than the dose-significant gamma emitting ROC (Co-60, Cs-137, Eu-152 and Eu-154) are identified at concentrations greater than MDC.

A. If a plant-derived gamma emitting radionuclide other than the ROC were identified at concentrations greater than MDC, then perform an investigation to assess the dose significance of the identified radionuclide. Consider obtaining additional samples as part of the investigation.

NOTE

The mean, maximum and 95% Upper Confidence Level (UCL) of the surrogate ratios for concrete core samples taken in the Containment, WGTV and WTB basements were calculated in LaCrosse*Solutions* Technical Support Document RS-TD-313196-001, "Radionuclides of Concern During LACBWR Decommissioning" (Reference 2.10) and are presented in Attachment 4.

iv. Using the radionuclide mixture ratios applicable to the survey unit, infer HTD ROC by a surrogate approach or by direct scaling.

A. Cs-137 is the principle surrogate radionuclide for Sr-90.

B. The maximum ratios will be used in the surrogate calculations during FSS unless area specific ratios are determined by continuing characterization.

C. If area specific ratios are used, the ratios and the basis for their use will be documented in the FSS Sample Plan and the Release Record.

4.3.3 Calculate the Sum-of-Fractions (SOF) for each sample or measurement.

NOTE

LC-FS-TSD-002, "Operational Derived Concentration Guideline Levels for FSS" (Reference 2.23) provides the DCGLs used for FSS. Attachment 5 presents the Base Case and Operational DCGLs for soils ($DCGL_S$). Attachment 6 presents the Base Case and Operational DCGLs for buried pipe ($DCGL_{BP}$). Attachment 7 presents the Base Case and Operational DCGLs for basement structures ($DCGL_B$). Attachment 8 presents the Base Case and Operational DCGLs for above grade buildings ($DCGL_{AGB}$).

For multiple radionuclides, the unity rule applies.

NOTE

If a surrogate DCGL was calculated as part of the survey design for the FSS (section 5.4.4 of LC-FS-PR-002, "Final Status Survey Package Development" [Reference 2.11]), then the surrogate DCGL calculated will be used for the selected surrogate radionuclide. HTD ROC radionuclide concentration(s) can also be derived through direct scaling.

a. Denote the appropriate DCGL(s) value for each ROC.

NOTE

Operational DCGL values are used to determine measurement SOF.

b. Calculate a SOF for each sample or measurement by dividing the reported concentration by the Operational DCGL. If a sample has multiple ROCs, then the SOF for each ROC will be summed to provide a total SOF for the sample or measurement.

i. If the SOF for one or more individual sample(s) or measurement(s) is greater than one in a Class 1 or Class 2 FSS unit, or greater than 0.5 in a Class 3 FSS unit, then:

A. Notify the RP/FSS Manager.

B. Initiate an investigation in accordance with step 4.5. This may include the acquisition of additional measurements to bound the area of elevated activity.

C. Perform an assessment to determine if the basis for the current classification of the survey unit is still valid. If it is determined that the classification basis is no longer valid, then proceed to step 4.6.

ii. If the SOF for all individual samples or measurements is less than one in a Class 1 or Class 2 FSS unit, or less than 0.5 in a Class 3 FSS unit, then proceed to next step.

NOTE

For soil survey units, if both surface (grade to 1 meter below grade) and subsurface (greater than 3.28 feet below grade) soil samples are taken, then statistical data will be determined for each stratum that was sampled as part of the statistical sample population.

NOTE

For FSS, only samples or measurements taken as part of the systematic sample population for the survey unit are used to derive statistical data. Biased, judgmental and/or investigation samples are compared directly against the respective Operational DCGL.

4.3.4 Derive and list the basic statistical data for each analyzed radionuclide or direct measurement in the systematic sample population to be used to demonstrate compliance for the survey unit. At a minimum, the statistics will include:

- Minimum concentration for each ROC in the data set.
- Maximum concentration for each ROC in the data set.
- Mean concentration for each ROC in the data set.
- Median concentration for each ROC in the data set.
- Standard deviation for each ROC in the data set.

4.3.5 For soil samples, compare the mean concentration for each ROC in the data set against the Memorandum of Understanding criteria presented in Attachment 9 (Industrial/Commercial Soil Concentrations). If the mean concentration of any ROC is greater than the values presented in Attachment 9, then stop data assessment and notify the RP/FSS Manager. The RP/FSS Manager shall notify Energy*Solutions* senior management.

4.3.6 Assess the scan survey results for the survey unit.

NOTE

When performing an FSS in an excavation, the individual performing data validation shall be cognizant of data anomalies that may be indicative of a source term at a greater depth than the excavation. For example, if all scan readings are in the 10k cpm to 13k cpm range but one area shows 20k cpm, although the 20k cpm may be below the investigation levels, the anomalous reading may warrant an investigation to verify there is no source term at a greater depth.

a. Compare the reported scan results to the appropriate scan investigation level for the survey unit. Scan investigation levels are presented in Attachment 10.

b. If a scan measurement exceeds an investigation level, then ensure that a biased sample or measurement was taken at the flagged location.

4.3.7 Denote the results of any biased or judgmental samples and/or measurements taken in the survey unit.

a. Divide the concentration for each ROC by the Operational DCGL for the ROC to derive a SOF for determining if an investigation is warranted. If a sample has multiple ROCs, then the SOF for each ROC will be summed to provide a total SOF for the sample/measurement.

i. If the SOF for one or more individual sample(s) or measurement(s) is greater than one in a Class 1 or Class 2 FSS unit, or greater than 0.5 in a Class 3 FSS unit, then:

A. Notify the RP/FSS Manager.

B. Initiate an investigation in accordance with step 4.5. This may include the acquisition of additional measurements to bound the area of elevated activity.

C. Perform an assessment to determine if the basis for the current classification of the survey unit is still valid. If it is determined that the classification basis is no longer valid, then proceed to step 4.6.

ii. If the SOF for all individual judgmental samples or measurements are less than one in a Class 1 or Class 2 FSS unit, or less than 0.5 in a Class 3 FSS unit, then proceed to next step.

