Lacrosse Boiling Water Reactor

FINAL STATUS SURVEY FINAL REPORT – PHASE 2

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Prepared By:	R. Yetter **Director of Radiological Site Closure**	**Date:**	12/11/19
Reviewed By:	P. Hollenbeck **Radiological Engineer**	**Date:**	12/12/19
Reviewed By:	R. Yetter III **FSS Specialist**	**Date:**	12/12/19
Reviewed By:	S. Roberts **VP Radiological Programs**	**Date:**	12/12/19
Approved By:	S. Zoller **FSS Manager**	**Date:**	12/12/19

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1 Introduction

1.1 Executive Summary

The purpose of this Phase 2 Final Status Survey (FSS) Final Report is to provide a summary of the survey results and overall conclusions which demonstrate that the La Crosse Boiling Water Reactor (LACBWR) facility, or portions of the site, meets the 25 mrem/yr release criterion as established in Nuclear Regulatory Commission (NRC) Regulation 10 CFR 20.1402, *Radiological Criteria for Unrestricted Use*. This Phase 2 FSS Final Report encompasses all above-grade building survey units and all buried piping survey units that will remain on site at the time of license termination. The FSS results provided herein demonstrate that any residual radioactivity results in a Total Effective Dose Equivalent (TEDE) to an average member of the critical group (AMCG) that does not exceed 25 mrem/yr and that the residual radioactivity has been reduced to levels that are as low as reasonably achievable (ALARA). The release criterion is translated into site-specific Derived Concentration Guideline Levels (DCGLs) for assessment and summary.

This report documents that FSS activities were performed consistent with the guidance provided in the LACBWR *License Termination Plan* (LTP) (Reference 1); NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) (Reference 2); LC-QA-PN-001, *Final Status Survey Quality Assurance Project Plan (QAPP)* (Reference 3); LC-FS-PR-002, *Final Status Survey Package Development* (Reference 4); LC-FS-PR-015, *Final Status Survey for Structures* (Reference 5); LC-FS-PR-010, *Isolation and Control for Final Status Survey* (Reference 6); LC-FS-PR-008, *Final Status Survey Data Assessment* (Reference 7); LC-FS-PR-018, *Radiation Surveys of Pipe Interiors Using Sodium/Cesium Iodide Detectors* (Reference 8); LC-FS-TSD-003, *Assessment of the LACBWR Circulating Water Discharge Pipe Final Status Survey Data for Detection Efficiency and Detector Background* (Reference 9); LC-FS-TSD-005, *MCNP Modeling of Water Discharge Pipes for the Lacrosse Boiling Water Reactor* (Reference 10); as well as other various station implementing procedures.

This FSS Final Report has been written consistent with the guidance provided in NUREG-1757, Vol. 2, *Consolidated Decommissioning Guidance - Characterization, Survey, and Determination of Radiological Criteria* (Reference 11); MARSSIM; and the requirements specified in LC-FS-PR-009, *Final Status Survey Data Reporting* (Reference 12).

To facilitate the data management process, FSS Final Reports incorporate multiple Survey Unit Release Records. Release Records are complete and unambiguous records of the as-left radiological status of specific survey units. Sufficient data and information are provided in each Release Record to enable an independent re-creation and evaluation at some future time of both the survey activities and the derived results.

This Phase 2 Final Report specifically addresses eight (8) above-grade building survey units and ten (10) buried pipe survey units. This report contains a compilation of all eighteen (18) Release Records that are within the Phase 2 scope. Table 1-1 provides a listing of all the survey units addressed in this report, along with their classifications. Figure 1-1 depicts the locations of the survey units in relation to the LACBWR site as well as survey unit boundaries.

Table 1-1 Phase 2 Survey Units

Survey Unit	Type	Survey Unit Description	Class
B2-010-101	AGB	LACBWR Crib House	2
B2-010-102	AGB	G-3 Crib House	2
B2-010-103	AGB	LACBWR Administration Building	2
B3-012-101	AGB	Back-up Control Center	3
B3-012-102	AGB	Transmission Sub-Station Switch House	3
B3-012-103	AGB	G-1 Crib House	3
B3-012-104	AGB	Barge Wash Break Room	3
B3-012-109	AGB	Security Shack	3
S1-011-102	BP	Circulating Water Discharge Pipe	1
S2-011-103 A	BP	De-Icing Line	2
S2-011-103 B	BP	Low Pressure Service Water	2
S2-011-103	BP	Circulating Water Intake Pipe	2
S3-012-109 A	BP	Storm Drain 1	3
S3-012-109 B	BP	Storm Drain 2	3
S2-011-101 A	BP	Storm Drain 3	3
S2-011-101 B	BP	Storm Drain 6	3
S3-012-102 A	BP	Storm Drain 4	3
S3-012-102 B	BP	Storm Drain 5	3
AGB = Above-Grade Building BP = Buried Piping			

All FSS activities essential to data quality have been implemented and performed under approved procedures. Trained individuals, using properly calibrated instruments and laboratory equipment that are sensitive to the suspected contaminants, performed the FSS of the Phase 2 survey units. The survey data for all Phase 2 survey units demonstrate that the dose from residual radioactivity is less than the maximum annual dose which corresponds to the release criterion for license termination for unrestricted use specified in 10 CFR 20.1402 and support the release of these areas from the 10 CFR 50 license. Additionally, the ALARA requirement of 10 CFR 20.1402 has been satisfied.

As stated above, this report contains only the results of the FSS that address the dose due to buried piping and above-grade buildings. The dose from groundwater will be calculated using the Groundwater Exposure Factors presented in Chapter 6 of the LTP. Because the industrial use scenario does not include irrigation the only exposure pathway from groundwater is potable water from an onsite well. The results of the dose calculation for groundwater will be presented in a separate final report.

Figure 1-1 Phase 2 Survey Unit Locations

1.2 Phased Submittal Approach

To minimize the incorporation of redundant historical assessment and other FSS program information, and to facilitate potential phased releases from the current license, FSS Final Reports will be prepared in a phased approach. LaCrosse*Solutions* estimates that a total of three (3) FSS Final Reports will be generated and submitted to the NRC during the decommissioning project.

Release of Non-Impacted Open lands

On June 27, 2016, LaCrosse*Solutions* submitted a request to release a portion of the LACBWR site from the 10 CFR 50 license (DPR-45) in accordance with 10 CFR 50.83, *Release of Part of a Power Reactor Facility or Site for Unrestricted Use*, and 10 CFR 100, *Reactor Site Criteria* (ADAMS Accession No. ML16181A068). A report was generated for the request that addressed the release of 88 of the 165 acres that comprise the LACBWR site. That report contains a summary of the final assessment performed as well as a summary of the characterization surveys performed of these non-impacted open-land survey units. LaCrosse*Solutions* reviewed and assessed the subject property to ensure that the radiological condition of these land areas will have no adverse impact on the ability of the site, in aggregate, to meet the 10 CFR 20, Subpart E, *Radiological Criteria for License Termination*. The five (5) survey units incorporated within the report are classified as non-impacted, and as such, no statistical tests, scan measurements, static measurements, or elevated measurement comparisons were required. The release of the non-impacted areas from the license(s) was approved by the NRC on April 12, 2017.

Phase 1 and 3 Final Status Survey Final Reports

As discussed above, LaCrosse*Solutions* anticipates three (3) FSS Final Report submittals. The schedule and identity of survey units included in each of the remaining submittals were developed based on a review of the demolition and FSS schedule, as well as in consideration of NRC review requirements. The demolition schedule, including the cleanup of demolition debris to allow survey access, is dynamic and subject to continued refinement. With potential changes in the decommissioning schedule, it is possible that interim submittals will be filed with the NRC with the goal of providing Survey Unit Release Records as soon as possible to support review and the potential release of the survey units.

The Phase 1 FSS Final Report was submitted to NRC for review on September 17, 2019, and included four (4) sub-grade excavation survey units, three (3) open land survey units, and two (2) structure basement survey units. The Phase 3 FSS Final Report will encompass all remaining open land areas and sub-grade excavations, as well as groundwater. Table 1-2 provides a list of survey units within the Phase 1 and Phase 3 submittals as well as partial site release.

Table 1-2 Listing of Survey Units within the Phase 1 and Phase 3 FSS Final Report Phased Submittals as well as Partial Site Release

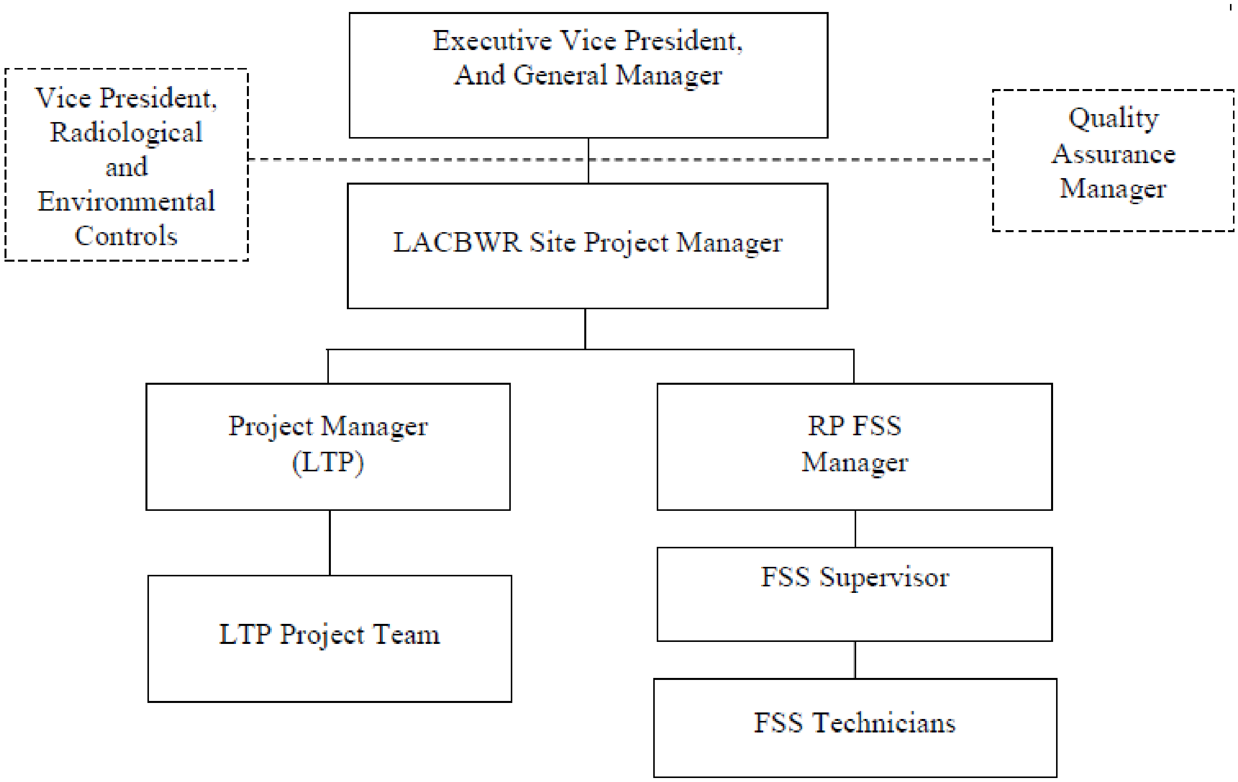
Survey Unit	Survey Unit Description	Class	Phase
L4-012-103	G-3 Coal Plant Grounds	Non-Impacted	-
L4-012-105	Coal Pile Grounds	Non-Impacted	-
L4-012-106	Capped Ash Impoundment Grounds	Non-Impacted	-
L4-012-107	Grounds East of Highway 35	Non-Impacted	-
L4-012-108	Hwy 35/Railroad Right of Way Grounds	Non-Impacted	-
L1-SUB-DRS	RCA North Area	1	1
L1-SUB-TDS	TB, Sump, Pit, Diesel	1	1
L1-SUB-LES	LSA, Eat Shack, Septic	1	1
L1-010-101 C	Waste Treatment Building	1	1
L2-011-102	Area South of LSE Fence	2	1
L2-011-103	LACBWR Crib House, Surrounding Area	2	1
L3-012-102	Transmission Switch Yard	3	1
B1-010-001	Reactor Building	1	1
B1-010-004	Waste Gas Tank Vault	1	1
L1-010-101	Reactor Building, WTB, WGTV, Ventilation Stack Grounds	1	3
L1-010-102	Turbine Building, Turbine Office Building, 1B Diesel Generator Building Grounds	1	3
L1-010-103	LSA Building, Maintenance Eat Shack Grounds	1	3
L1-010-104	North LSE Grounds	1	3
L1-010-105	North Interim Debris Storage Area	1	3
L1-010-106	North Loading Area	1	3
L1-010-107	Outside East LSE Area	1	3
L2-011-101	Area North of LSE Fence	2	3
L2-011-104	G3 Crib House, Circ. Water Discharge Land	2	3
L3-012-101	North End of Licensed Site	3	3
L3-012-109	Plant Access, ISFSI Haul Road Grounds	3	3
L1-SUB-CDR	Stack, Pipe Tunnel, RPGPA	1	3
L1-SUB-TDS A	Eastern Portion TB, Sump, Pit, Diesel	1	3
L1-SUB-TDS B	RPGPA Area	1	3

2 Final Status Survey Program Overview

Elements of the FSS Program consist of the methods used in planning, designing, conducting, and evaluating FSS at the LACBWR site to demonstrate that the premises are suitable for unrestricted use in accordance with the criteria for decommissioning in Title 10 CFR 20, Subpart E. Final Status Surveys serve as key elements to demonstrate that the TEDE to an AMCG from residual radioactivity does not exceed 25 mrem/yr, and that all residual radioactivity at the site is reduced to levels that are ALARA.

To implement the FSS Program, LaCrosse*Solutions* established the Characterization/License Termination (C/LT) Group, within the Radiation Protection division, with sufficient management and technical resources to fulfill project objectives. The C/LT Group is responsible for the safe completion of all surveys related to characterization and final site closure. Approved site procedures and detailed technical support documents (TSD) direct the FSS process to ensure consistent implementation and adherence to applicable requirements. Figure 2-1 provides an organizational chart of the C/LT Group.

