LA CROSSE BOILING WATER REACTOR
FINAL STATUS SURVEY RELEASE RECORD

STORM DRAIN 6
SURVEY UNIT S2-011-101 B

REVISION 1

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LIST OF ACRONYMS AND ABBREVIATIONS

ALARA	As Low As Reasonably Achievable
CWD	Circulating Water Discharge
DQO	Data Quality Objective
DCGL	Derived Concentration Guideline Level
$DCGL_{BP}$	Buried Pipe Base Case Derived Concentration Guideline Level
FSS	Final Status Survey
HSA	Historical Site Assessment
IC	Insignificant Contributors
ID	Internal Diameter
LACBWR	La Crosse Boiling Water Reactor
LTP	License Termination Plan
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MCNP	Monte Carlo Neutral Particle
MDC	Minimum Detectable Concentration
NaI	Sodium Iodide
$OpDCGL_{BP}$	Buried Pipe Operational Derived Concentration Guideline Level
PVC	Polyvinyl Chloride
QAPP	Quality Assurance Project Plan
QC	Quality Control
ROC	Radionuclides of Concern
SOF	Sum of Fractions
TEDE	Total Effective Dose Equivalent
TSD	Technical Support Document
UCL	Upper Confidence Limit

1. EXECUTIVE SUMMARY

This Final Status Survey (FSS) Release Record for survey unit S2-011-101 B, Storm Drain 6, has been generated in accordance with LaCrosse*Solutions* procedure LC-FS-PR-009, *Final Status Survey Data Reporting* (Reference 1) and satisfies the requirements of Section 5.11 of the *La Crosse Boiling Water Reactor License Termination Plan* (LACBWR LTP) (Reference 2).

An FSS sample plan for this survey unit was developed in accordance with LaCrosse*Solutions* procedures LC-FS-PR-002, *Final Status Survey Package Development* (Reference 3) and LC-FS-PR-018, *Radiation Surveys of Pipe Interiors Using Sodium/Cesium Iodide Detectors* (Reference 4), the LACBWR LTP, and with guidance from NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) (Reference 5).

Survey Unit S2-011-101 B has a MARSSIM classification of 2. A survey plan was designed based upon use of the Sign Test as the nonparametric statistical test for compliance. Both the Type I (α) and Type II (β) decision error rates were set at 0.05. As a systematic measurement population, twenty-one (21) static gamma measurements were acquired from the survey unit. The data assessment results for survey unit S2-011-101 B indicate that the maximum Sum of Fractions (SOF), considering the concentration of all applicable Radionuclides of Concern (ROC) either by direct measurement or by inference, is equal to 0.4149 when applying the respective Operational Derived Concentration Guideline Levels ($OpDCGL_{BP}$) for buried pipe. The mean SOF when applying the respective Base Case DCGLs ($DCGL_{BP}$) is 0.0611. This SOF equates to a dose for the survey unit of 1.5278 mrem/yr.

2. SURVEY UNIT DESCRIPTION

S2-011-101 B is an impacted Class 2 buried pipe survey unit. The survey unit consists of the interior surface of Storm Drain 6, which is a 10” Internal Diameter (ID) Polyvinyl chloride (PVC) pipe that is approximately 84 feet (26 m) in length. The system collected water from the roadway east of the Administration Building to run off into the Storm Drain through the catch basin that leads to the 10” ID PVC pipe. The pipe then runs into a 48” Concrete Storm Drain that leads to the Mississippi River. The total interior surface area of Storm Drain 6 is 20.42 m^2 (204,293 cm^2). See Attachment 1 of this report for figures and maps depicting survey unit S2-011-101 B.

3. CLASSIFICATION BASIS

Based on the *La Crosse Boiling Water Reactor Historical Site Assessment* (HSA) (Reference 6), open land survey unit L1-010-101 was identified as a Class 1 survey unit.

The Storm Drain 6 resides in survey unit L1-010-101 and, as such, is considered a Class 2 system.

Based upon review of the historical information and completion of a final Survey Unit Classification Worksheet from LC-FS-PR-006, *Survey Unit Classification* (Reference 7), the correct final classification of survey unit S2-011-101 B was determined to be Class 2.