4.3.8 Calculate the mean dose for the survey unit based on the mean concentration from each ROC.

a. Divide the mean concentration derived in step 4.3.4 by the Base Case DCGL for the ROC to derive a mean SOF for each ROC.

b. Sum the SOF for each ROC to derive the mean SOF for the survey unit.

c. Multiply the mean SOF by 25 mrem/yr. to derive the mean dose for the survey unit in units of mrem/yr.

4.3.9 Prepare a map for the survey unit that includes the following information:

a. The survey unit boundaries.

b. The locations corresponding to the coordinates for each systematic measurement or sample.

c. The locations corresponding to the coordinates where any elevated scan measurements were detected.

d. The locations corresponding to the coordinates for each biased or investigation measurement or sample.

NOTE

Refer to section 8.2.2.2 of MARSSIM (Reference 2.2) for examples and methods for the graphical representation of data.

4.3.10 Display the data using graphical representation by creating a "posting plot", a "Quantile plot" and a Histogram.

4.4. Performance of Sign Test.

NOTE

Statistical testing will only be applied to the systematic sampling and/or measurement populations. For soil survey units, the statistical test will be performed on the systematic sample population that represents the as-left grade of the surface soil.

4.4.1 If every measurement in the systematic sample population is less than or equal to the applicable Operational DCGL, or has a SOF less than one, then a statistical test is not required and proceed to step 4.5.2.

NOTE

For FSS, the Sign Test will be used to evaluate the remaining residual radioactivity in each survey unit against the applicable Operational DCGL. The Sign Test is the most appropriate test for LCSRP FSS results because background is expected to constitute a small fraction of the DCGL.

4.4.2 Perform the Sign test as follows:

NOTE

Attachment 11, "Sign Statistical Test", or an equivalent form can be used to document the performance of the Sign test. Data can also be processed using one or more of the following methods: the use of pre-programmed computer databases, computer spreadsheets, electronic calculators and hand calculations.

a. List the survey unit measurements, 1, 2, 3…, *n*; where *n* = the number of measurements.

NOTE

Gross activity measurements taken on structural surfaces will be corrected for material specific gross background activity.

b. List the summed SOF for each measurement from step 4.3.3(b) as the weighted sum (W_S).

c. Subtract the weighted sum (W_s) from unity (one) to obtain the difference.

d. Discard differences where the value is exactly zero and reduce *n* by the number of such zero measurements.

e. Count the number of positive differences. The result is the test statistic S^+, or critical value.

NOTE

In accordance with LTP Chapter 5, the Type I decision error that was used for FSS design was set at 0.05

f. Compare the value of S^+ to the critical values in Table I.3 of MARSSIM. Critical values may also be calculated using the following equation:

a.

$$Critical\ Value = \frac{N}{2} + \frac{1.645}{2}\sqrt{N}$$

Where:

N = Number of Samples

i. If S+ is greater than or equal to the critical value for the Type 1 Error (α), then the null hypothesis can be rejected and the survey data set passes the Sign Test.

ii. If S+ is less than the critical value, then the survey data set fails the Sign Test.

4.4.3 If the survey unit passes the statistical test, then the FSS Release Record for this survey unit may be generated in accordance with procedure LC-FS-PR-009, *"Final Status Survey Data Reporting."* If the survey unit fails the statistical test, then inform the RP/FSS Manager and further analyze the data to determine why the statistical test failed.

a. If it appears that the failure is caused by the presence of radioactivity concentrations that will require further remediation, then proceed to step 4.5.

b. If it appears that the failure is due to statistical fluctuations, then the survey unit may be resurveyed and another set of discrete measurements or samples collected for statistical analysis. A larger number of measurements may increase the probability of passing the statistical test if the survey unit actually meets the site release criterion.

c. If it appears the power of the test is insufficient due to the number of measurements, then a retrospective power analysis for the test may be performed as described in Appendices I.9 and I.10 of MARSSIM to determine if additional data may be collected and included in the data set.

4.5. Investigations

NOTE

If the survey unit is a Basement FSS unit, Buried Pipe FSS unit or designated as an Open Land Class 2 or Class 3 FSS unit, then an Elevated Measurement/Sample is defined as residual radioactivity in concentrations greater than the Operational DCGLs (or 0.5 times the Operational DCGL in a Class 3 FSS unit). In a Class 1 Open Land FSS unit, the Elevated Measurement Comparison is applicable. In both scenarios, the Base Case DCGLs are used in this calculation.

4.5.1 If the survey unit fails the statistical test or, if a measurement/sample(s) exceeds the FSS Investigation Levels presented in Attachment 10 or, if the mean SOF for the survey unit exceeds one or, if the mean SOF exceeds the *a priori* fractions used for survey design in Attachment 12 or, if the sum of the mean SOF for all FSS units in a basement exceeds one, then proceed to step 4.5.3.

4.5.2 If the survey unit has passed the statistical test, and does not have any volumetric sample, scan or static measurements in excess of the investigation levels, and the mean SOF is less than the *a priori* fraction used for survey design in Attachment 12, then commence the generation of the FSS Release Record for this survey unit in accordance with procedure LC-FS-PR-009, *"Final Status Survey Data Reporting"*.

NOTE

At LCSRP, Elevated Measurement Comparison (EMC) only applies to Class 1 open land survey units.

NOTE

Investigation(s) can also be processed using alternate formats, pre-programmed computer databases, computer spreadsheets, electronic calculators and hand calculations provided that all requisite data is included.

4.5.3 If the results of the FSS require an investigation, then initiate Attachment 13, "Final Status Survey Investigation" or equivalent.

4.5.4 Document the reason for the investigation.

4.5.5 List the locations and sample or measurement results that exceed the investigation levels.

4.5.6 Using the sample or measurement coordinates or locations, assess if the elevated area has been adequately bounded. If the elevated area has not been adequately bounded, then take additional samples or measurements as necessary to establish the boundaries of the elevated area.

NOTE
Use of location plots on a map of the survey unit is an effective tool to determine bounding and area size.