Figure 2-1 Characterization/License Termination Group Organizational Chart



2.1 Survey Planning

The program development and survey planning phases were initiated in 2015 by the Energy*Solutions* TSD RS-TD-313196-003, *La Crosse Boiling Water Reactor Historical Site Assessment* (HSA) (Reference 13) and the initiation of the characterization process. The characterization process is iterative and will continue until, in some cases, the time of completing FSS. The HSA consisted of a review of site historical records regarding plant incidents, radiological survey documents, and routine and special reports submitted by Dairyland Power to various regulatory agencies. Along with these assessments, interviews with current and past site personnel, reviews of historical site photos, and extensive area inspections were performed to meet the following objectives:

- Develop the information necessary to support FSS design, including the development of Data Quality Objectives (DQOs) and survey instrument performance standards.
- Develop the initial radiological information to support decommissioning planning, including building decontamination, demolition, and waste disposal.
- Identify any unique radiological or health and safety issues associated with decommissioning.
- Identify the potential and known sources of radioactive contamination in systems, surface or subsurface soils, groundwater, and on structures.
- Divide the LACBWR site into manageable survey units for survey and classification purposes.
- Determine the initial classification of each survey unit as non-impacted or impacted. Impacted survey units are further designated as Class 1, 2, or 3, as defined in MARSSIM.

DQOs are qualitative and quantitative statements derived from the DQO process that clarify technical and quality objectives, define the appropriate type of data, and specify the tolerable levels or potential decision errors used as the basis for establishing the quality and quantity of data required to support inference and decisions. This process, described in MARSSIM and procedures LC-FS-PR-002, *Final Status Survey Package Development* and LC-FS-PR-015, *Final Status Survey for Structures,* is a series of graded planning steps found to be effective in establishing criteria for data quality and guiding the development of FSS sample plans. DQOs developed and implemented during the initial phase of planning directed all data collection efforts.

The DQO approach consists of the following seven steps:

- **State the Problem** – This step provides a clear description of the problem, identification of planning team members (especially the decision makers), a conceptual model of the hazard to be investigated, and the estimated resources required to perform the survey. The problem associated with FSS is to determine whether a given survey unit meets the radiological release criterion of 10 CFR 20.1402.

- **Identify the Decision** – This step consists of developing a decision statement based on a principal study question (i.e., the stated problem) and determining alternative actions that may be taken based on the answer to the principle study question. Alternative actions identify the measures to resolve the problem. The decision statement combines the principal study question and alternative actions into an expression of choice among multiple actions. For the FSS, the principal study question is: "Does residual radioactive contamination present in the survey unit exceed the established DCGL values?" The alternative actions may include no action, investigation, resurvey, remediation, and reclassification.
- **Identify Inputs to the Decision** – The information required depends on the type of media under consideration (e.g., soil, water, or concrete) and whether existing data are sufficient or if new data are needed to make the decision. If the decision can be based on 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, direct measurement, or sampling) will need to be determined.
- **Define the Study Boundaries** – This step includes identification of the target population of interest, the spatial and temporal features of that population, the time frame for collecting the data, practical constraints, and the scale of decision making. In FSS, the target population is the set of samples or direct measurements that constitute an area of interest. The medium of interest is specified during the planning process. The spatial boundaries include soil depth, area dimensions, contained water bodies, and natural boundaries. Temporal boundaries include activities impacted by time-related events including weather conditions, season, operation of equipment under different environmental conditions, resource loading, and work schedule.
- **Develop a Decision Rule** – This step 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 and includes action level conditions and the statistical parameter of interest.
- **Specify Tolerable Limits on Decision Errors** – This step incorporates hypothesis testing and probabilistic sampling distributions to control the decision errors during data analysis. Hypothesis testing is a process based on the scientific method that compares a baseline condition (the null hypothesis) to an alternative condition (the alternative hypothesis). Hypothesis testing rests on the premise that the null hypothesis is true and that sufficient evidence must be provided to reject it.
- **Optimize the Design for Obtaining Data** – The final step in the DQO process leads to the development of an adequate survey design. Gamma and beta scans provide information on piping interiors and structure surfaces that have residual radioactivity greater than background and allow appropriate selection of biased sampling and measurement locations. This data will be evaluated and used to refine the scope of field

activities to optimize implementation of the FSS design and ensure the DQOs are met. For buried piping and above-grade structures, compliance with the release criteria is shown by obtaining static measurements at randomly chosen, systematic and judgmental locations, depending on the classification.

Buried piping is defined as below ground pipe located outside of structures and basements. The dose assessment methods and resulting DCGLs for buried piping are described in detail in LTP Chapter 6, section 6.20. The buried piping was separated into two categories. The first category included the summation and grouping of all impacted buried pipe other than the Circulating Water Discharge (CWD) Pipe and is designated as the "Buried Pipe Group." The second category consisted of the CWD Pipe only. The separation of the CWD pipe was necessary because the geometry of the CWD pipe was significantly different than the other pipes, and the pipes are located in distinctly different parts of the site.

Energy*Solutions* TSD RS-TD-313196-004, *LACBWR Soil DCGL, Basement Concrete DCGL, and Buried Pipe DCGL* (Reference 14) and LTP Chapter 6, Section 6.20, provide the exposure scenarios and modeling parameters that were used to calculate the site-specific buried pipe DCGLs. The final DCGLs to be used during FSS account for the fact that the dose from the *In Situ* and Excavation scenarios must be summed in the conceptual model for buried pipe dose assessment (i.e., the *In Situ* and Excavation scenarios occur in parallel). For buried piping standard methods for RESRAD parameter selection and uncertainty analysis were used consistent with guidance in NUREG-1757. The AMCG is the Industrial Worker. The summed Buried Pipe DCGLs (Base Case) are reproduced in Table 2-1 below. The Insignificant Contributor (IC) dose percentages for each of the buried pipe scenarios were used to adjust each buried pipe DCGL to account for the dose from the eliminated IC radionuclides.

Table 2-1 Base Case DCGLs for Buried Pipe ($DCGL_{BP}$)

Radionuclide	Buried Pipe Group $DCGL_{BP}$ (dpm/100 cm^2)	Circ Water Discharge $DCGL_{BP}$ (dpm/100 cm^2)
Co-60	7.50E+04	7.75E+04
Sr-90	5.16E+05	7.55E+05
Cs-137	3.18E+05	3.30E+05
Eu-152	1.64E+05	1.67E+05
Eu-154	1.52E+05	1.56E+05

Each radionuclide-specific Base Case DCGL is equivalent to the level of residual radioactivity (above background levels) that could, when considered independently, result in a TEDE of 25 mrem/yr to an AMCG. 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 values are designated as Operational DCGLs and are then used as the DCGL for the FSS design of the survey unit (calculation of surrogate DCGLs, investigation levels, etc.). Details of the Operational DCGLs derived for each dose component and the basis for the applied *a priori* dose fractions are provided in LaCrosse*Solutions* TSD LC-FS-TSD-002, *Operational Derived Concentration Guideline Levels for Final Status Survey* (Reference 15). The Operational DCGLs for buried pipe are provided in Table 2-2.

Table 2-2 Operational DCGLs for Buried Pipe ($OpDCGL_{BP}$)

Radionuclide	Buried Pipe Group $OpDCGL_{BP}$ (dpm/100 cm^2)	Circ Water Discharge $OpDCGL_{BP}$ (dpm/100 cm^2)
Co-60	1.57E+04	1.63E+04
Sr-90	1.08E+05	1.58E+05
Cs-137	6.68E+04	6.94E+04
Eu-152	3.44E+04	3.51E+04
Eu-154	3.20E+04	3.27E+04

The above-grade buildings listed in Table 1-1 were subjected to FSS using the screening values for building surface contamination from Table H.1 of NUREG-1757, Vol. 2, Appendix H. The survey approach that was used to radiologically assess the residual radioactivity in these above grade structures consisted of beta/gamma surface scans and static measurements.

Table 2-3 provides the Above-Grade Building Base Case DCGLs ($DCGL_{AGB}$) and Operational DCGLs ($OpDCGL_{AGB}$) of the main Radionuclides of Concern (ROC) used for the FSS of the Phase 2 survey units.

Table 2-3 Base Case and Operational DCGLs for the Above-Grade Buildings

Radionuclide	Above-Grade Building Base Case DCGL ($DCGL_{AGB}$) (dpm/100 cm^2)	Above-Grade Building Operational DCGL ($OpDCGL_{AGB}$) (dpm/100 cm^2)
Co-60	7,100	1,136
Sr-90	8,700	1,392
Cs-137	28,000	4,480
Eu-152	12,700	2,032
Eu-154	11,500	1,840

The development of information to support decommissioning planning and execution was accomplished through a review of all known site radiological and environmental records. Much of this information was consolidated in the HSA, and in files containing copies of records maintained pursuant to Title 10 CFR 50.75(g) (1).

An initial objective of site characterization was to correlate the impact of a radiological event to physical locations on the LACBWR site and to provide a means to correlate subsequent survey data. To satisfy these objectives, the entire 164-acre site was divided into survey units. Survey unit size determination was based upon the specific area and the most efficient and practical size needed to bound the lateral and vertical extent of contamination identified in the area.

Classification, as described in MARSSIM, is the process by which an area or survey unit is described according to its radiological characteristics and potential for residual radioactivity. Residual radioactivity could be evenly distributed over a large area, appear as small areas of elevated activity, or a combination of both. Therefore, the adequacy and effectiveness of the FSS process depends upon properly classified survey units to ensure that areas with the highest potential for contamination receive a higher degree of survey effort.

The suggested surface area limits provided in MARSSIM were used to establish the initial set of survey units for the LTP. A survey unit is a portion of a structure, buried piping or open land area that is surveyed and evaluated as a single entity following FSS. Survey units were delineated to physical areas with similar operational history or similar potential for residual radioactivity. To the extent practical, survey units were established with relatively compact shapes, and highly irregular shapes were avoided unless the unusual shape was appropriate for the site operational history or the site topography. For identification, survey units were assigned a five-digit number that could be further modified by a letter for future divisions if needed (i.e., if the classification changes, then the corresponding survey unit size limitation changes). Physically, land survey unit boundaries were determined using commercially available mapping software with coordinates consistent with the Wisconsin State Plane North American Datum (NAD) 1983 coordinate system. Table 2-4 provides an outline for classification versus area size for survey units consistent with MARSSIM.

Table 2-4 Typical Final Status Survey Unit Areas

Classification	Area Type	Suggested Area
Class 1	Land	Up to 2,000 m^2
	Structure	Up to 100 m^2
Class 2	Land	2,000 to 10,000 m^2
	Structure	100 to 1,000 m^2
Class 3	Land	No Limit
	Structure	No Limit

Prior to FSS, each survey unit's classification is reviewed and verified in accordance with the LTP and its implementing procedures. A classification change to increase the class (e.g., Class 2 to Class 1) may be implemented without notification to regulatory authorities. However, a classification change to decrease the class (e.g., Class 1 to Class 2) may be implemented only after accurate assessment and approval from regulatory authorities as detailed in the LTP and its implementing procedures. Typically, reclassification occurs after the evaluation of continuing characterization results or emergent data indicates a more restrictive classification is required. Final classification was performed in conjunction with the preparation of the FSS sample plans. The sample plans reconcile legacy characterization data with more recent continuing characterization data to verify that the final classification is correct.

LTP Chapter 2 provides detailed characterization data that describes current contamination levels in the above-grade buildings from the characterization campaign conducted from September 2014 through August 2015. No characterization was performed of buried piping prior to the performance of FSS. The initial survey data for basements was based on core samples obtained from the walls and floors of the Reactor Building, Waste Treatment Building (WTB) and the balance of the basement structures (primarily the Piping Tunnels) at biased locations with elevated contact dose rates, contamination levels, and/or evidence of leaks/spills. During subsequent characterizations, additional cores were obtained from the Reactor Building and the Waste Gas Tank Vault (WGTV). Surface and subsurface soil samples were taken in each impacted open land survey unit (including soil beneath and adjacent to basements) and analyzed for the presence of plant-derived radionuclides.

It is assumed that the contaminated water that caused concrete contamination would be similar to any potential source of soil contamination. Consequently, the ROC and radionuclide mixture derived for the concrete was considered to be reasonably representative of soils and buried piping for FSS planning and implementation. This assumption was verified during FSS sampling as described below. Note that due to the expectation of very low concentrations of soil and piping contamination, any uncertainties in the application of the concrete derived radionuclide mixture to soil and buried piping would be very unlikely to cause significant dose variability in relation to the 25 mrem/yr dose criteria.

Energy*Solutions* TSD RS-TD-313196-001, *Radionuclides of Concern During LACBWR Decommissioning* (Reference 16) evaluates the results of the concrete core analysis data from the Reactor Building, WTB, Piping Tunnels and WGTV and refines the initial suite of potential ROC by evaluating the dose significance of each radionuclide.

Insignificant dose contributors were determined consistent with the guidance contained in section 3.3 of NUREG-1757. In all soil and concrete scenarios, Cs-137, Co-60, Sr-90, Eu-152 and Eu-154 contribute nearly 100% of the total dose. The remaining radionuclides were designated as insignificant dose contributors and are eliminated from further detailed

evaluation. Therefore, the final ROCs for LACBWR soil, basement concrete, and buried piping are Cs-137, Co-60, Sr-90, Eu-152 and Eu-154.

The results of surface and subsurface soil characterization in the impacted area surrounding LACBWR indicate that there is minimal residual radioactivity in soil. Based on the characterization survey results to date, LACBWR does not anticipate the presence of significant soil contamination in any remaining subsurface soil that has not yet been characterized. In addition, minimal contamination is expected in the buried piping that LACBWR plans to leave in place.

The final suite of potential radionuclides and the mixture to be applied to soil and buried piping is provided in Table 2-5. Note, as described in Chapter 6 of the LTP, these values for soil/pipe are intended to be applied to above grade buildings and other materials not associated with the Reactor Building or WGTV.

Table 2-5 Dose Significant Radionuclides and Mixture (1)

Radionuclide	Soil/Pipe Mixture Fraction (2)
Co-60	6.44E-02
Sr-90	9.81E-02
Cs-137	8.29E-01
Eu-152	5.49E-03
Eu-154	2.81E-03

(1) From Table 5-2 of the LTP
(2) The values for Soil/Pipe are intended to be applied to above grade buildings and other materials not associated with the Reactor Building or WGTV.

Characterization results determined that Co-60 and/or Cs-137 would be the primary ROC for the majority of survey design. All the FSS results provided in this report utilize Cs-137 as the primary ROC. Cs-137 and Co-60 characterization data for the survey units discussed in this report were used to determine the expected variability, number of samples required, and investigation levels for FSS design.