4. DATA QUALITY OBJECTIVES

FSS planning and design relies on a properly executed Data Quality Objective (DQO) process to ensure, through compliance with explicitly defined inputs and boundaries, that the primary objective of the survey is satisfied. The DQO process is described in the LACBWR LTP in accordance with MARSSIM. The appropriate design for a given survey was developed using the DQO process as outlined in Appendix D of MARSSIM.

The DQO process incorporated hypothesis testing and probabilistic sampling distributions to control decision errors during data analysis. Hypothesis testing is a process based on the scientific method that compares a baseline condition to an alternate condition. The baseline condition is technically known as the null hypothesis. Hypothesis testing rests on the premise that the null hypothesis is true and that sufficient evidence must be provided for rejection. In designing the survey plan, the underlying assumption, or null hypothesis was that residual activity in the survey unit exceeded the release criteria. Rejection of the null hypothesis would indicate that residual activity within the survey unit does not exceed the release criteria. Therefore, the survey unit would satisfy the primary objective of the FSS sample plan.

The primary objective of the FSS sample plan is to demonstrate that the level of residual radioactivity in survey unit S2-011-101 B did not exceed the release criteria specified in the LTP and that the potential dose from residual radioactivity is As Low As Reasonably Achievable (ALARA).

Energy*Solutions* Technical Support Document (TSD) RS-TD-313196-001, *Radionuclides of Concern during LACBWR Decommissioning* (Reference 8) established the basis for an initial suite of potential ROC for decommissioning. Insignificant contributors (IC) were determined consistent with the guidance contained in Section 3.3 of NUREG-1757, Volume 2, Revision 1, *Consolidated Decommissioning Guidance – Characterization, Survey, and Determination of Radiological Criteria, Final Report* (Reference 9). 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 IC 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.

LTP, Section 6.14.1 discusses the process used to derive the ROC for the decommissioning of LACBWR, including the elimination of IC from the initial suite. Table 4-1 presents the ROC for the decommissioning of buried pipe at LACBWR and the normalized mixture fractions based on the radionuclide mixture.

Table 4-1 - Dose Significant Radionuclides and Mixture for Buried Pipe

Radionuclide	Fraction of Total Activity (normalized)(1)
Co-60	0.064
Sr-90	0.098
Cs-137	0.829
Eu-152	0.005
Eu-154	0.003

(1) Based on maximum percent of total activity from Table 22 of RS-TD-313196-001, normalized to one for the dose significant radionuclides.

The LTP, Section 5.2, states that 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 Total Effective Dose Equivalent (TEDE) of 25 mrem/yr to an Average Member of the Critical Group. 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. The reduced DCGLs (i.e., “Operational” DCGLs) can be related to the Base Case DCGLs as an expected fraction of dose based on an *a priori* assessment of what the expected dose should be based on the results of site characterization, process knowledge, and the extent of planned remediation. The Operational DCGL is then used as the DCGL for the FSS design of the survey unit (i.e., calculation of surrogate DCGLs and investigations levels). Details of the Operational DCGLs derived for each dose component and the basis for the applied *a priori* dose fractions are provided in LC-FS-TSD-002, *Operational Derived Concentration Guideline Levels for Final Status Survey* DCGL (Reference 10).

The dose contribution from each ROC is accounted for using the SOF to ensure that the total dose from all ROC does not exceed the dose criterion. A Base Case DCGL that is established for the average residual radioactivity in a survey unit is equivalent to a $DCGL_W$. The $DCGL_W$ can be multiplied by Area Factors to obtain a Base Case DCGL that represents the same dose to an individual for residual radioactivity over a smaller area within a survey unit.

At LACBWR, compliance is demonstrated through the summation of dose from five (5) distinct source terms for the end state (basements, soils, buried pipe, above-ground structures, and groundwater). When applied to buried pipe, the DCGLs are expressed in units of activity per surface area (dpm/100 cm^2).