4.5.7 List the bounding samples or measurements for each elevated area.

4.5.8 If the survey unit is designated as Class 2, then proceed to step 4.5.10. If the survey unit is designated as Class 3, then proceed to step 4.5.11. If the survey unit is designated as Class 1, then perform an investigation as follows:

a. In each elevated area, denote the Base Case DCGL for each ROC pertinent to the elevated sample(s).

b. Calculate an area in square meters for the identified elevated area(s).

NOTE
Attachment 14 presents the Area Factors (AF) for surface soils.

c. If the survey unit is a Class 1 open land survey unit, then select the appropriate Area Factor (AF) from Attachment 14 that corresponds to the elevated area and to the radionuclide with the elevated activity.

d. For all other survey units (Basements, Buried Pipe or Open Land FSS units classified as Class 2 or Class 3), calculate an Area Adjustment Factor (AAF) for the elevated area by dividing the survey unit size in m^2 by the area of the elevated area in m^2.

e. Calculate an adjusted DCGL (or $DCGL_{EMC}$ for Class 1 soils) for each applicable ROC in each elevated area by multiplying the applicable Base Case DCGL by the AF or AAF as appropriate.

NOTE

The Average Radioactivity Fraction (f_{AVG}) is calculated using only sample results from the systematic sample population that are located outside of any identified elevated area.

f. Sum the products of the average concentration for each ROC divided by its respective Base Case DCGL to derive the Average Radioactivity Fraction (f_{AVG}) for the survey unit.

g. Calculate an Elevated Radioactivity Fraction (f_{ELEV}) for each identified elevated area.

i. Determine the average concentration (τj) for each ROC in each identified elevated area.

ii. Subtract the average concentration for each ROC (δ_j) for the survey unit from step 4.5.8(f) from the average concentration (τ_j) for each ROC in each identified elevated area from step 4.5.8(g)i.

iii. Divide the elevated area ROC concentration (τ_j-δ_j) by the adjusted DCGL (or $DCGL_{EMC}$ for Class 1 soils) from step 4.5.8(e) to derive a Fraction of $DCGL_{ELEV}$ (f_{ROC}) for each radionuclide.

iv. Sum the Fraction of $DCGL_{ELEV}$ (f_{elev}) values for each pertinent radionuclide to derive the Elevated Radioactivity Fraction (f_{ELEV}) for the elevated area.

h. Sum the Elevated Radioactivity Fractions (f_{ELEV}) for each elevated area.

i. Add the Average Radioactivity Fraction (f_{AVG}) from step 4.5.8(f) to the summed Elevated Radioactivity Fractions (f_{ELEV}). This value represents the mean SOF for this survey unit.

j. Compare the mean SOF for the survey unit with the *a priori* fractions used for survey design in Attachment 12.

k. Multiply the SOF by 25 mrem/yr. This is the assigned dose to this survey unit, adding the dose from elevated areas to the mean of the systematic measurements/samples.

4.5.9 If the survey unit is classified as FSS Class 1, and the mean SOF for the survey unit is greater than unity (1) or, if the mean SOF exceeds the *a priori* fraction used for survey design in Attachment 12, then proceed to step 4.6. If mean SOF is less than or equal to unity (1) and, less than the *a priori* fraction used for survey design in Attachment 12, then the survey unit will pass FSS, the investigation is complete and the and the FSS Release Record for this survey unit may be generated in accordance with procedure LC-FS-PR-009, *"Final Status Survey Data Reporting"*.

4.5.10 If the survey unit is classified as a FSS Class 2 survey unit, and any biased or investigative sample or measurement taken in the survey unit is equal to or greater than its respective Operational DCGL or, if the mean SOF exceeds the *a priori* fraction used for survey design in Attachment 12 then proceed to step 4.6 If the action level has not been exceeded, and, if the mean SOF is less than the *a priori* fraction used for survey design in Attachment 12, then the investigation is complete and the FSS Release Record for this survey unit may be generated in accordance with procedure LC-FS-PR-009, *"Final Status Survey Data Reporting"*.

4.5.11 If the survey unit is classified as a FSS Class 3 survey unit, and any biased or investigative sample or measurement taken in the survey unit is equal to or greater than 50% of its respective Operational DCGL or, if the mean SOF exceeds the *a priori* fraction used for survey design in Attachment 12, then proceed to step 4.6. If the action level has not been exceeded and, if the mean SOF is less than the *a priori* fraction used for survey design in Attachment 12, then the investigation is complete and the FSS Release Record for this survey unit may be generated in accordance with procedure LC-FS-PR-009, *"Final Status Survey Data Reporting"*.

4.6. Corrective Actions for Final Status Survey Failure

4.6.1 If the survey unit did not pass FSS, then initiate Attachment 15, "Corrective Actions for Final Status Survey Failure" or equivalent. Attachment 16, "Remediation, Reclassification and Resurvey Actions," provides potential corrective actions that may be taken as corrective actions for the FSS failure of a survey unit. These corrective actions may require remediation, reclassification, and/or resurvey.

4.6.2 Submit completed form to the RP/FSS Manager for approval.

4.6.3 When the RP/FSS Manager has approved the corrective action, then prepare a revision (addendum), as appropriate, to the FSS Survey Plan in accordance with LC-FS-PR-002, ***"****Final Status Survey Package Development"*. If any new survey units were created from existing survey units, then prepare a new survey design in accordance with LC-FS-PR-002, ***"****Final Status Survey Package Development"*.

5. ATTACHMENTS AND CORRESPONDING TABLES

5.1. Attachment 1, "Final Status Survey Data Quality Objectives Review Checklist"

5.2. Attachment 2, "Final Status Survey Preliminary Survey Data Summary"

5.3. Attachment 3, "Dose Significant Radionuclides and Mixture"

5.4. Attachment 4, "Final Sr-90 to Cs-137 Surrogate Ratios"

5.5. Attachment 5, "Base Case and Operational DCGLs for Soil"

5.6. Attachment 6, "Base Case and Operational DCGLs for Buried Pipe"

5.7. Attachment 7, "Base Case and Operational DCGLs for Basements"

5.8. Attachment 8, "Base Case and Operational DCGLs for Above Ground Buildings"

5.9. Attachment 9, "Memorandum of Understanding"

5.10. Attachment 10, "Final Status Survey Investigation Levels"

5.11. Attachment 11, "Sign Statistical Test"

5.12. Attachment 12, "*a priori* Dose Fractions (*f*)"

5.13. Attachment 13, "Final Status Survey Investigation"

5.14. Attachment 14, "Area Factors for Soils"

5.15. Attachment 15, "Corrective Actions for Final Status Survey Failure"

5.16. Attachment 16, "Remediation, Reclassification and Resurvey Actions"

ATTACHMENT 1

FINAL STATUS SURVEY DATA QUALITY OBJECTIVES REVIEW CHECKLIST

Page 1 of 2

Survey Area: No. _____ **Description:** _____
Survey Unit: No. _____ **Description:** _____
Classification: _____