2.2 Survey Design

Final Status Surveys for the LACBWR site are designed following LaCrosse*Solutions* procedures, the LTP, and MARSSIM guidance. FSS design utilizes the combination of traditional scanning surveys, systematic or random measurement/sampling protocols, and investigative or judgmental methodologies to evaluate survey units relative to the applicable release criteria for open land, buried pipe, structure basements or above-grade building sample plans.

Survey design objectives included a verification of the survey instrument's ability to detect the radiation(s) of interest relative to the DCGL. As standard practice to ensure that this objective was consistently met, portable radiation detection instruments used in FSS were calibrated on a yearly frequency with a National Institute of Standards and Technology (NIST) traceable source in accordance with Energy*Solutions* procedures. Instruments were response checked before and after use. Minimum Detectable Count Rates (MDCR) were established and verified prior to FSS. Control and accountability of survey instruments were maintained and documented to assure quality and prevent the loss of data.

Based upon classification, a percentage of the surface area in the survey unit was selected and scanned with portable beta/gamma radiation detection instruments. Information obtained during the survey was automatically logged by the instrument for review and analysis. Scan and measurement coordinates were identified using a random or systematic sample tool in Visual Sample Plan (VSP). For above grade buildings, structure dimensions and coordinates based on a local origin selected by the survey designer were used to identify measurement locations in the field. Investigational samples or measurements were collected at areas of elevated scan readings. All details and instructions were incorporated into the survey unit's FSS sample plan. The recommended survey coverage based on survey unit classification is provided below in Table 2-6.

Table 2-6 Recommended Survey Coverage for FSS (1)

Classification	Surface Scans	Soil Samples/Static Measurements
Class 1	100%	Number of sample/measurement locations for statistical test, additional samples/measurements to investigate areas of elevated activity
Class 2	10% to 100%, Systematic and Judgmental	Number of sample/measurement locations for statistical test
Class 3	Judgmental	Number of sample/measurement locations for statistical test

(1) From Table 5-15 of the LTP

The general approach prescribed by MARSSIM for FSS requires that at least a minimum number of measurements or samples be taken within a survey unit, so that the non-parametric statistical tests used for data assessment can be applied with adequate confidence. Decisions regarding whether a given survey unit meets the applicable release criterion are made based on the results of these tests.

Designated sediment samples from piping internals, when available, were sent to an off-site laboratory for Hard-to-Detect (HTD) analysis (Sr-90). Laboratory DQO and analysis results were summarized in release records and reported as actual results, not '<MDC.' Sample

report summaries within the release records included unique sample identification, analytical method, radioisotope, result, uncertainty of two standard deviations, laboratory data qualifiers, units, and required Minimum Detectable Concentration (MDC).

Another consideration of survey design was the use of surrogates. In lieu of analyzing every sample for HTD radionuclides, the development and application of Surrogate Ratio DCGLs as described in MARSSIM, Section 4.3.2 was applied to estimate HTD radionuclides. Surrogate ratios allow for expedient decision making in characterization, remediation planning, or FSS design.

A surrogate is a mathematical ratio where an Easy-to-Detect (ETD) radionuclide (e.g., Cs-137) concentration is related to an HTD radionuclide (e.g., Sr-90) concentration. From the analytical data, a ratio is developed and applied in the survey scheme for samples taken in the area. Details and applications of this method are provided in section 5.2.9 of the LTP.

2.3 Survey Implementation

FSS implementation of the Phase 2 survey units started in March, 2018, and completed in October, 2019. Implementation was the physical process of the FSS sample plan execution for a given survey unit. Each sample plan was assigned to an FSS Supervisor for implementation and completion, in accordance with LaCrosse*Solutions* procedures and the FSS QAPP. The tasks included in the implementation were:

- Verification and validation of personnel training as required by Training Department and Radiation Protection procedures.
- Monitoring instrument calibration as detailed in LC-RP-PG-003, *Radiological Instrumentation Program* (Reference 17) and LC-RP-PR-060, *Calibration and Initial Set Up of the 2350-1* (Reference 18).
- Implementation of applicable operating and health and safety procedures.
- Implementation of isolation and control of the survey unit in accordance with LC-FS-PR-010, *Isolation and Control for Final Status Survey.*
- Determination of the number of samples and measurements required to meet DQOs as described in LC-FS-PR-002, *Final Status Survey Package Development* and LC-FS-PR-015, *Final Status Survey for Structures*.
- Determination of sample and measurement locations and creation of survey unit maps displaying the locations in accordance with LC-FS-PR-002.
- Proper techniques for collecting and handling FSS samples in accordance with LC-FS-PR-004, *Sample Media Collection for Site Characterization and Final Status Survey* (Reference 19).
- Proper techniques for collecting FSS measurements for buried pipe in accordance with LC-FS-PR-018, *Radiation Surveys of Pipe Interiors Using Sodium/Cesium Iodide Detectors*.

- Maintaining Quality Assurance/Quality Control requirements (i.e., replicate measurements or samples) in accordance with LC-QA-PN-001, *Final Status Survey Quality Assurance Project Plan*.
- Sample Chain-of-Custody maintained in accordance with LC-FS-PR-005, *Sample Media Preparation for Site Characterization and Final Status Survey* (Reference 20).
- Sample submission to approved laboratories in accordance with LC-FS-PR-012, *Chain of Custody Protocol* (Reference 21).
- Application of the DCGLs to sample and measurement results in accordance with the Data Quality Assessment (DQA) process as detailed in LC-FS-PR-008, *Final Status Survey Data Assessment.*
- Determination of investigation methodology and corrective actions, if applicable.

For buried piping, compliance with the Operational DCGL values, as presented in Table 2-2, were demonstrated by measurements of total surface contamination and by the collection of sediment samples when available. The acquisition of direct gamma measurements involved the insertion of appropriately sized detectors into the pipe interior by a simple "push-pull" methodology, whereby the position of the detector in the piping system can be easily determined in a reproducible manner. By using a sled or other spacers, the detectors were configured in a fixed geometry relative to the surveyed surface, thus creating a situation where an appropriate efficiency can be calculated. The detectors are then deployed into the actual pipe and timed measurements were acquired at intervals commensurate with the contamination potential of the pipe. A conservative "area of detection" is assumed for each pipe size. It is also conservatively assumed that any activity is uniformly distributed in the area of detection.

A static measurement was acquired at a pre-determined interval for the areal coverage to be achieved. The measurement output represents the gamma activity in gross cpm for each foot of piping traversed. Background is subtracted, then the value is converted to dpm using an efficiency factor based on the calibration source and the efficiency correction factors detailed in TSD LC-FS-TSD-005, *MCNP Modeling of Water Discharge Pipes for the La Crosse Boiling Water Reactor*. The total activity in dpm is then converted to activity per unit area commensurate with the pipe diameter, resulting in measurement results in units of dpm/100 cm^2. A surrogate correction based upon the radionuclide distribution present in the pipe is then applied to the gamma activity to account for the presence of other non-gamma emitting radionuclides in the mixture. During data assessment, the measurement results are compared to the buried pipe Operational DCGLs.

For above-grade buildings, compliance with the Operational DCGL values, as presented in Table 2-3, were demonstrated by beta static measurements of total surface contamination and augmented by beta scans at the frequency and locations specified in Table 2-6. Depending on the survey unit classification, randomly selected or systematic static measurements were

obtained using a Ludlum 2350-1 data logger coupled to a 125 m^2 Ludlum Model 44-116 detector (100 cm^2 actual detector area).

The FSS implementation and completion process resulted in the generation of field data and analysis data consisting of measurements taken with handheld radiation detecting equipment, observations noted in field logs, and radionuclide specific analyses. Data were stored electronically on the Energy*Solutions* common network with controlled accessibility.

2.4 Survey Data Assessment

Prior to proceeding with data evaluation and assessment, the assigned FSS Supervisor ensured consistency between the data quality and the data collection process and the applicable requirements.

The DQA process is an evaluation method used during the assessment phase of FSS to ensure the validity of FSS results and demonstrate achievement with the FSS sample plan objectives. A key step in the data assessment process converts all of the survey results to DCGL units, if necessary. The individual measurements and sample concentrations are compared to the Operational DCGL for evidence of small areas of elevated activity or results that are statistical outliers. When practical, graphical analyses of survey data that depicts the spatial correlation of the measurements was used.

For buried piping, the dose contribution from each ROC was accounted for using the Sum-of-Fractions (SOF) to ensure that the total dose from all ROC does not exceed the dose criterion. The SOF or "unity rule" was applied to the data used for the survey planning, and data evaluation and statistical tests since multiple radionuclide-specific measurements will be performed or the concentrations inferred based on known relationships. The application of the unity rule served 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 $DCGL_W$ (used for the nonparametric statistical test) becomes one (1).

For above-grade buildings, the dose contribution was calculated by multiplying the mean gross activity fraction of the adjusted gross Base Case DCGL by 25 mrem/yr. Although multiple ROC are present in the survey unit, the unity rule was not applied because of the nature of the survey technique (beta static measurement versus gamma static measurements or the collection of volumetric media samples).

The Base Case DCGLs ($DCGL_{BP}$ and $DCGL_{AGB,}$ for buried pipe and above-grade buildings, respectively) are directly analogous to the $DCGL_W$ as defined in MARSSIM. The use and application of the unity rule was be performed in accordance with section 4.3.3 of MARSSIM.

For the survey units addressed by this final report, the survey data was evaluated using the Sign Test (as described in the LTP). The Sign Test is a one-sample statistical test that compares data directly to the release criteria. Combined with an effective sampling scheme,

passing the Sign Test satisfies the release criteria. Selection of the Sign Test is prudent and conservative in the assumption that the radionuclides being considered are not present in background or are at levels at a small fraction of the applicable release criteria. Furthermore, any background contribution (e.g., Cs-137 from global fallout) in the sample increases the likelihood of failing the survey unit, which is conservative. If the release criteria were exceeded or if results indicated the need for additional data points, appropriate further actions were implemented, usually through the issue of an addendum to the FSS sample plan.

2.5 Quality Assurance and Quality Control Measures

Quality assurance and control measures were employed throughout the FSS process to ensure that all decisions were based on data of acceptable quality. Quality assurance and control measures were applied to ensure:

- The FSS sample plan was correctly implemented.
- DQOs were properly defined and derived.
- The DQA process was used to assess results.
- All data and samples were collected by individuals with the proper training and in adherence to approved procedures and sample plans.
- All instruments were properly calibrated.
- All collected data was validated, recorded, and stored in accordance with approved procedures.
- All required documents were properly maintained.
- Corrective actions were prescribed, implemented and tracked, as necessary.

Independent laboratories used for analysis of the samples collected during FSS maintain Quality Assurance Plans designed for their facility. LaCrosse*Solutions* reviewed these plans, as required by the FSS QAPP, prior to selection of a laboratory for FSS sample analysis to ensure standards are acceptable.

The Characterization/License Termination Group has undergone surveillance by the Energy*Solutions* QA department on a consistent basis throughout the project at LACBWR. The QA surveillances have scrutinized the LTP, C/LT procedures, sample plans, release records, and other C/LT records. The responses to the QA surveillances are captured in the Corrective Action Program (CAP).

3 Site Information

3.1 Site Description

The La Crosse Boiling Water Reactor was a 50-Megawatt Electric (MWe) BWR that is owned by Dairyland Power Cooperative (Dairyland). This unit, also known as Genoa 2, is located on the Dairyland Genoa site on the east shore of the Mississippi River about 1 mile

south of the Village of Genoa, Vernon County, Wisconsin, and approximately 19 miles south of the city of La Crosse, WI. See Figure 3-1 for a map showing the site location.

The licensed site comprises a total of 163.5 acres which is owned by Dairyland, with LACBWR comprising only 1.5 acres. The site is accessed by a road on the south side of the plant, off of Highway 35. The prominent features on the site are shown in Figures 3-2 and 3-3.

Figure 3-1 Site Regional Location

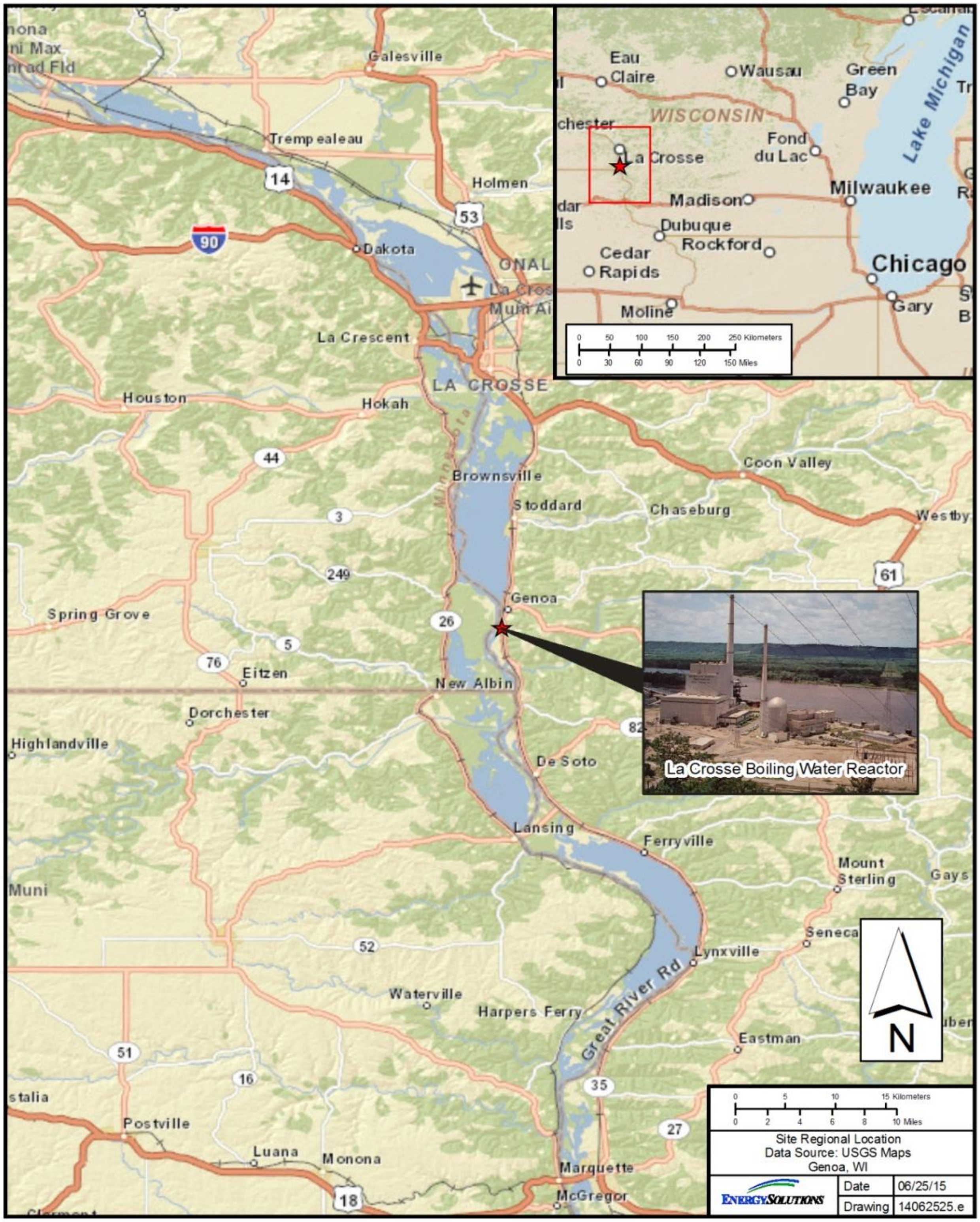


Figure 3-2 Site Overview

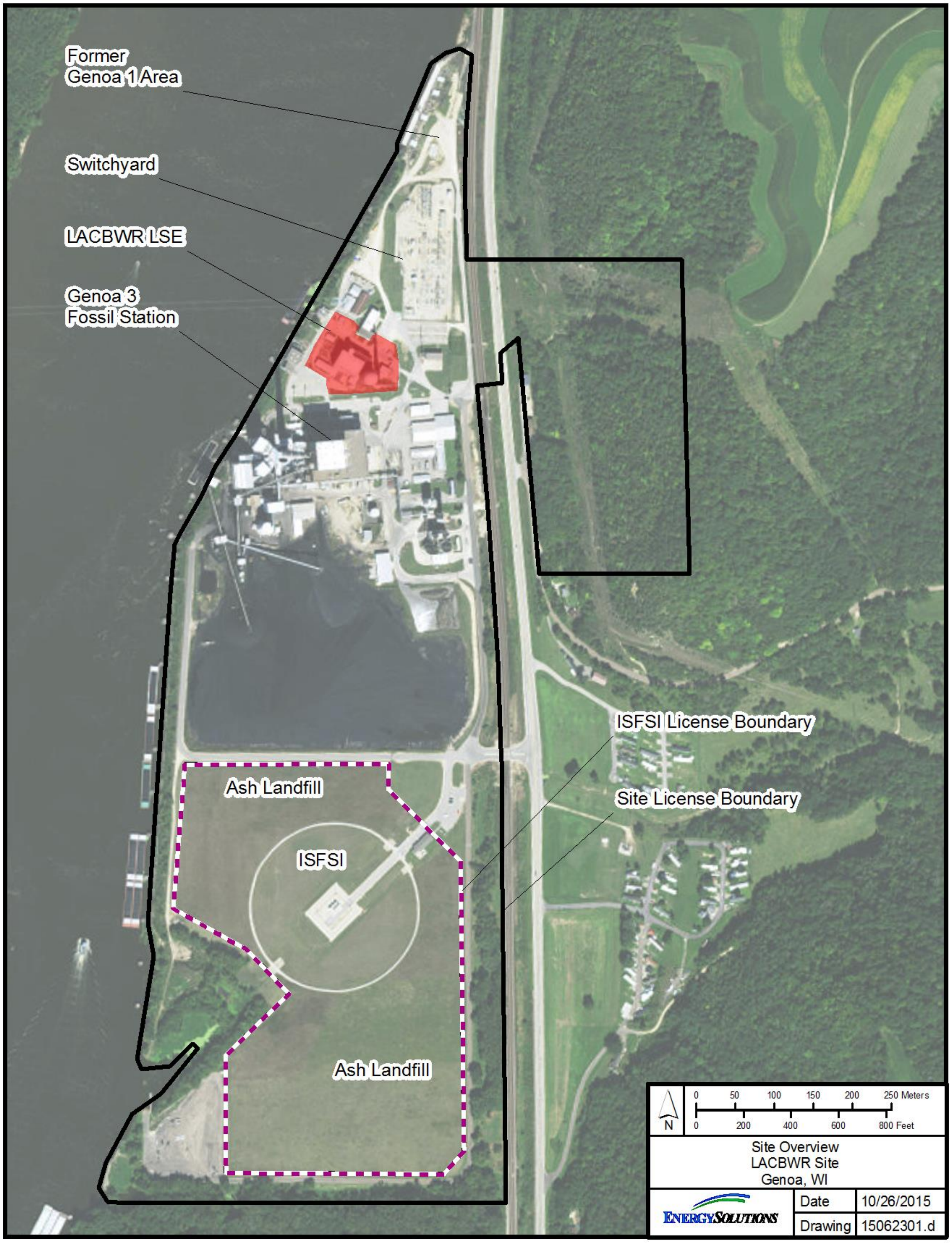
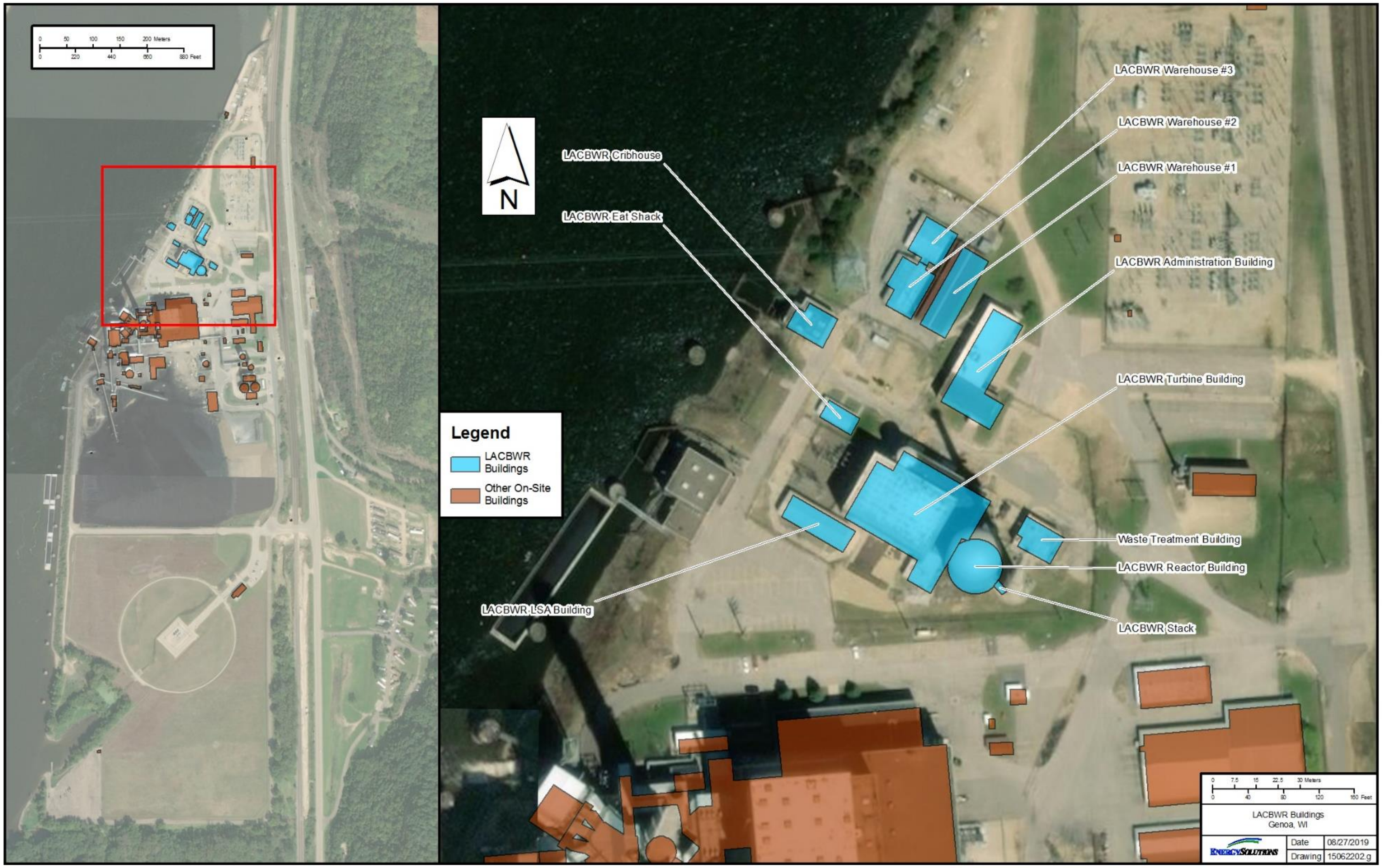


Figure 3-3 LACBWR Buildings



The site is licensed under Possession Only License No. DPR-45 with Docket Numbers of 50-409 for LACBWR and 72-046 for the Independent Spent Fuel Storage Installation (ISFSI). Key milestones during the life of the plant are:

- Allis-Chalmers, under contract with the AEC, designed, fabricated, constructed and performed startup of the LACBWR from 1962 to 1967,
- Dairyland entered into a contact to purchase steam from the nuclear plant to operate a turbine-generator for production of electricity: June 1962,
- Allis-Chalmers dockets application for construction: November 5, 1962,
- Initial Criticality achieved: July 11, 1967,
- Low power testing completed: September 1967,
- Provisional Operating authorization issued (DPRA-6): October 31, 1969,
- Provisional Operating License, DPRA-45 issued: August 28, 1973,
- LACBWR permanently shut down: April 30, 1987,
- Final reactor defueling was completed on June 11, 1987, and
- Completion of fuel loading into the ISFSI was completed on September 19, 2012.

The reactor was critical for a total of 103,287.5 hours. The 50 MWe generator was on line for 96,274.6 hours. The total gross electrical energy generated was 4.047 Gigawatt-Hours (GWH). The unit availability factor was 62.9%.

The LACBWR unit consisted of major buildings and structures such as the Reactor Building, Turbine Building, 1B Diesel Generator Building, Waste Treatment Building, Underground Gas Storage Tank Vault, Ventilation Stack, Low Specific Activity (LSA) building and others which have undergone decommissioning (see Figure 3-3). Intermittent systems dismantlement and metallic radioactive equipment have been removed since 2007, including the Reactor Pressure Vessel. The ISFSI, located south of the Genoa 3 fossil station, became operational in 2012 and holds five above-ground Dry Storage Casks with 333 spent fuel assemblies.

3.2 Survey Unit Description

The following information is a description of each Phase 2 survey unit at the time of FSS from March, 2018 until October, 2019. During this period, the FSS of eight (8) above-grade building survey units, and ten (10) buried pipe survey units were completed.

<u>Survey Unit B2-010-101, LACBWR Crib House</u>

B2-010-101 is an impacted Class 2 above-grade building survey unit. The survey unit consists of the interior and exterior surfaces of the LACBWR Crib House. The LACBWR Crib House provided circulating water for the condenser and service water systems. The LACBWR Crib House measures 14.5 m long by 11 m wide by 6 m high, which equates to a total surface area of 1,060 m^2.

The survey unit was split into interior and exterior, with 14 required compliance measurements each, to accommodate the MARSSIM recommended survey unit size restrictions.

Survey Unit B2-010-102, G-3 Crib House

B2-010-102 is an impacted Class 2 above-grade building survey unit. The G-3 Crib House is utilized as the circulatory water pumping station for the G-3 Goal Plant. The survey unit consists of the interior and exterior surfaces of a main building, an east addition, and a south addition. The total surface area of the survey unit is 2,873 m^2.

The survey unit was split into two sub-survey units (main building and the south addition) to accommodate MARSSIM recommended survey unit size restrictions. Fourteen (14) measurements were obtained on the interior and exterior of each of the two buildings for a total of fifty-six (56) compliance measurements.

Survey Unit B2-010-103, LACBWR Administration Building

B2-010-103 is an impacted Class 2 above-grade building survey unit. The Administration building is a two-story metal and brick structure located directly north of the LACBWR RCA. The Administration building is used as an office building for staff and records and was also used as a laboratory for environmental analyses. The surface area of the survey unit is 5,433 m^2.

The survey unit was split into eight sub-survey units (A through H), with 14 required compliance measurements each, to accommodate the MARSSIM recommended survey unit size restrictions.

Survey Unit B3-012-101, Back-up Control Center

B3-012-101 is an impacted Class 3 above-grade building survey unit. The Back-up Control Center is a two-story building which was utilized for the Genoa 3 Power Plant and consists of the interior and exterior surfaces of the structure. The surface area of the survey unit is 1,710 m^2.

Survey Unit B3-012-102, Transmission Sub-Station Switch House

B3-012-102 is an impacted Class 3 above-grade building survey unit. The Transmission Sub-Station Switch House is a one-story building and consists of the interior and exterior surfaces of the structure. The surface area of the survey unit is 861 m^2.

Survey Unit B3-012-103, G-1 Crib House

B3-012-103 is an impacted Class 3 above-grade building survey unit. The survey unit consists of the interior and exterior surfaces of the G-1 Crib House. The G-1 Crib House is located in the North Yard of the site and was a tool room for Genoa 3 personnel. The surface area of the survey unit is 296 m^2.

Survey Unit B3-012-104, Barge Wash Break Room

B3-012-104 is an impacted Class 3 above-grade building survey unit. The survey unit consists of the interior and exterior surfaces of the Barge Wash Break Room which is located in the North Yard of the site. The survey unit was utilized as a break room by personnel that worked on barges. The surface area of the survey unit is 116 m^2.

Survey Unit B3-012-109, Security Shack

B3-012-109 is an impacted Class 3 above-grade building survey unit and consists of the interior and exterior surfaces of the Security Station. The Security Station served as the security force housing and access point for the Dairyland Power property. The survey unit is a small one-story building with a surface area of 122 m^2.

Survey Unit S1-011-102, Circulating Water Discharge Pipe

S1-011-102 is an impacted Class 1 buried pipe survey unit. The survey unit consists of the interior surface of the CWD Pipe, which is 60” internal diameter (ID) steel pipe that runs 421’ from the Turbine Building to a combined discharge structure on the banks of the Mississippi River. The interior surface area of the CWD Pipe is 614 m^2.

Survey Unit S2-011-103 A, De-Icing Line

S2-011-103 A is an impacted Class 2 buried pipe survey unit. The survey unit consists of the interior surface of the De-Icing Line, which is an 18” ID steel pipe that runs approximately 105 feet (32 m) from the LACBWR Crib House to the Turbine Building. The total interior surface area of the De-Icing Line is 46 m^2.