Reviewer: _____ **Date:** _____ **Time:** _____

1.	Have all measurements and/or analysis results that will be subjected to data analysis for FSS been individually reviewed and validated in accordance with step 4.1 of this procedure?	Yes ☐	No ☐ (explain)
2.	Have all systematic measurements and/or samples been taken or acquired at the locations specified in the FSS Survey Plan and the FSS Sample Instructions?	Yes ☐	No ☐ (explain)
3.	Have all scans surveys been performed of the areas specified as required in the FSS Survey Plan and the FSS Sample Instructions? (applicable to FSS only)	Yes ☐	No ☐ (explain)
4.	Was a meter circumference scanned around each systematic sample or measurement location? (applicable to Land survey units only)	Yes ☐	No ☐ (explain)
5.	Have all biased measurements and/or samples been taken or acquired at the locations specified in the FSS Survey Plan & the FSS Sample Instructions?	Yes ☐	No ☐ (explain)
6.	Have duplicate and/or split samples or measurements been taken or acquired at each location designated as a QC sample?	Yes ☐	No ☐ (explain)
7.	Were the instruments used to measure or analyze the survey data capable of detecting the ROCs or gross activity at a MDC less than the specified target MDC?	Yes ☐	No ☐ (explain)
8.	Are the MDCs and the assumptions used to develop the MDCs appropriate for the instruments and methods used to analyze the data?	Yes ☐	No ☐ (explain)
9.	Was the calibration of all instruments that were used to measure or analyze data, current at the time of use?	Yes ☐	No ☐ (explain)
10.	Were the instruments successfully response-checked before use and, where required, after use on the day the data was measured?	Yes ☐	No ☐ (explain)
11.	Was the custody of samples collected for laboratory analysis tracked from the point of collection until final results were obtained?	Yes ☐	No ☐ (explain)
12.	Do the QC sample results meet the acceptance criteria as specified in LC-QA-PN-001, *"Final Status Survey Quality Assurance Project Plan(QAPP)"*(Reference 2.5)	Yes ☐	No ☐ (explain)

If "No" was the response to any of the questions above, then document the discrepancy as well as any corrective actions that were taken to resolve the discrepancy.

ATTACHMENT 1

FINAL SURVEY DATA QUALITY OBJECTIVES REVIEW CHECKLIST

Survey Area: No. _____ **Description:** _____

Survey Unit: No. _____ **Description:** _____

Discrepancy; _____

Corrective Actions Taken; _____

13. Have the corrective actions resolved the discrepancies with the data? ---------- Yes ☐ No ☐
    a. If "No", then forward this form to the RP / FSS Manager.
14. The following questions will be answered by the RP / FSS Manager.
    a. If the answer to question 13 was "No", then is the affected data still valid? ---------- Yes ☐ No ☐
    b. If "No", then are the existing valid measurements or samples sufficient to demonstrate compliance for the survey unit? ---------- Yes ☐ No ☐
    c. If "No", then direct the acquisition of additional measurements or samples as necessary to demonstrate compliance for the survey unit.

Prepared by (FSS Supervisor): _____ (Print Name) _____ (Signature) _____ (Date)

Approved by: _____ (RP / FSS Manager) _____ (Signature) _____ (Date)

ATTACHMENT 2

FSS PRELIMINARY SURVEY DATA SUMMARY

Page 1 of 3

SYSTEMATIC MEASUREMENTS

FSS Unit		**Description**							**Classification**	
Type	**Structural Surface**	**Surface Area**		m2		Description				

Sample ID	Location ID# (Grid No.)	FOV (m^2)	ROC	Measured Activity (pCi/m^2)	Ratio	Inferred Activity (pCi/m^2)	Operational DCGL (pCi/m^2)	Fraction of $DCGL_{OPS}$	$DCGL_{OPS}$ SOF
			Cs-137						
			Co-60						
			Eu-152						
			Eu-154						
			Sr-90						
			Cs-137						
			Co-60						
			Eu-152						
			Eu-154						
			Sr-90						
			Cs-137						
			Co-60						
			Eu-152						
			Eu-154						
			Sr-90						

ATTACHMENT 2

FSS PRELIMINARY SURVEY DATA SUMMARY

Page 2 of 3

SYSTEMATIC MEASUREMENT STATISTICS

Max Individual Systematic Measurement SOF = _____ **Mean Systematic Measurement SOF =** _____

Number of Systematic Measurements = _____ **Number of Systematic Measurements with SOF ≥1 =** _____

Number of QC Measurements = _____ **# of Measurements with SOF ≥0.1 (HTD Assessment) =** _____

Systematic

ROC	Mean (pCi/m2)	Median (pCi/m2)	Max (pCi/m2)	Min (pCi/m2)	δ	BcDCGL (pCi/m2)	Avg SOF per ROC	Avg Dose per ROC
Cs-137								
Co-60								
Eu-152								
Eu-154								
Sr-90								

SOF ASSIGNED TO SURVEY UNIT (SYSTEMATIC AVG.) = -

DOSE ASSIGNED TO SURVEY UNIT (SYSTEMATIC AVG.) = - mrem/yr

ATTACHMENT 2

FSS PRELIMINARY SURVEY DATA SUMMARY

Page 3 of 3

JUDGMENTAL MEASUREMENTS

FSS Unit		**Description**							**Classification**	
Type	**Structural Surface**	**Surface Area**		m2		Description				