Survey Unit S2-011-103 B, Low Pressure Service Water

S2-011-103 B is an impacted Class 2 buried pipe survey unit. The survey unit consists of the interior surface of the Low Pressure Service Water (LPSW) Pipe, which is a 16” ID steel pipe that runs approximately 44’. The interior surface area of the LPSW Pipe is 17 m^2.

Survey Unit S2-011-103, Circulating Water Intake Pipe

S2-011-103 is an impacted Class 2 buried pipe survey unit. The survey unit consists of the interior surface of the Circulating Water Intake (CWI) Pipe, which is two (2) 42” ID steel pipes that merge into a 60” ID steel pipe that runs from the LACBWR Crib House to the Turbine Building. The total length of pipe is approximately 46.5 feet (14.17 m). The total interior surface area of the CWI Pipe is 57 m^2.

Survey Unit S3-012-109 A, Storm Drain (SD) 1

S3-012-109 A is an impacted Class 3 buried pipe survey unit. The survey unit consists of the interior surface of the SD 1 pipe, which is a 10” ID Polyvinyl Chloride (PVC) pipe that is used to direct storm water out of the roadway south of the Backup Control Center (BCC) building. The total length of pipe is approximately 195 feet (59.4 m). The total interior surface area of SD 1 is 47.4 m^2.

Survey Unit S3-012-109B, Storm Drain 2

S3-012-109 B is an impacted Class 3 buried pipe survey unit. The survey unit consists of the interior surface of the SD 2 pipe, which is 48" ID concrete pipe that runs approximately 624' from a culvert east of the BCC westward where it discharges into the Mississippi River. The interior surface area of the SD 2 Pipe is 729 m^2.

Survey Unit S2-011-101A, Storm Drain 3

S2-011-101 A is an impacted Class 2 buried pipe survey unit. The survey unit consists of the interior surface of the SD 3 pipe, which is a 10" ID PVC buried pipe that resides to the east of the LACBWR Administration Building. The total length of pipe is approximately 104.5 feet (31.85 m). The total interior surface area of the pipe is 26 m^2.

Survey Unit S2-011-101B, Storm Drain 6

S2-011-101 B is an impacted Class 2 buried pipe survey unit. The survey unit consists of the interior surface of SD 6, which is a 10" ID PVC pipe that runs approximately 84 feet (26 m). The storm drain system collected water from the roadway east of the Administration Building and ran north where it connected to a 48" concrete storm drain (SD 2) that leads to the Mississippi River. The total interior surface area of SD 6 is 20.42 m^2.

Survey Unit S3-012-102A, Storm Drain 4

S3-012-102A is an impacted Class 3 buried pipe survey unit. The survey unit consists of the interior surface of the SD 4 pipe, which is a 12" ID clay buried pipe that resides to the north of the Switchyard. The total length of pipe is approximately 330 feet (100.58 m). The total interior surface area of the pipe is 96.31 m^2.

Survey Unit S3-012-102B, Storm Drain 5

S3-012-102B is an impacted Class 3 buried pipe survey unit. The survey unit consists of the interior surface of the SD 5 pipe, which is a 30" ID vitrified clay buried pipe that runs east-west underneath the northern portion of the Switchyard. The total length of pipe is approximately 400 feet (121.92 m). The total interior surface area of the pipe is 291.86 m^2.

3.3 Summary of Historical Radiological Data

The site historical radiological data for this Phase 2 FSS Final Report at LACBWR incorporates the results of the HSA issued in November 2015 and characterization surveys completed in November 2016.

3.3.1 Historical Site Assessment

The HSA was a detailed investigation to collect existing information (from the start of LACBWR activities related to radioactive materials or other contaminants) for the site and its surroundings. The HSA focused on historical events and routine operational processes that resulted in contamination of plant systems, onsite buildings, surface and subsurface soils

within the RCA. It also addressed support structures, open land areas and subsurface soils outside of the RCA but within the owner-controlled area. The information compiled by the HSA was used to establish initial area survey units and their MARSSIM classifications. This information was used as input into the development of site-specific DCGLs, remediation plans and the design of the FSS. The scope of the HSA included potential contamination from radioactive materials, hazardous materials, and other regulated materials. The HSA did not provide information related to buried piping and therefore, initial survey unit classifications for buried piping were based on process knowledge.

The objectives of the HSA were to:

- Identify potential, likely, or known sources of radioactive and chemical contaminants based on existing or derived information.
- Distinguish portions of the site that may need further action from those that pose little or no threat to human health.
- Provide an assessment of the likelihood of contaminant migration.
- Provide information useful to subsequent continuing characterization surveys.
- Provide an initial classification of areas and structures as non-impacted or impacted.
- Provide a graded initial classification for impacted soils and structures in accordance with MARSSIM guidance.
- Delineate initial survey unit boundaries and areas based upon the initial classification.

The survey units established by the HSA were used as initial survey units for characterization. Prior to characterization, survey unit sizes were adjusted in accordance with the guidance provided in MARSSIM section 4.6 for the suggested physical area sizes for survey units for FSS.

For the above-grade building survey units of interest in this report, the HSA indicated that the presence of residual radioactivity in concentrations in excess of the unrestricted release criteria was not expected; however, two (2) of the above-grade building survey units (LACBWR Crib House and G-3 Crib House) were designated as Class 2 due to their residing in a Class 2 land area, and one (1) above-grade building survey unit (LACBWR Administration Building) was designated Class 2 due the presence of radioactive materials in unsealed forms and had areas where low concentrations of radioactive materials were handled (laboratory areas).

The HSA did not identify any of the above-grade buildings that are included in this final report as Class 1 structures.

3.3.2 Characterization Surveys

Site characterization of the LACBWR facility was performed in accordance with Energy*Solutions* procedure LC-FS-PN-002, *Characterization Survey Plan* (Reference 22), which was developed to provide guidance and direction to the personnel responsible for

implementing and executing characterization survey activities. The Characterization Survey Plan was exercised in conjunction with implementing procedures and survey unit specific survey instructions (sample plans) that were developed to safely and effectively acquire the requisite characterization data.

Characterization data acquired through the execution of the Characterization Survey Plan was used to meet three primary objectives:

- Provide radiological inputs necessary for the design of FSS.
- Develop the required inputs for the LTP.
- Support the evaluation of remediation alternatives and technologies and estimate waste volumes.

The final output of the initial site characterization was Energy*Solutions* GG-EO-313196-RS-RP-001, *LACBWR Radiological Characterization Survey Report for October and November 2014 Field Work – November 2015* (Reference 23) and LaCrosse*Solutions* TSD LC-RS-PN-164017-001, *Characterization Survey Report*. These reports contained minimal data relevant to the eight (8) above-grade buildings within the scope of this final report.

To close the data gaps identified in the initial characterization reports, additional characterization surveys were performed specific to seven of the eight above-grade buildings in November 2016. PG-EO-313196-SV-PL-001, *Characterization Plan No. 001, Outside Buildings* (Reference 24) was prepared and implemented to characterize the interior and exterior surfaces of the G-3 Crib House, LACBWR Crib House, Backup Control Center, Barge Wash Break Room, G-1 Crib House, Security Shack, and the Transmission Sub-Station Switch House. In total, fifty-six (56) static beta measurements were collected in the buildings (eight [8] in each of seven [7] buildings). No measurements exceeded their respective action levels. A summary of the static measurements is presented in Table 3-1. The summary statistics for the characterization data are provided in Table 3-2.

Table 3-1 Static Measurements for Characterization of Above-Grade Buildings

No. of Meas.	Static Beta Measurements (dpm/100 cm^2)						
	LACBWR Crib House	G-3 Crib House	Transmission Sub-Station Switch House	Transmission Sub-Station Switch House	Barge Wash Break Room	G-1 Crib House	Security Station
1	313	1,264	588	213	0	751	0
2	13	13	363	226	38	0	150
3	0	38	0	0	0	0	0
4	1,702	26	88	889	0	1,514	0
5	138	0	0	376	0	0	38
6	0	450	0	238	0	551	100
7	0	100	0	0	163	438	225
8	0	2,203	651	0	0	1,089	13

Table 3-2 Summary Statistics for Characterization of Above-Grade Buildings

Mean (dpm/100 cm^2)	Median (dpm/100 cm^2)	Minimum (dpm/100 cm^2)	Maximum (dpm/100 cm^2)	Standard Deviation (dpm/100 cm^2)
267	32	0	2,203	473

Additional discussion regarding the characterization surveys of the subject above-grade buildings is provided in each of the subject release records (see Appendices A1 through A8; Appendices A9 through A18 [FSS Release Records for buried piping survey units] do not detail characterization data as no characterization was performed due to inaccessibility).

3.3.3 Continuing Characterization

Previously inaccessible areas identified in LTP Section 2.4 were characterized during the continuing characterization process. None of the eighteen (18) survey units within the scope of this report were identified for continuing characterization.

3.3.4 Remedial Action Support Surveys

None of the eighteen (18) survey units within the scope of this report required remediation and therefore, Remedial Action Support Surveys were not required.

3.4 Conditions at the Time of Final Status Survey

The above-grade building and buried piping survey units in this report had little to no changes in condition occurring since the shut-down of LACBWR. In above-grade building survey units, the interior and exterior structure surfaces were dry and reasonably free of debris. No conditions prohibited the proper collection of scan or static measurements. Some of the

structures were still being utilized to support G-3 operations (e.g., LACBWR, G-1 and G-3 Crib Houses) and Dairyland Power personnel stored tools and equipment in these structures. In these instances, the miscellaneous tools, materials and equipment were surveyed during the FSS in accordance with LC-FS-PR-017, *Unconditional Release of M&E and Secondary Structures* (Reference 25). In buried pipe survey units, the interior surfaces of the pipes were reasonably free of debris. The only conditions that prohibited the proper collection of measurements were some of the pipes that interfaced with the Mississippi River had water in them that did not allow access to a portion of the pipe. The data collected indicates any contamination in these areas would be well below the DCGLs and would not change the conclusion reached for the entire survey unit. These instances are discussed in further detail in the relevant release records.

Prior to FSS, areas ready for survey were isolated and controlled under LC-FS-PR-010, *Isolation and Control for Final Status Survey.* This included posting of the area as well as notifications to site personnel. Permission must be obtained from C/LT staff to enter and work in these areas. A routine surveillance program monitored for any inadvertent personnel access or anomalies with procedurally defined recovery and reporting protocols in the event of any impact to these survey unit's as-left radiological conditions.

3.5 Identification of Potential Contaminants

Energy*Solutions* TSD RS-TD-313196-001, *Radionuclides of Concern During LACBWR Decommissioning* established the basis for an initial suite of potential ROC for decommissioning. 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 of less than two years, an initial suite of potential ROC for the decommissioning of LACBWR was prepared (see Table 5-1 in the LTP).

LTP Chapter 2 provides detailed characterization data that describes current contamination levels in the basements and soils from the characterization campaign conducted from September 2014 through August 2015. The initial survey data for basements was based on core samples obtained from the walls and floors of the Reactor Building, WTB and the balance of the basement structures (primarily the Piping Tunnels) at biased locations with elevated contact dose rates, contamination levels, and/or evidence of leaks/spills. During subsequent characterizations, additional cores were obtained from the Reactor Building and the WGTV. Surface and subsurface soil samples were taken in each impacted open land survey unit (including soil beneath and adjacent to basements) and analyzed for the presence of plant-derived radionuclides. TSD RS-TD-313196-001 evaluates the results of the concrete core analysis data from the Reactor Building, WTB, Piping Tunnels and WGTV and refines the initial suite of potential ROC by evaluating the dose significance of each radionuclide.

Insignificant dose contributors were determined consistent with the guidance contained in section 3.3 of NUREG-1757. In all soil and concrete scenarios, Cs-137, Co-60, Sr-90, Eu-152 and Eu-154 contribute nearly 100% of the total dose. The remaining radionuclides were designated as insignificant dose contributors and are eliminated from further detailed evaluation. Therefore, the final ROCs for LACBWR soil, basement concrete and buried piping are Cs-137, Co-60, Sr-90, Eu-152 and Eu-154.

3.6 Radiological Release Criteria

All FSSs for the survey units detailed in this report were conservatively designed to the Operational DCGLs for buried pipe and above-grade buildings, and all results were compared to these values. However, since the release criteria were based on the Base Case DCGL, surpassing the Operational DCGL did not disqualify a survey unit from meeting the release criteria provided that the data passed the Sign Test and the Base Case DCGL was not exceeded. The Buried Piping Base Case DCGLs and Operational DCGLs are provided in Tables 2-1 and 2-2, respectively. The Above-Grade Building Operational DCGLs and Base Case DCGLs are provided in Table 2-3.

4 Final Status Survey Protocol

4.1 Data Quality Objectives

The DQO process as outlined in Section 2 of this report was applied for each FSS sample plan and contains basic elements common to all FSS sample plans at LACBWR. An outline of those elements presented in the sample plans are as follows:

<u>State the Problem</u>

The problem: To demonstrate that the level of residual radioactivity in a survey unit does not exceed the release criteria of 25 mrem/yr TEDE and that the potential dose from residual radioactivity is ALARA.

Stakeholders: The primary stakeholders interested in the answer to this problem are LaCrosse*Solutions* LLC, Dairyland Power Generation LLC, the Wisconsin Department of Health Services and the United States Nuclear Regulatory Commission (USNRC).

The Planning Team: The planning team consisted of the assigned Radiological Engineer or FSS Supervisor with input from other C/LT personnel as well as the Safety Department. The primary decision maker was the FSS Supervisor with input from the C/LT Manager.

Schedule: The approximate time projected to mobilize, implement, and asses an FSS unit was between four (4) and ten (10) days.

Resources: The following resources were necessary to implement an FSS sample plan:

- Radiological Engineer or FSS Supervisor to prepare the plan and evaluate data.
- FSS Supervisor to monitor and coordinate field activities.

- Graphics/GPS Specialist to prepare survey maps, layout diagrams, composite view drawings, and other graphics as necessary to support survey design and reporting.
- FSS Technicians to perform survey activities, collect survey measurement data, and collect media samples.
- Chemistry/Analysis laboratory staff to analyze samples as necessary.

Identify the Decision

Principal Study Question: Are the residual radionuclide concentrations found in buried pipe and above-grade buildings equal to or below site-specific DCGLs?

Alternate Actions: Alternative actions include failure of the survey unit, remediation, reclassification, and resurvey.

The Decision: If the survey unit fails to demonstrate compliance with the release criteria, then the survey unit is not suitable for unrestricted release. The DQA process is reviewed to identify the appropriate additional action or combination of actions.

Identify Inputs to the Decision

Information Needed: The survey unit requires an evaluation of residual activity and its surface area. The HSA and characterization surveys were preliminary sources of information for FSS; however, the results were not sufficient to provide the current as-left radiological conditions. New measurements of sample media are needed to determine the concentration and variability for those radionuclides potentially present at the site at the time of FSS. For the above-grade building survey units, beta scans are needed to identify areas of elevated activity and beta static measurements of total surface contamination are needed as compliance measurements. For buried piping survey units, compliance was demonstrated by measurements of total surface contamination augmented by the collection of sediment samples when available.

Historical Information: The classification as originally identified in the HSA and the verification of that classification during characterization. A summary of site processes or incidents that occurred in the survey unit.

Radiological Survey Data: The current radiological survey data from characterization, RASS, RA, or turnover surveys. This information is used to develop a sample size for FSS.

Radionuclides of Concern: The ROC are presented in Table 2-5 of this final report.

Basis for the Action Level: The investigation and action levels for FSS were selected in accordance with Table 5-16 of the LTP, recreated below as Table 4-1.

Table 4-1 FSS Investigation Levels

Classification	Scan Investigation Levels	Direct Investigation Levels
Class 1	>Operational DCGL or >MDC_{scan} if MDC_{scan} is greater than Operational DCGL	>Operational DCGL
Class 2	>Operational DCGL or >MDC_{scan} if MDC_{scan} is greater than Operational DCGL	>Operational DCGL
Class 3	>Operational DCGL or >MDC_{scan} if MDC_{scan} is greater than Operational DCGL	>0.5 Operational DCGL

During the data analysis of the FSS results, concentrations for the HTD ROC Sr-90 are inferred using a surrogate approach. The 95% Upper Confidence Limit (UCL) of the Cs-137 fractions was chosen to represent the overall nuclide mix for soils/buried pipe, the Reactor Building, and the WGTV. The surrogate ratio for soil/buried pipe is given in Table 4-2.

Table 4-2 Soil/Buried Pipe Surrogate Ratio

Radionuclides	Ratio
Sr-90/Cs-137	0.502

The equation for calculating a surrogate DCGL is as follows:

Equation 1

$$Surrogate_{DCGL} = \frac{1}{\left[\left(\frac{1}{DCGL_{Sur}}\right) + \left(\frac{R_2}{DCGL_2}\right) + \left(\frac{R_3}{DCGL_3}\right) + \cdots \left(\frac{R_n}{DCGL_n}\right)\right]}$$

Where:

$DCGL_{Sur}$ = Surrogate radionuclide DCGL

$DCGL_{2,3\ldots n}$ = DCGL for radionuclides to be represented by the surrogate

R_n = Ratio of concentration (or nuclide mixture fraction) of radionuclide “n” to surrogate radionuclide

Using the Buried Pipe Group Operational DCGLs presented in Table 2-2 and the ratio from Table 4-2, the following surrogate calculation was performed:

Equation 2

$$Surrogate_{DCGL\,(Cs-137)} = \frac{1}{\left[\left(\frac{1}{6.68E+04_{(Cs-137)}}\right) + \left(\frac{0.502}{1.08E+05_{(Sr-90)}}\right)\right]}$$
$$= 5.10E+04\ dpm/100\ cm^2$$

The surrogate Operational DCGL for Cs-137 is then used in the calculation of the gross gamma Operational DCGL, as calculated in Equation 3.

Equation 3

$$Surrogate_{DCGL\ (gamma)} = \frac{1}{\left[\left(\frac{0.071}{1.57E+04_{(Co-60)}}\right)+\left(\frac{0.919}{5.10E+04_{Cs-137}}\right)+\left(\frac{0.006}{3.44E+04_{(Eu-152)}}\right)+\left(\frac{0.003}{3.20E+04_{(Eu-154)}}\right)\right]} = 4.37E+04\ dpm/100\ cm^2$$

The action level for buried pipe survey units (other than the CWD Pipe) was equivalent to the calculated gross gamma Operational DCGL of 4.37E+04 dpm/100 cm^2.

Using the CWD Pipe Operational DCGLs presented in Table 2-2 and the ratio from Table 4-2, the following surrogate calculation was performed:

Equation 4

$$Surrogate_{DCGL\ (Cs-137)} = \frac{1}{\left[\left(\frac{1}{6.94E+04_{(Cs-137)}}\right)+\left(\frac{0.502}{1.58E+05_{(Sr-90)}}\right)\right]} = 5.69E+04\ dpm/100\ cm^2$$

The surrogate Operational DCGL for Cs-137 is then used in the calculation of the gross gamma Operational DCGL, as calculated in Equation 3.

Equation 5

$$Surrogate_{DCGL\ (gamma)} = \frac{1}{\left[\left(\frac{0.071}{1.63E+04_{(Co-60)}}\right)+\left(\frac{0.919}{5.69E+04_{Cs-137}}\right)+\left(\frac{0.006}{3.51E+04_{(Eu-152)}}\right)+\left(\frac{0.003}{3.27E+04_{(Eu-154)}}\right)\right]} = 4.81E+04\ dpm/100\ cm^2$$

The action level for CWD buried pipe survey unit was equivalent to the calculated gross gamma Operational DCGL of 4.81E+04 dpm/100 cm^2.

For the FSS of above-grade buildings, Adjusted Gross DCGLs are calculated. This is done because radionuclide-specific data is not acquired with static measurements. The equation for calculating the Adjusted Gross Operational DCGL is as follows:

Equation 6

$$DCGL_{AG} = \frac{1}{\left[\left(\frac{f_1}{DCGL_1}\right) + \left(\frac{f_2}{DCGL_2}\right) + \cdots \left(\frac{f_i}{DCGL_i}\right)\right]}$$

Where: $DCGL_{AG}$ = Adjusted Gross DCGL in units of dpm/100 cm^2

$DCGL_i$ = Gross DCGL for detectable radionuclide in units of dpm/100 cm^2

f_i = Mixture fraction of detectable radionuclides

Using Equation 6, Table 2-3, and Table 2-5, the Adjusted Gross Operational DCGL was calculated as follows:

Equation 7

$$OpDCGL_{AG} = \frac{1}{\left[\left(\frac{0.0644}{1136_{(Co-60)}}\right) + \left(\frac{0.0981}{1392_{(Sr-90)}}\right) + \left(\frac{0.829}{4480_{(Cs-137)}}\right) + \left(\frac{0.00549}{2032_{(Eu-152)}}\right) + \left(\frac{0.00281}{1840_{(Eu-154)}}\right)\right]} = 3160\ dpm/100\ cm^2$$

The Adjusted Gross Operational DCGL was calculated as 3,160 dpm/100 cm^2.

Using Equation 3, Table 2-3, and Table 2-5, the Adjusted Gross Base Case DCGL was calculated as follows:

Equation 8

$$BcDCGL_{AG} = \frac{1}{\left[\left(\frac{0.0644}{7100_{(Co-60)}}\right) + \left(\frac{0.0981}{8700_{(Sr-90)}}\right) + \left(\frac{0.829}{28000_{(Cs-137)}}\right) + \left(\frac{0.00549}{12700_{(Eu-152)}}\right) + \left(\frac{0.00281}{11500_{(Eu-154)}}\right)\right]} = 19751\ dpm/100\ cm^2$$

The Adjusted Gross Base Case DCGL was calculated as 19,751 dpm/100 cm^2. The mean activity from the FSS measurements is compared to the Adjusted Gross Base Case DCGL, and the dose contribution from the survey unit is calculated.

Investigation Levels: Table 4-1 provides the investigation levels for the Phase 2 survey units.

Define the Boundaries of the Survey

Boundaries of the Survey: The actual physical boundaries as stated for each survey unit.

Temporal Boundaries: Estimated times and dates for the survey. Scanning and sampling in a survey unit was normally performed only during daylight and dry weather.

Constraints: The most common constraints were the weather, temperature, and water intrusion in buried pipe survey units.

Develop a Decision Rule

Decision Rule: If any measurement data exceeded the action levels specified in the survey plans, alternative actions would be taken.

Specify Tolerable Limits on Decision Errors

The Null Hypothesis: Residual radioactivity in the survey unit exceeds the release criteria.

Type I Error: This is also known as the "α" error. This is the error associated with incorrectly concluding the null hypothesis has been rejected. In accordance with LTP section 5.6.4.1.1, the α error was set at 0.05 (5%).

Type II Error: This is also known as the "β" error. This is the error associated with incorrectly concluding the null hypothesis has been accepted. In accordance with LTP section 5.6.4.1.1, the β error was set at 0.05 (5%).

The Lower Bound of the Gray Region (LBGR): Typically, the LBGR was set at 50% of the Operational DCGL. In using the unity rule, the Operational DCGL becomes one (1) and the LBGR is set as 0.5. In survey unit B2-010-103, the LBGR was set at the mean of the characterization data set.

Optimize Design

Type of Statistical Test: The Sign Test was selected as the non-parametric statistical test for FSS. The Sign Test is conservative as it increases the probability of incorrectly accepting the null hypothesis (i.e., the conclusion will be that the survey unit does not meet the release criteria) and does not require the selection or use of a background reference area.

Number of Measurements/Samples Required for the Sign Test: All above-grade building survey units had a relative shift of three (3), which corresponds to fourteen (14) systematic or randomly located measurements for use with the Sign Test. The locations of the samples and measurements were determined using the software Visual Sample Plan (VSP). For buried piping survey units, the number of measurements was determined based on the length of the pipe and the classification. For example, in a Class 2 pipe that is 100 feet in length and has a 50% scan frequency requirement, a static measurement would be collected every two (2) linear feet traversed through the pipe for a total of at least fifty (50) distinct measurements over the entire accessible pathway of the piping system.

Number of Judgmental Measurements/Samples and Locations: Typically, a minimum of one (1) judgmental sample or measurement was required in each Phase 2 survey unit. The selection of additional judgmental samples or measurements was at the discretion of the FSS Supervisor. Locations chosen for judgmental investigation were usually areas of interest (e.g., low points, drain covers, cracks, pipe elbows).

Number of Scan Areas and Locations: For Class 3 survey units, a minimum of 5% of the accessible surface area was scanned. For Class 2 survey units, 25% to 50% of the accessible surface area was scanned. For Class 1 survey units, 100% of the accessible surface area was scanned. Because there were no areas with elevated contamination potential in the Class 3 above-grade building survey units, a scan area was developed around each randomly selected static measurement location that, when totaled, equated to the required scan frequency percentage of the total surface area. Additional scans were performed at the locations of judgmental measurements. For the Class 1 and Class 2 above-grade building survey units detailed in this report, scan areas were established based on the systematic grid.

For the survey of interior pipe surfaces, areal coverage is achieved by the "area of detection" for each static measurement collected. Scanning, in the traditional context, is not applicable to the survey of pipe internal surfaces.

Number of Measurements/Samples for Quality Control: The implementation of quality control measures as referenced by LTP Chapter 5, section 5.9.3 and the QAPP included the collection of replicate measurements, as appropriate, at a frequency of 5% of the measurement/sample set. The locations for replicate measurements/samples were selected randomly using a random number generator.

Power Curve: The Prospective Power Curve, developed using characterization data and MARSSIM Power 2000 or COMPASS software, showed adequate power for the survey design in each of the survey units.

4.2 Survey Unit Designation and Classification

Procedure LC-FS-PR-006, *Survey Unit Classification* (Reference 26), defines the decision process for classifying an area in accordance with the LTP and MARSSIM. During the FSS of areas submitted for this Phase 2 Final Report, no survey units were reclassified.

4.3 Background Determination

During scanning of above-grade survey units, ambient backgrounds were determined, and the technician established the Alarm Set Point (ASP) based on the background for each specific scan area. For buried pipe survey units, background was established at the opening to the pipe or established using a mock-up of a similar diameter pipe. The results of the background study are provided in Attachment 7 to procedure LC-FS-PR-018, *Radiation Surveys of Pipe Interiors Using Sodium/Cesium Iodide Detectors*. Because background measurements generally showed a response that was higher than the measurements taken within the CWD pipe, and because the calibration geometry did not accurately depict the actual measurement conditions in the pipe, LC-FS-TSD-003, *Assessment of the LACBWR Circulating Water Discharge Pipe Final Status Survey Data for Detection Efficiency and Detector Background* was developed to resolve these two conditions without re-surveying the pipe, a substantial effort since the pipe has been filled/grouted.

Each survey unit release record (enclosed as appendices to this report) discusses background determination in further detail.

4.4 Final Status Survey Sample Plans

The level of effort associated with planning a survey is based on the complexity of the survey unit and nature of the hazards. Guidance for preparing FSS plans is provided in procedure LC-FS-PR-002, *Final Status Survey Package Development* and LC-FS-PR-015, *Final Status Survey for Structures*. The FSS sample plans for all Phase 2 survey units use an integrated sample design that combines scanning surveys and static measurements.

4.5 Survey Design

4.5.1 Determination of Number of Data Points

The number of static measurements for the FSS of above-grade buildings was determined in accordance with procedures LC-FS-PR-002, *Final Status Survey Package Development*, LC-FS-PR-015, *Final Status Survey for Structures,* and MARSSIM. The relative shift (Δ/σ) for the survey unit data set is defined as shift (Δ), which is the Upper Boundary of the Gray Region (UBGR), or the DCGL, minus the LBGR, divided by sigma (σ), which is the standard deviation of the data set used for survey design. As the calculated relative shift for all above-grade building survey units was greater than three (3), a value of 3 was used. The sample size from Table 5.5 in MARSSIM that equates to α and β errors of 0.05 and a relative shift of three (3) is fourteen (14). As a conservative measure, and to address Class 2 survey unit size restrictions, a total of twenty-eight (28) measurements were collected in survey unit B2-010-101, fifty-six (56) measurements were collected in survey unit B2-010-102 and one-hundred and twelve (112) measurements were collected in survey unit B2-010-103. For buried piping survey units, the number of measurements was determined based on the length of the pipe and the classification.

A breakdown of the measurements collected for the Phase 2 survey units is provided in Table 4-3.