Sample ID	Location ID# (Grid No.)	FOV (m^2)	ROC	Measured Activity (pCi/m^2)	Ratio	Inferred Activity (pCi/m^2)	Operational DCGL (pCi/m^2)	Fraction of $DCGL_{OPS}$	$DCGL_{OPS}$ SOF
			Cs-137						
			Co-60						
			Eu-152						
			Eu-154						
			Sr-90						
			Cs-137						
			Co-60						
			Eu-152						
			Eu-154						
			Sr-90						

AVERAGE SOF (JUDGMENTAL) =

Max Judgmental SOF=

Number of Judgmental Measurements with SOF ≥1 =

Number of Judgmental Measurements =

# of Measurements with SOF ≥0.1 (HTD Assessment) =

ATTACHMENT 3

DOSE SIGNIFICANT RADIONUCLIDES AND MIXTURE[1]

Radionuclide	Soil/Pipe Mix Fraction[2]	Rx Bldg. Mix Fraction	WGTV Mix Fraction
Co-60	7.14E-02	8.44E-02	1.03E-02
Cs-137	9.19E-01	9.08E-01	9.76E-01
Eu-152	6.09E-03	3.39E-03	9.75E-03
Eu-154	3.11E-03	4.60E-03	3.49E-03

1.) Based on maximum percent of total activity from Table 22 of La Crosse*Solutions* RS-TD-313196-001, *"Radionuclides of Concern for Soil and Basement Fill Model Source Terms"* (Reference 2.10), normalized to one for the dose significant radionuclides.

2.) The values for Soil/Pipe are intended to be applied to above grade buildings and other materials not associated with the Rx Bldg. or WGTV.

ATTACHMENT 4

FINAL SR-90 TO CS-137 SURROGATE RATIOS

Building or Area	Sr-90/Cs-137 Surrogate Activity Ratio
WGTV	6.75E-02
Rx Bldg.	5.00E-01
Tunnel[1]	2.24E-02
WTB[1]	4.82E-01
Soils[2]	5.02E-01

1.) These buildings are not in the site end-state.
2.) The soil designation represents all concrete core bores and could also be used for other miscellaneous structures (e.g., above grade structures) to remain if needed.

ATTACHMENT 5

BASE CASE DCGLS FOR SOIL ($DCGL_S$)

ROC	Soil DCGL (pCi/g)
Co-60	1.06E+01
Sr-90	5.47E+03
Cs-137	4.83E+01
Eu-152	2.36E+01
Eu-154	2.19E+01

OPERATIONAL DCGLS FOR SOIL ($OpDCGL_S$)

ROC	Soil $OpDCGL_S$ (pCi/g)
Co-60	3.83
Sr-90	1970.45
Cs-137	17.39
Eu-152	8.51
Eu-154	7.89

ATTACHMENT 6

BASE CASE DCGLS FOR BURIED PIPE ($DCGL_{BP}$)

ROC	Buried Pipe Group (dpm/100 cm^2)	Buried Pipe Circulating Water Discharge (dpm/100 cm^2)
Co-60	7.51E+04	7.75E+04
Sr-90	5.16E+05	7.56E+05
Cs-137	3.19E+05	3.30E+05
Eu-152	1.64E+05	1.67E+05
Eu-154	1.53E+05	1.56E+05

OPERATIONAL DCGLS FOR BURIED PIPE ($OpDCGL_{BP}$)

ROC	Buried Pipe Group $OpDCGL_{BP}$ (dpm/100 cm^2)	Buried Pipe Circulating Water Discharge $OpDCGL_{BP}$ (dpm/100 cm^2)
Co-60	2.25E+04	2.33E+04
Sr-90	1.55E+05	2.27E+05
Cs-137	9.56E+04	9.91E+04
Eu-152	4.93E+04	5.02E+04
Eu-154	4.58E+04	4.67E+04

ATTACHMENT 7

BASE CASE DCGLS FOR BASEMENTS ($DCGL_B$)

ROC	Rx Bldg $DCGL_B$ (pCi/m^2)	WGTV $DCGL_B$ (pCi/m^2)
Co-60	5.16E+06	4.10E+06
Sr-90	1.45E+07	6.40E+06
Cs-137	2.17E+07	1.76E+07
Eu-152	1.19E+07	9.69E+06
Eu-154	1.10E+07	8.97E+06

OPERATIONAL DCGLS FOR BASEMENTS ($OpDCGL_B$)

ROC	Rx Bldg $OpDCGL_B$ (pCi/m^2)	WGTV $OpDCGL_B$ (pCi/m^2)
Co-60	3.61E+05	2.87E+05
Sr-90	1.02E+06	4.48E+05
Cs-137	1.52E+06	1.23E+06
Eu-152	8.33E+05	6.78E+05
Eu-154	7.71E+05	6.28E+05

ATTACHMENT 8

BASE CASE DCGLS FOR ABOVE GRADE BUILDINGS ($DCGL_{AGB}$)

ROC	Above Grade Building (dpm/100 cm^2)
Co-60	7100
Sr-90	8700
Cs-137	28000
Eu-152	12700
Eu-154	11500

OPERATIONAL DCGLS FOR ABOVE GRADE BUILDINGS ($OpDCGL_{AGB}$)

ROC	Above Grade Building $OpDCGL_{AGB}$ (dpm/100 cm^2)
Co-60	1136
Sr-90	1392
Cs-137	4480
Eu-152	2032
Eu-154	1840

ATTACHMENT 9
NUREG-1757, Volume 1, Rev. 2
Appendix H

Table H.1 Consultation Triggers for Residential and Commercial/Industrial Soil Contamination (MOU Table 1)

Except for radium-226, thorium-232, or total uranium, concentrations should be aggregated using a sum of the fraction approach to determine site-specific consultation trigger concentrations. This table is based on single contaminant concentrations for residential and commercial/industrial land use when using generally accepted exposure parameters. Table users should select the appropriate column based on the site's reasonably anticipated land use.