Table 4-3 Number of Measurements for FSS

Survey Unit	Random/Systematic Static Measurements	Judgmental Static Measurements	Investigational Samples or ISOCS Measurements
B2-010-101	28	2	0
B2-010-102	56	4	0
B2-010-103	112	35	0
B3-012-101	14	1	0
B3-012-102	14	1	0
B3-012-103	14	1	0
B3-012-104	14	1	0
B3-012-109	14	1	0
S1-011-102	510	2	0
S2-011-103 A	50	2	0
S2-011-103 B	23	3	0
S2-011-103	29	1	0
S3-012-109 A	20	2	1(1)
S3-012-109 B	60	1	0
S2-011-101 A	33	1	0
S2-011-101 B	21	1	0
S3-012-102 A	33	1	0
S3-012-102 B	40	1	0

(1) ISOCS measurement taken to verify NORM.

4.5.2 Measurement Locations

Measurement locations in above-grade building survey units were determined using the software VSP. Pacific Northwest National Laboratory (PNNL) created VSP for the United States Department of Energy. Structure drawings, with all relevant survey surfaces represented, was constructed in or imported into VSP. The VSP software designated the measurement locations with coordinates based on a local origin established on the drawing (an x, y system in meters). For those locations where access was impractical or unsafe, alternate measurement locations were generated and documented.

Systematic measurement locations for buried pipe survey units were designated at the appropriate linear increments necessary to satisfy the minimum scan frequency.

4.6 Instrumentation

Radiation detection and measurement instrumentation for performing FSS is selected to provide both reliable operation and adequate sensitivity to detect the ROC identified at the site at levels sufficiently below the Operational DCGL. Detector selection is based on detection sensitivity, operating characteristics, and expected performance in the field.

The DQO process includes the selection of instrumentation appropriate for the type of measurement to be performed and that are calibrated to respond to a radiation field under controlled circumstances. Instruments are also evaluated periodically for adequate performance to established quality standards and ensure that they are sensitive enough to detect the ROC with a sufficient degree of confidence. For example, when determining instrument MDCR, an index of sensitivity (*d'*) of 1.38 was used to provide a correct detection rate of 95% and a false positive rate of 60%.

The field instrumentation will, to the extent practicable, use data logging to automatically record measurements to minimize transcription errors.

Specific implementing procedures control the issuance, use, and calibration of instrumentation used for FSS. The specific DQOs for instruments are established early in the planning phase for FSS activities, implemented by standard operating procedures and executed in the FSS sample plan.

4.6.1 Detector Efficiencies

The Ludlum Model 2350-1 Data Logger coupled with the Ludlum Model 44-116 beta scintillation detector was selected as the primary radiation detection instrumentation for performing scanning and static measurements in above-grade building survey units. Instrument efficiencies (ε_i) are derived from the surface emission rate of the radioactive source(s) used during the instrument calibration. Total efficiency (ε_t) is calculated by multiplying the instrument efficiency (ε_i) by the surface efficiency (ε_s) commensurate with the radionuclide's beta energy using the guidance provided in ISO 7503-1, Part 1, *Evaluation of Surface Contamination, Beta-emitters (maximum beta energy greater than 0.15 MeV) and alpha-emitters* (Reference 27).

The Ludlum Model 2350-1 Data Logger coupled with the Ludlum Model 44-10 NaI detector was selected as the instrument of choice for collecting static measurements in buried pipe survey units. For the survey of pipe internals, the detector was erroneously calibrated for a specific geometry of a 3,050 cm^2 (1 ft x 1 m) area of contamination on the bottom of the pipe, resulting in inaccurate detector efficiencies and inaccurate calculations for activity per area. TSD LC-FS-TSD-005, *MCNP Modeling of Water Discharge Pipes for the La Crosse Boiling Water Reactor* was written to address the discrepancy in efficiency and area of detection. The TSD details the Monte-Carlo Neutral Particle (MCNP) radiation transport code that modeled the response of a NaI detector to a calibration source for several different

pipe sizes. The MCNP models resulted in efficiency correction factors. The calculated efficiency from original source calibration was multiplied by the correction factors to obtain an efficiency that more realistically portrays the specific contamination geometry of the pipe.

4.6.2 Detector Sensitivities

The evaluation of above-grade buildings and buried piping requires a detection methodology of sufficient sensitivity for the identification of small areas of potentially elevated activity. Scanning measurements are performed by passing a hand-held detector, primarily the Ludlum Model 44-116 for above-grade buildings and the Ludlum Model 44-10 NaI detector for buried piping, in gross count rate mode across the surface under investigation.

For scanning in above-grade buildings, the Ludlum Model 44-116 detector moved at a speed not to exceed 3” per second while maintaining the detector at a distance of 0.5” or less from the surface being surveyed. The audible and visual signals were monitored for detectable increases in count rate. An observed count rate increase resulted in further investigation to verify findings and to define the level and extent of residual radioactivity. An *a priori* determination of scanning sensitivity was performed to ensure that the measurement system (including the surveyor) was able to detect concentrations of radioactivity at levels below the regulatory release limit. The specified performance level and surveyor efficiency was expressed in terms of scan MDCR. This sensitivity is the lowest count rate that can be reliably detected at any given background by the measurement system. The specified MDCR correlates to the targeted MDC. This approach represents the surface scanning process for land areas defined in NUREG-1507, *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions* (Reference 28).

Scan surveys were not performed in buried piping. The detector sensitivity while obtaining gamma static measurements is discussed in detail in Energy*Solutions* TSD RS-TD-313196-006, *Ludlum Model 44-10 Detector Sensitivity* (Reference 29) and which examines the gamma sensitivity for a 5.08 by 5.08 cm (2” x 2”) NaI detector to several radionuclide mixtures of Co-60 and Cs-137, as well as LC-FS-PR-018.

4.6.3 Instrument Maintenance and Control

Control and accountability of survey instruments were maintained to assure the quality and prevent the loss of data. All personnel operating radiological instruments, analysis equipment, measurement location equipment, etc., were qualified to operate any assigned equipment and recognize irregular results and indications.

4.6.4 Instrument Calibration

Instruments and detectors were calibrated for the radiation types and energies of interest or to a conservative energy source. Instrument calibrations were documented with calibration

certificates and/or forms and maintained with the instrumentation and project records. Calibration labels were also attached to all portable survey instruments. Prior to using any survey instrument, the current calibration was verified and all operational checks were performed.

Instrumentation used for FSS was calibrated and maintained in accordance with approved LaCrosse*Solutions* site calibration procedures. Radioactive sources used for calibration were traceable to the NIST and were obtained in standard geometries to match the type of samples being counted. When a characterized high-purity germanium (HPGe) detector was used, suitable NIST-traceable sources were used for calibration, and the software set up appropriately for the desired geometry. If vendor services were used, these were obtained in accordance with purchasing requirements for quality related services, to ensure the same level of quality.

4.7 Survey Methodology

4.7.1 Surveys in Above-Grade Building Survey Units

The LTP specifies the minimum amount of scanning required for each survey unit classification as summarized in Table 2-6. The total fraction of scanning coverage is determined during the DQO process with the amount, and location(s) based on the likelihood of finding elevated activity during FSS.

LTP Chapter 5, Section 5.6.4.4 states that for Class 3 survey units, judgmental surface scans will typically be performed on areas with the greatest potential of contamination. For above-grade buildings, this will include surface drainage areas, ventilation exhaust locations, cracks and low collection points. Section 5.6.4.4 further notes that in the absence of these features, the locations of these judgmental scans will be at the discretion of the survey designer. For most above-grade buildings, reviews of historical information provided in the HSA, combined with the results of the walk-down of the survey unit in preparation for the FSS, did not indicate any areas for increased contamination potential. In these instances, the survey designers used discretion to choose the scan locations. Because there were no areas with elevated contamination potential, the scan areas were selected at the random measurement locations with sufficient scan area at each location to meet the required scan percentage as defined in the FSS survey design. This allowed for the scanned areas to be evenly distributed throughout the survey unit.

For the Class 1 and Class 2 above-grade survey units, scan areas were established based on the systematic grid. For all above-grade buildings a minimum of one (1) judgmental scan location was prescribed.

Static measurements for total surface contamination were obtained at each scan location at the location of the highest scan reading and at any areas that required an investigation. The detector was placed directly on the surface being surveyed and a one-minute count was

logged. As previously discussed, the number of static measurements taken in above-grade building survey units is provided in Table 4-3.

Areas with elevated readings were marked and investigational measurements were collected. During the collection scan and static measurements, the technician recorded data and observations in a Field Log. This log documented field activities and other information pertaining to the survey. Additionally, all scan and static measurement data was downloaded and stored electronically.

Table 4-4 provides a summary of the scan percentages performed in each above-grade building survey unit.

Table 4-4 Summary of Total Area Scanned for Above-Grade Buildings

Survey Unit	Survey Unit Classification	Area (m^2)	Area Scanned (m^2)	% Scan
B2-010-101	2	1,060	322	30
B2-010-102	2	2,873	780	27
B2-010-103	2	5,433	1,345	25
B3-012-101	3	1,710	185	11
B3-012-102	3	861	95	11
B3-012-103	3	296	33	11
B3-012-104	3	116	15	13
B3-012-109	3	122	15	12

4.7.2 Surveys in Buried Pipe Survey Units

The acquisition of direct measurements within buried pipes involves the insertion of appropriately sized detectors into the pipe interior by a simple "push-pull" methodology, whereby the position of the detector in the piping system can be easily determined in a reproducible manner. The detectors are configured in a fixed geometry relative to the surveyed surface, thus creating a situation where an appropriate efficiency can be calculated. The detectors are then deployed into the actual pipe and timed measurements are acquired at intervals commensurate with the contamination potential of the pipe. A conservative "area of detection" is assumed for each pipe size. It is also conservatively assumed that any activity is uniformly distributed in the area of detection.

The measurement output represents the gamma activity in gross cpm for each foot of piping traversed. This measurement value in cpm is then converted to dpm using the efficiency of the detector. The total activity in dpm is then converted to activity per unit area commensurate with the pipe diameter, resulting in measurement results in units of dpm/100 cm^2. A surrogate correction based upon the radionuclide distribution present in the pipe is

then applied to the gamma emission to account for the presence of other non-gamma emitting radionuclides in the mixture.

Standard scan surveys were not performed in buried pipe survey units; however, a field-of-view can be determined at each static measurement location and an estimate of scan (measured) area can be made. Table 4-5 provides a summary of the scan percentages performed in each buried pipe survey unit.

Table 4-5 Summary of Total Area Scanned for Buried Pipe

Survey Unit	Survey Unit Classification	Area (m^2)	Area Scanned (m^2)	% Scan
S1-011-102	1	614	614	100
S2-011-103 A	2	46	22	48
S2-011-103 B	2	17	9	53
S2-011-103	2	57	42	74
S3-012-109 A	3	47	5	11
S3-012-109 B	3	729	70	10
S2-011-101 A	2	25	8	32
S2-011-101 B	2	20	5	25
S3-012-102 A	3	96	10	10
S3-012-102 B	3	292	29	10

4.8 Quality Control Surveys

The method used for evaluating Quality Control (QC) replicate measurements collected in support of the FSS program is specified in the FSS QAPP. The acceptance criteria for replicate static measurements is that the same conclusion is reached for each measurement. This is defined as the replicate measurement being within 20% of the standard measurement. In cases where the replicate measurement is not within 20% of the standard measurement, but both measurements are below the Operational DCGL, there is an acceptable agreement. A minimum of 5% of the measurement locations used in the FSS design were selected randomly for QC evaluation using a random number generator.

QC replicate measurements were used to assess errors associated with measurement heterogeneity and measurement methodology. It is desirable that when analyzed, there is agreement between the replicate measurements to their respective measurement, resulting in data acceptance. If there was no agreement, the FSS Supervisor or FSS Manager evaluated the magnitude and impact on survey design, the implementation and evaluation of results, as well as the need to obtain confirmatory measurements. If the FSS Supervisor or FSS Manager had determined that the discrepancy affected quality or was detrimental to the implementation of FSS, then a Condition Report (CR) would have been issued.

No CRs were issued, and there was either an acceptable agreement between standard and replicate measurements in every Phase 2 survey unit or, if not, no further action was deemed necessary (replicate measurements were far below Operational DCGL). Results of QC replicate measurements are provided as attachments in each of the survey unit release records which are attached as appendices to this final report.

To maintain the quality of the FSS, isolation and control measures were implemented prior to, during, and upon completion of FSS until there was no risk of recontamination or when the survey area will be released from the license. Following FSS, and until the area is released, a semi-annual surveillance will be performed on FSS completed survey units. This includes an inspection of area postings, inspection of the area for signs of excavation, dumping or disturbance. In the event that isolation and control measures were compromised, a follow-up survey may be performed after evaluation.

5 Survey Findings

Procedure LC-FS-PR-008, *Final Status Survey Data Assessment,* provides guidance to C/LT personnel to interpret survey results using the DQA process during the assessment phase of FSS activities.

The DQA process is the primary evaluation tool to determine that data is of the right type, quality and quantity to support the objectives of the FSS sample plan. The five steps of the DQA process are:

- Review the sample plan DQOs and the survey design.
- Conduct a preliminary data assessment.
- Select the statistical test.
- Verify the assumptions of the statistical test.
- Draw conclusions from the data.

Data validation descriptors described in MARSSIM Table 9.3 were used during the DQA process to verify and validate collected data as required by the FSS QAPP.

5.1 Survey Data Conversion

During the data conversion, the FSS Supervisor or FSS Manager evaluated raw data for problems or anomalies encountered during sample plan activities (sample collection and analysis, handling and control, etc.) including the following:

- Recorded data,
- Missing values,
- Deviation from established procedure, and
- Analysis flags.

Once resolved, initial data conversion, which is part of preliminary data assessment was performed and consisted of converting the data into units relative to the release criteria (e.g., dpm/100 cm^2) and calculating basic statistical quantities (e.g., mean, median, standard deviation). Tables 5-1 provides a summary of the basic statistical properties in the Phase 2 systematic or random measurement populations.

Table 5-1 Basic Statistical Data for Phase 2 Systematic/Random Measurement Populations

Survey Unit	Class	Measurements	Statistical Summary Gross Activity (dpm/100 cm^2)		
			Max	Mean	Std. Dev.
B2-010-101	2	28	1,732	401	603
B2-010-102	2	56	1,488	274	340
B2-010-103	2	112	1,199	113	249
B3-012-101	3	14	596	240	191
B3-012-102	3	14	313	56	89
B3-012-103	3	14	762	269	290
B3-012-104	3	14	102	19	33
B3-012-109	3	14	215	43	66
S1-011-102	1	510	5,434	273	737
S2-011-103 A	2	50	6,184	2,623	760
S2-011-103 B	2	23	3,191	2,508	595
S2-011-103	2	29	5,726	4,996	390
S3-012-109 A	3	20	50,608	23,953	12,975
S3-012-109 B	3	60	5,485	4,435	708
S2-011-101 A	2	33	17,646	14,549	1,197
S2-011-101 B	2	21	18,150	12,744	2,476
S3-012-102 A	3	33	2,949	558	827
S3-012-102 B	3	40	15,561	13,380	1,119

Tables 5-2 provides a summary of the basic statistical properties for the Phase 2 judgmental and investigational measurement populations.