Radionuclide	Residential Soil Concentration	Industrial/Commercial Soil Concentration
H-3	228 pCi/g	423 pCi/g
C-14	46 pCi/g	123,000 pCi/g
Na-22	9 pCi/g	14 pCi/g
S-35	19,600 pCi/g	32,200,000 pCi/g
Cl-36	6 pCi/g	10,700 pCi/g
Ca-45	13,500 pCi/g	3,740,000 pCi/g
Sc-46	105 pCi/g	169 pCi/g
Mn-54	69 pCi/g	112 pCi/g
Fe-55	269,000 pCi/g	2,210,000 pCi/g
Co-57	873 pCi/g	1,420 pCi/g
Co-60	4 pCi/g	6 pCi/g
Ni-59	20,800 pCi/g	1,230,000 pCi/g
Ni-63	9,480 pCi/g	555,000 pCi/g
Sr-90+D	23 pCi/g	1,070 pCi/g
Nb-94	2 pCi/g	3 pCi/g
Tc-99	25 pCi/g	89,400 pCi/g
I-129	60 pCi/g	1,080 pCi/g
Cs-134	16 pCi/g	26 pCi/g
Cs-137+D	6 pCi/g	11 pCi/g
Eu-152	4 pCi/g	7 pCi/g
Eu-154	5 pCi/g	8 pCi/g
Ir-192	336 pCi/g	544 pCi/g
Pb-210+D	15 pCi/g	123 pCi/g
Ra-226	5 pCi/g	5 pCi/g
Ac-227+D	10 pCi/g	21 pCi/g
Th-228+D	15 pCi/g	25 pCi/g
Th-232	5 pCi/g	5 pCi/g
U-234	401 pCi/g	3,310 pCi/g
U-235+D	20 pCi/g	39 pCi/g
U-238+D	74 pCi/g	179 pCi/g
total uranium	47 mg/kg	1230 mg/kg
Pu-238	297 pCi/g	1,640 pCi/g
Pu-239	259 pCi/g	1,430 pCi/g
Pu-241	40,600 pCi/g	172,000 pCi/g
Am-241	187 pCi/g	568 pCi/g
Cm-242	32,200 pCi/g	344,000 pCi/g
Cm-243	35 pCi/g	67 pCi/g

ATTACHMENT 10

FSS INVESTIGATION LEVELS

FSS Investigation Levels

Survey Unit Classification	Scan Investigation Levels:	Direct Measurement Investigation Levels:
Class 1	> $DCGL_w$ or >MDC_{scan} if MDC_{scan} is greater than $DCGL_w$	> $DCGL_w$
Class 2	> $DCGL_W$ or > MDC_{scan} if MDC_{scan} is greater than $DCGL_W$	> $DCGL_w$
Class 3	> $DCGL_W$ or > MDC_{scan} if MDC_{scan} is greater than $DCGL_W$	> 0.5 $DCGL_w$

ATTACHMENT 11

SIGN STATISTICAL TEST

Survey Area					Description						
Survey Unit					Description						
Classification					Type I Error			Number of Measurements			
#	SOF (Ws)	1-Ws	Sign								
1											
2											
3											
4											
5											
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Number of positive differences (S+)											
		Critical Value									
	Survey Unit			the Acceptance Criteria							
Prepared by:											
			(Print Name)					(Signature)			(Date)
Peer Reviewed by:											
			(Print Name)					(Signature)			(Date)

ATTACHMENT 12

a priori DOSE FRACTIONS (*f*)

FSS Unit	Source Term/Media for FSS	*a priori* Fraction, *f*
Basement	Floor and Walls	0.07
Groundwater "Other Basement"	Floor and Walls	0.01
Soil	Soil	0.36
Buried Pipe	Buried Pipe	0.30
Groundwater "Other Buried Pipe"	Buried Pipe	0.06
Above Grade Building	Floor, Walls, Ceiling	0.16
Existing Groundwater	Groundwater Monitoring Results	0.04
	Sum	1.0

ATTACHMENT 13

FINAL STATUS SURVEY INVESTIGATION

Page 1 of 8

Survey Area: No. _____ **Description:** _____ **Classification:** _____

Survey Unit: No. _____ **Description:** _____

Performed by: _____ **Date:** _____ **Time:** _____

1. Reason for Investigation

☐ FSS Sample(s) with Result(s) > Investigation Levels
☐ FSS Measurement(s) with Results(s) > Investigation Levels
☐ Other _____
☐ Scan Measurement(s) > Investigation Levels
☐ Failure of Statistical Test

2. Identified Elevated Sample(s)

Sample ID	Location		Radionuclides-of-Concern											
			Cs-137		_____		_____		_____		_____		_____	
	Northing	Easting	_____	Fraction	_____	Fraction	_____	Fraction	_____	Fraction	_____	Fraction	_____	Fraction

ATTACHMENT 13

FINAL STATUS SURVEY INVESTIGATION

3. Bounding of Identified Elevated Area(s)
   a. Is the elevated area(s) adequately verified and bounded by the existing samples? Yes ☐ No ☐
      1) If "Yes", then proceed to step 4
      2) If "No", then prepare an addendum to the FSS Survey Plan for this survey unit to take additional samples as necessary to adequately verify and bound the identified area(s) of suspected elevated activity.

   b. Bounding Sample(s)

Sample ID	Location		Radionuclides-of-Concern											
			Cs-137		_____		_____		_____		_____		_____	
	Northing	Easting	_____	Fraction	_____	Fraction	_____	Fraction	_____	Fraction	_____	Fraction	_____	Fraction

ATTACHMENT 13

FINAL STATUS SURVEY INVESTIGATION Page 3 of 8

4. Elevated Measurement Comparison

   If the survey unit is a Basement FSS unit, Buried Pipe FSS unit or classified as an Open Land Class 2 or Class 3 FSS unit, then Elevated Measurement/Sample is defined as residual radioactivity in concentrations greater than the Operational DCGLs (or 0.5 the Operational DCGL in a Class 3 FSS unit). In a Class 1 Open Land FSS unit, the Elevated Measurement Comparison is applicable. In both scenarios, the Base Case DCGLs are used in this calculation.

   a. In each elevated area, denote the Base Case DCGL applicable to each ROC.
   b. Calculate an area in square meters for the identified elevated area(s).
   c. If the survey unit is a Class 1 Open Land FSS unit, then select the appropriate Area Factor (AF) from Attachment 13 that corresponds to the area and to the radionuclide with the elevated activity.
   d. For all other survey units, calculate an Area Adjustment Factor (AAF) by dividing the survey unit size in m^2 by the area of the elevated area in m^2.

Elevated Area #1 Area Size: _____ m^2

	Cs-137	_____	_____	_____	_____	_____
DCGL	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g
AF or AFF						

Elevated Area #2 Area Size: _____ m^2

	Cs-137	_____	_____	_____	_____	_____
DCGL	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g
AF or AFF						

Elevated Area #3 Area Size: _____ m^2

	Cs-137	_____	_____	_____	_____	_____
DCGL	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g
AF or AFF						

ATTACHMENT 13
FINAL STATUS SURVEY INVESTIGATION

e. Calculate the adjusted DCGL (or $DCGL_{EMC}$ for Class 1soil) for each applicable radionuclide by multiplying the applicable DCGL for the elevated measurement(s) or sample(s) by the AF or AAF as appropriate.

Elevated Area #1

	Cs-137	_____	_____	_____	_____	_____
$DCGL_{ADJ}$	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g

Elevated Area #2

	Cs-137	_____	_____	_____	_____	_____
$DCGL_{ADJ}$	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g

Elevated Area #3

	Cs-137	_____	_____	_____	_____	_____
$DCGL_{ADJ}$	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g

f. Calculate the Average Radioactivity Fraction for the survey unit as follows:

Note: The Average Radioactivity Fraction is calculated using only sample results from the systematic sample population that are located outside of any identified elevated area.

	Cs-137	_____	_____	_____	_____	_____
Avg. Concentration of Radionuclide (δ_j)	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g
Base Case DCGL	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g
Average Fraction of DCGL (f_j)						

1) Sum the "Fraction of DCGL (f_j)" values for each pertinent radionuclide to derive the Average Radioactivity Fraction (f_{avg}) = _____

ATTACHMENT 13

FINAL STATUS SURVEY INVESTIGATION Page 5 of 8

g. Calculate an Elevated Radioactivity Fraction (f_{ELEV}) for each identified elevated area as follows;

1) Determine the average concentration (τ_j) for each radionuclide in each identified elevated area.
2) Subtract the Average Concentration of Radionuclide (δ_j) for each radionuclide from step 4f from the average radionuclide concentration (τ_j) in the elevated area and divide this value by the $DCGL_{ADJ}$ from step 4e to derive a Fraction of $DCGL_{ELEV}$ (f_{ROC}) for each radionuclide.
3) Sum the Fraction of $DCGL_{ELEV}$ (f_{ROC}) values for each pertinent radionuclide to derive the Elevated Radioactivity Fraction (f_{EMC}) for the elevated area.

Elevated Area #1

	Cs-137	_____	_____	_____	_____	_____
Avg. Concentration of Elevated Area (τ_j)	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g
Avg. Concentration of Radionuclide (δ_j)	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g
$(\tau_j - \delta_j)$ =	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g
$DCGL_{ELEV}$						
Fraction of $DCGL_{EMC}$ (f_{ROC})						

Elevated Radioactivity Fraction (f_{ELEV}) for Elevated Area #1 _____

Elevated Area #2

	Cs-137	_____	_____	_____	_____	_____
Avg. Concentration of Elevated Area (τ_j)	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g
Average Concentration of Survey Unit (δ_j)	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g
$(\tau_j - \delta_j)$ =	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g
$DCGL_{ELEV}$						
Fraction of $DCGL_{EMC}$ (f_{ROC})						

Elevated Radioactivity Fraction (f_{ELEV}) for Elevated Area #2 _____

ATTACHMENT 13

FINAL STATUS SURVEY INVESTIGATION Page 6 of 8

Elevated Area #3

	Cs-137	_____	_____	_____	_____	_____
Avg. Concentration of Elevated Area (τ_j)	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g
Average Concentration of Survey Unit (δ_j)	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g
$(\tau_j - \delta_j)$ =	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g
$DCGL_{ELEV}$						
Fraction of $DCGL_{EMC}$ (f_{ROC})						

Elevated Radioactivity Fraction (f_{ELEV}) for Elevated Area #3 _____

h. Sum the Elevated Radioactivity Fractions (f_{ELEV}) for each elevated area. _____

i. Add the Average Radioactivity Fraction (f_{avg}) from step 4f to the summed Elevated Radioactivity Fractions (f_{ELEV}). This value represents the SOF for this survey unit. _____

j. If the SOF is less than or equal to unity (1), then the survey unit will pass. If the SOF is greater than unity (1), then the need for additional remediation is likely.

5. Investigation Conclusions

a. All FSS Units

1) Did the survey unit fail the statistical test or, does the mean SOF (using Operational DCGLs) exceed unity or, does an individual FSS Investigation Levels (Attachment 7) or, the Total Mean Dose exceeds 25 mrem/yr. or, the sum of the Mean measurement/sample exceed the Base Case DCGL? Yes ☐ No ☐

(If "Yes", then initiate Attachment 14, "Corrective Actions for Final Radiation Survey Failure". If "No", then proceed to next step applicable to the classification of the survey unit complete and no further action is required.)

b. FSS Class 3 Survey Unit

1) Is the concentration for any radionuclide reported in any systematic, biased or investigative sample taken in the survey unit equal to or greater than 50% of its respective $DCGL_w$? Yes ☐ No ☐

ATTACHMENT 13
FINAL STATUS SURVEY INVESTIGATION

(If "Yes", then initiate Attachment 15, "Corrective Actions for Final Radiation Survey Failure". If "No", then the investigation is complete and no further action is required.)

c. FSS Land Class 2 Survey Unit

1) Is the concentration for any radionuclide reported in any systematic, biased or investigative sample taken in the survey unit equal to or greater than its respective Operational DCGL? ☐ Yes ☐ No

(If "Yes", then initiate Attachment 14, "Corrective Actions for Final Radiation Survey Failure". If "No", then the investigation is complete and no further action is required.)

d. FSS Land Class 1 Survey Unit

1) Is the concentration for any radionuclide reported in any systematic, biased or investigative sample taken in the survey unit equal to or greater than its respective Operational DCGL? ☐ Yes ☐ No

(If "Yes", then proceed to next step. If "No", then the investigation is complete and no further action is required.)