Table 5-2 Basic Statistical Properties of Phase 2 Judgmental Measurement Populations

Survey Unit	Class	Measurements	Statistical Summary Gross Activity (dpm/100 cm^2)		
			Max	Mean	Std. Dev.
B2-010-101	2	2	371	185	262
B2-010-102	2	4	632	161	314
B2-010-103	2	35	242	28	61
B3-012-101	3	1	286	286	N/A
B3-012-102	3	1	0	0	N/A
B3-012-103	3	1	847	847	N/A
B3-012-104	3	1	0	0	N/A
B3-012-109	3	1	0	0	N/A
S1-011-102	1	2	6,056	5,962	133
S2-011-103 A	2	2	2,842	2,392	636
S2-011-103 B	2	3	2,941	2,701	339
S2-011-103	2	1	5,141	5,141	N/A
S3-012-109 A	3	2	32,666	23,145	13,464
S3-012-109 B	3	1	5,656	5,656	N/A
S2-011-101 A	2	1	14,724	14,724	N/A
S2-011-101 B	2	1	0	0	N/A
S3-012-102 A	3	1	10,573	10,573	N/A
S3-012-102 B	3	1	13,337	13,337	N/A

5.2 Survey Data Verification and Validation

Items supporting DQO sample design and data are reviewed for completeness and consistency. This includes:

- Classification history and related documents,
- Site description,
- Survey design and measurement locations,
- Analytic method and detection limits and that the required analytical method(s) are adequate for the radionuclides of concern,
- Sampling variability provided for the radionuclides of interest,
- QC measurements have been specified,
- Survey and sampling result accuracy have been specified,
- MDC limits,
- Field conditions for media and environment, and

- Field records.

Documentation, as listed, is reviewed to verify completeness and that it is legible:

- Field and analytical results,
- Chain-of-custody,
- Field Logs,
- Instrument issue, return and source check records,
- Instrument downloads, and
- Measurement results relative to measurement location.

After completion of these previously mentioned tasks, a Preliminary Data Assessment record was initiated. This record served to verify that all data are in standard units in relation to the DCGLs and requires the calculation of the statistical parameters needed to complete data evaluation which at a minimum, included the following:

- The number of observations (i.e., samples or measurements),
- The range of observations (i.e., minimum and maximum values),
- Mean,
- Median, and
- Standard deviation.

In order to adequately evaluate the data set, consideration as additional options included the coefficient of variation, measurements of relative standing (such as percentile), and other statistical applications as necessary (frequency distribution, histograms, skew, etc.). Finalization of the data review consisted of graphically displaying the data in distributions and percentiles plots.

5.3 Anomalous Data/Elevated Scan Results and Investigation

In survey unit S3-012-109 A, elevated scan readings at a bend in the pipe resulted in investigations, which included the collection of ISOCS measurements. This process was documented in accordance with LC-FS-PR-008, *Final Status Survey Data Assessment*. ISOCS data was collected above the ground at measured locations where the pipe elevated readings occurred. Collection of soil samples at the same points were performed for additional information and to be conservative. After review of data it was verified to be a geometry anomaly causing the slightly higher than normal readings but less than the $DCGL_{BP}$. Additional information is provided in the release record for survey unit S3-012-109 A.

No other anomalies were identified in Phase 2 survey units.

5.4 Evaluation of Number of Measurement Locations in Survey Units

An effective tool utilized to evaluate the number of samples collected in the sampling scheme is the Retrospective Power Curve generated by MARSSIM Power 2000 or COMPASS. The Retrospective Power Curve shows how well the survey design achieved the DQOs. For reporting purposes, all release records include a Retrospective Power Curve analysis indicating that the sampling design had adequate power to pass the FSS release criteria (i.e., an adequate number of samples was collected).

5.5 Comparison of Findings with Derived Concentration Guideline Levels

As previously described in Section 2.4, the SOF or "unity rule" was applied to FSS data obtained in buried piping in accordance with the guidance provided in Section 2.7 of NUREG-1757, Vol. 2, and the LTP. This was accomplished by calculating a fraction of the Operational DCGL for each measurement by dividing the reported concentration by the Operational DCGL. Surrogate Operational DCGLs for Cs-137, which take into account the HTD radionuclide Sr-90, were calculated as part of the survey design for the FSS, but were only used to develop action levels. During data assessment, activities for Sr-90 were inferred based on the HTD ratio in Table 4-2 and compared to their respective DCGLs.

A Base Case SOF was calculated for each ROC by dividing the reported concentration by the Base Case DCGL. A Base Case SOF of one (1) is equivalent to the decision rule, meaning any measurement with a SOF of one (1) or greater, would not meet the 25 mrem/yr release criteria. The mean Base Case SOF was multiplied by 25 to establish the dose attributed to a survey unit.

For above-grade buildings, the dose contribution was calculated by multiplying the mean gross activity fraction of the adjusted gross Base Case DCGL by 25 mrem/yr. Although multiple ROC are present in the survey unit, the unity rule was not applied because of the nature of the survey technique (beta static measurement versus gamma static measurements or the collection of volumetric media samples).

In accordance with Section 5.5.4 of the LTP, the dose from elevated judgmental measurements (measurements exceeding SOF of 1 when compared to the Operational DCGL) is accounted for using an area-weighted approach. An area-weighted SOF is calculated and added to the average systematic measurement SOF. The product of this summation is then used to calculate the overall dose assigned to the survey unit. During the FSS of all Phase 2 survey units, no judgmental measurements exceeded the SOF of 1 when compared to the Operational DCGL

The Elevated Measurement Comparison (EMC) was not required for the survey units addressed by this report.

A summary of the SOF and dose contribution for each Phase 2 survey unit is provided in Table 5-5.

Table 5-3 Mean Base Case SOF or Mean Fraction of the Adjusted Gross Base Case DCGL and Dose Contribution

Survey Unit	Mean Base Case SOF	Mean Fraction of Adjusted Gross Base Case DCGL	Dose (mrem/yr)
B2-010-101	-	0.0203	0.5081
B2-010-102	-	0.0139	0.3469
B2-010-103	-	0.0057	0.1426
B3-012-101	-	0.0122	0.3038
B3-012-102	-	0.0028	0.0711
B3-012-103	-	0.0136	0.3409
B3-012-104	-	0.0010	0.0239
B3-012-109	-	0.0022	0.0541
S1-011-102	0.0012	-	0.0299
S2-011-103A	0.0126	-	0.3155
S2-011-103B	0.0120	-	0.3006
S2-011-103	0.0240	-	0.6005
S3-012-109A	0.1204	-	3.0112
S3-012-109B	0.0213	-	0.5317
S2-011-101A	0.0696	-	1.7407
S2-011-101B	0.0611	-	1.5278
S3-012-102A	0.0028	-	0.0712
S3-012-102B	0.0645	-	1.6121

5.6 Description of ALARA to Achieve Final Activity Levels

Section N.1.5 of NUREG-1757, Vol. 2, states that "For residual radioactivity in soil at sites that may have unrestricted release, generic analyses show that shipping soil to a low-level waste disposal facility is unlikely to be cost effective for unrestricted release, largely because of the high costs of waste disposal. Therefore, shipping soil to a low-level waste disposal facility generally does not have to be evaluated for unrestricted release." Section 4.4.1 of LTP Chapter 4 presents a simple ALARA analysis for the excavation and disposal of soils as low-level radioactive waste that confirms the statement in section N.1.5 of NUREG-1757, Vol. 2 that the cost of disposing excavated soil as low-level radioactive waste is clearly greater than the benefit of removing and disposing of soil with residual radioactivity concentrations less than the dose criterion. Since the cost is greater than the benefit, it is not

ALARA to excavate and dispose of soils with residual radioactivity concentrations below the DCGL.

Section 4.4.2 of LTP Chapter 4 presents the ALARA analysis for basement structures. The ALARA analysis based on cost benefit analysis shows that further remediation of concrete beyond that required to demonstrate compliance with the 25 mrem/yr dose criterion is not justified.

"Housekeeping" and cleanup of survey units was completed prior to turnovers for FSS, and good housekeeping practices were employed during FSS. Good housekeeping practices and properly executed isolation and control in survey units mitigated any potential cross-contamination and ensured that the reported residual activity levels were accurate and final.

5.7 NRC/Independent Verification Team Findings

According to NRC IR Nos. 05000409/2018001 (DNMS) (Reference 30) and 07200046/2018001 (DNMS) (Reference 31), on February 13, 2019, the NRC completed inspection activities at LACBWR, which included the observation of FSS and confirmatory surveys of sub-surface land survey units L1-SUB-DRS, L1-SUB-TDS, and L1-SUB-LES, as well as S1-011-102. The inspectors determined that the LaCrosse*Solutions* had properly remediated and performed FSS of the aforementioned survey units.

According to NRC IR Nos. 05000409/2019001 (DNMS) (Reference 32), on October 21, 2019, the NRC completed inspection activities at LACBWR, which included the observation of FSS and confirmatory surveys of various sub-surface and open land soil units, piping units, and B2-010-001. The inspectors had no finding in regards to the performance of FSS of the survey units.

6 Summary

FSS is the process used to demonstrate that the LACBWR buried piping and above-grade buildings comply with the radiological criteria for unrestricted use specified in 10 CFR 20.1402. The purpose of the FSS sample plan is to describe the methods to be used in planning, designing, conducting, and evaluating the FSS.

The two radiological criteria for unrestricted use specified in 10 CFR 20.1402 are: 1) the residual radioactivity that is distinguishable from background radiation results in a TEDE to an AMCG that does not exceed 25 mrem/yr, including that from groundwater sources of drinking water, and 2) the residual radioactivity has been reduced to levels that are ALARA.

The survey units addressed in this Final Report have met the DQOs of the FSS sample plans developed and implemented for each. In each survey unit, all identified ROC were used for statistical testing to determine the adequacy of the survey unit for FSS, the sample data passed the Sign Test, and a Retrospective Power Curve showed that adequate power was

achieved. Each of the survey units were properly classified. In accordance with the LTP Section 5.10, the survey units meet the release criterion.

7 References

1. *La Crosse Boiling Water Reactor License Termination Plan*
2. NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM)
3. LC-QA-PN-001, *Final Status Survey Quality Assurance Project Plan*
4. LC-FS-PR-002, *Final Status Survey Package Development*
5. LC-FS-PR-015, *Final Status Survey for Structures*
6. LC-FS-PR-010, *Isolation and Control for Final Status Survey*
7. LC-FS-PR-008, *Final Status Survey Data Assessment*
8. LC-FS-PR-018, *Radiation Surveys of Pipe Interiors Using Sodium/Cesium Iodide Detectors*
9. LC-FS-TSD-003, *Assessment of the LACBWR Circulating Water Discharge Pipe Final Status Survey Data for Detection Efficiency and Detector Background*
10. LC-FS-TSD-005, *MCNP Modeling of Water Discharge Pipes for the Lacrosse Boiling Water Reactor*
11. NUREG-1757, Vol. 2, *Consolidated Decommissioning Guidance - Characterization, Survey, and Determination of Radiological Criteria*
12. LC-FS-PR-009, *Final Status Survey Data Reporting*
13. RS-TD-313196-003, *La Crosse Boiling Water Reactor Historical Site Assessment*
14. RS-TD-313196-004, *LACBWR Soil DCGL, Basement Concrete DCGL, and Buried Pipe DCGL*
15. LC-FS-TSD-002, *Operational Derived Concentration Guideline Levels for Final Status Survey*
16. RS-TD-313196-001, *Radionuclides of Concern During LACBWR Decommissioning*
17. LC-RP-PG-003, *Radiological Instrumentation Program*
18. LC-RP-PR-060, *Calibration and Initial Set Up of the 2350-1*
19. LC-FS-PR-004, *Sample Media Collection for Site Characterization and Final Status Survey*
20. LC-FS-PR-005, *Sample Media Preparation for Site Characterization and Final Status Survey*

21. LC-FS-PR-012, *Chain of Custody Protocol*
22. LC-FS-PN-002, *Characterization Survey Plan*
23. GG-EO-313196-RS-RP-001, *LACBWR Radiological Characterization Survey Report for October and November 2014 Field Work – November 2015*
24. PG-EO-313196-SV-PL-001, Characterization Plan No. 001, Outside Buildings
25. LC-FS-PR-017, *Unconditional Release of M&E and Secondary Structures*
26. LC-FS-PR-006, *Survey Unit Classification*
27. ISO 7503-1, Part 1, *Evaluation of Surface Contamination, Beta-emitters (maximum beta energy greater than 0.15 MeV) and alpha-emitters*
28. NUREG-1507, *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions*
29. RS-TD-313196-006, *Ludlum Model 44-10 Detector Sensitivity*
30. NRC Inspection Report 05000409/2018001(DNMS)
31. NRC Inspection Report 07200046/2018001 (DNMS)
32. NRC Inspection Report 05000409/2019001 (DNMS)

8 Appendices

A1 FSS Release Record, Survey Unit B2-010-101

A2 FSS Release Record, Survey Unit B2-010-102

A3 FSS Release Record, Survey Unit B2-010-103

A4 FSS Release Record, Survey Unit B3-012-101

A5 FSS Release Record, Survey Unit B3-012-102

A6 FSS Release Record, Survey Unit B3-012-103

A7 FSS Release Record, Survey Unit B3-012-104

A8 FSS Release Record, Survey Unit B3-012-109

A9 FSS Release Record, Survey Unit S1-011-102

A10 FSS Release Record, Survey Unit S2-011-103 A

A11 FSS Release Record, Survey Unit S2-011-103 B

A12 FSS Release Record, Survey Unit S2-011-103

A13 FSS Release Record, Survey Unit S3-012-109 A

A14 FSS Release Record, Survey Unit S3-012-109 B

A15 FSS Release Record, Survey Unit S3-012-101 A

A16 FSS Release Record, Survey Unit S3-012-101 B

A17 FSS Release Record, Survey Unit S3-012-102 A

A18 FSS Release Record, Survey Unit S3-012-102 B