2) Does the summed Elevated Radioactivity Fractions (f_{ELEV}) from step 4h exceed unity (1)? ☐ Yes ☐ No

(If "Yes", then initiate Attachment 14, "Corrective Actions for Final Radiation Survey Failure". If "No", then the investigation is complete and no further action is required.)

6. Comments;

ATTACHMENT 13
FINAL STATUS SURVEY INVESTIGATION
Page 8 of 8

6. Comments (continued);

7. Approval

Prepared by (FSS Supervisor): _____ (Print Name) _____ (Signature) _____ (Date)

Reviewed by RP/FSS Manager: _____ (Print Name) _____ (Signature) _____ (Date)

ATTACHMENT 14

AREA FACTORS FOR SOIL

RROC	Area Factor (Unitless)				
	1 m^2	**2 m^2**	**5 m^2**	**10 m^2**	**100 m^2**
Co-60	9.44	5.56	3.07	2.04	1.19
Cs-137	9.11	5.42	3.01	2.00	1.18
Sr-90	11.21	6.66	3.69	2.45	1.41
Eu-152	9.30	5.50	3.04	2.02	1.18
Eu-154	9.38	5.54	3.06	2.03	1.18

ATTACHMENT 15

CORRECTIVE ACTIONS FOR FINAL STATUS SURVEY FAILURE

Survey Area: No. _____ **Description:** _____

Survey Unit: No. _____ **Description:** _____

Classification: _____

Performed by: _____ **Date:** _____ **Time:** _____

Resurvey, Reclassification or Remediation

Based upon the failure of the statistical test or the results of an investigation, the following action(s) are required.

Note: Use the guidance provided in Attachment 9 for determination of appropriate action(s).

☐ Resurvey Action(s) Required _____

☐ Reclassify Action(s) Required _____

☐ Remediate Action(s) Required _____

Approval

Prepared by (FSS Supervisor): _____ (Print Name) _____ (Signature) _____ (Date)

Approved by: _____ (RP/FSS Manager) _____ (Signature) _____ (Date)

ATTACHMENT 16

REMEDIATION, RECLASSIFICATION AND RESURVEY ACTIONS

Page 1 of 2

REMEDIATION			
Remediation Criteria			Proposed Remediation
Class 1 FSS Survey Unit	1) The SOF (using Base Case DCGL or $DCGL_{EMC}$ for soils) for survey unit is less than or equal to unity (1)		None
	2) The Elevated Radioactivity Fraction (f_{ELEV}) exceeds unity in 5% or less of the survey unit area.		Spot Remediation & Resurvey
	3) The Elevated Radioactivity Fraction (f_{ELEV}) exceeds unity in greater than 5% of the survey unit area.		General Remediation and Restart FSS
Class 1 Basement FSS Unit	1) The mean inventory fraction (total mean dose for the survey unit divided by the dose criterion of 25 mrem/yr) is greater than or equal to one.		General Remediation and Restart FSS
	2) The sum of the mean inventory fractions for each FSS unit contained within a building basement is greater than or equal to one.		
RECLASSIFICATION			
Reclassification Criteria			Proposed Action
Class 2 Survey Unit	One or several survey measurements (scan, sample or direct measurement) exceed the Operational DCGL or a portion of the survey unit is remediated.	The extent of the elevated area relative to the total area of the survey unit is minimal and the source of the residual radioactivity is known	Reclassify only the bounded discrete area of elevated activity to Class 1.
		The extent of the elevated area relative to the total area of the survey unit is minimal and the source of the residual radioactivity is unknown	Reclassify 2,000 m^2 for soils or 100 m^2 for structures around the area of elevated activity as Class 1.
		The extent of the elevated area relative to the total area of the survey unit is significant.	Reclassify the entire survey unit as Class 1.
Class 3 Survey Unit	One or several survey measurements (scan, sample or direct measurement) exceed 50% of the Operational DCGL or a portion of the survey unit is remediated.	The extent of the elevated area relative to the total area of the survey unit is minimal	Reclassify the area of elevated activity to Class 1 and create a Class 2 buffer zone of appropriate size around the area.
			Reclassify the area of elevated activity to Class 1 and create a Class 2 buffer zone of appropriate size around the area or
			Reclassify the area of elevated activity to Class 2.
		The extent of the elevated area relative to the total area of the survey unit is significant.	For soils, reclassify 10,000 m^2 around the area of elevated activity to Class 2. For structures, reclassify 1,000 m^2 around the area of elevated activity to Class 2.

ATTACHMENT 16

REMEDIATION, RECLASSIFICATION AND RESURVEY ACTIONS

Page 2 of 2

RESURVEY			
Resurvey Criteria			Proposed Action
Class 1 Survey Unit	The survey unit has been remediated.	The extent of the elevated area relative to the total area of the survey unit is minimal (≤ 5% of the total survey unit surface area).	Re-scan remediated area; collect replacement systematic population samples/measurements within the remediated area using random selection.
		The extent of the elevated area relative to the total area of the survey unit is significant (> 5% of the total survey unit surface area).	Resurvey entire survey unit using a new systematic survey design.
	Survey unit has been reclassified from a Class 2 survey unit.	No remediation was performed.	Increase scan or areal coverage to 100%. Additional statistical samples are not required.
Class 2 Survey Unit	Survey unit has been divided to accommodate a new Class 1 survey unit.	The area of the new Class 1 survey unit relative to the area of the initial Class 2 survey unit is minimal and no statistical samples were affected.	Increase scan or areal coverage in Class 2 survey unit.
		Statistical sample population was affected by the reclassification.	Increase scan or areal coverage in Class 2 survey unit and resurvey entire survey unit using a new survey design.
Class 3 Survey Unit	Survey unit has been divided to accommodate a new Class 2 survey unit.	The area of the new Class 2 survey unit relative to the area of the initial Class 3 survey unit is minimal.	Increase scan or areal coverage in Class 3 survey unit, collect replacement systematic population samples/measurements within the remediated area using random selection.
		The area of the new Class 2 survey unit relative to the area of the initial Class 3 survey unit is significant.	Resurvey entire survey unit using a new survey design.