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, 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 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 11) and LTP, 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). The summed Buried Pipe Base Case DCGLs are reproduced in Table 4-2 below. The IC dose percentages for each of the buried pipe scenarios were used to adjust each buried pipe Base Case DCGL to account for the dose from the eliminated IC radionuclides. The Operational DCGLs for Storm Drain 6 are provided in Table 4-3.

Table 4-2 - Base Case DCGLs for Buried Pipe Group

Radionuclide	$DCGL_{BP}$ (dpm/100 cm^2)
Co-60	7.50E+04
Sr-90	5.16E+05
Cs-137	3.18E+05
Eu-152	1.64E+05
Eu-154	1.52E+05

Table 4-3 - Operational DCGLs for Buried Pipe Group

Radionuclide	$OpDCGL_{BP}$ (dpm/100 cm^2)
Co-60	1.57E+04
Sr-90	1.08E+05
Cs-137	6.68E+04
Eu-152	3.44E+04
Eu-154	3.20E+04

Instrument DQOs included a verification of the ability of the survey instrument to detect the radiation(s) of interest relative to the Operational DCGL. Survey instrument response checks were required prior to issuance and after the instrument had been used. Control and accountability of survey instruments was required to assure the quality and prevent the loss of data.

In accordance with the LTP, the minimum acceptable minimum detectable concentration (MDC) for measurements obtained using field instruments was 50% of the applicable Operational DCGL.

5. SURVEY DESIGN

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*.

The DQO process validated that Co-60, Sr-90, Cs-137, Eu-152, and Eu-154 would be the ROC in survey unit S2-011-101B as presented in LTP Section 5.1. 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 Waste Gas Tank Vault. The surrogate ratio for soil/buried pipe is given in Table 5-1.

Table 5-1 – Soil 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 Operational DCGLs presented in Table 4-3 and the ratio from Table 5-1, 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 survey unit S2-011-101 B was equivalent to the calculated gross gamma Operational DCGL of 4.37E+04 dpm/100 cm^2.

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. For the survey of the Storm Drain 6 pipe, 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 LaCrosse Boiling Water Reactor* (Reference 12) 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 can be multiplied by the correction factors to obtain an efficiency that more realistically portrays the specific contamination geometry of the pipe. For a 10" ID PVC pipe, each measurement has a true Field-of-View (FOV) of 2,434 cm^2.

The Storm Drain 6 is approximately 84 feet of 10" ID PVC pipe, which equates to a surface area of 20.42 m^2 (204,293cm^2). The LTP states that a Class 2 FSS unit shall have an areal coverage of 10% to 100%. For survey unit S2-011-101 B, 25% survey coverage was selected. Therefore, one (1) measurement was to be collected every four (4) linear feet traversed through the pipe, for a total of at least twenty-one (21) distinct measurements over the entire accessible pathway of the piping system.

Each static measurement represents the gamma activity in gross counts per minute (cpm) for each specific measurement location. 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 LaCrosse Boiling Water Reactor*. The total activity in dpm is then adjusted for the assumed effective surface area commensurate with the pipe diameter, resulting in units of dpm/100 cm^2. The total gamma surface activity for each measurement was converted to an activity concentration for each gamma-emitting ROC, based on the normalized gamma mixture from Table 4-1. Concentrations for the HTD ROC Sr-90 were inferred using the surrogate approach in accordance with LTP Chapter 5.

The implementation of quality control measures as referenced in the LTP, Section 5.9, and LaCrosse*Solutions* LC-QA-PN-001, *Final Status Survey Quality Assurance Project Plan* (QAPP) (Reference 13), includes the collection of replicate static measurements on 5% of the systematic measurements collected in the survey unit, with the locations selected at random. Two (2) replicate static measurements were selected for Quality Control (QC) analysis for the FSS of this survey unit.

For this Class 2 buried pipe survey unit, the "Investigation Levels" for measurement results are those levels specified in LTP Chapter 5, Table 5-16, and are reproduced below in Table 5-2.

Table 5-2 – Investigation Levels

Classification	Scan Investigation Levels	Direct Investigation Levels
Class 2	>Operational DCGL or >MDC $_{scan}$ if MDC$_{scan}$ is greater than Operational DCGL	>Operational DCGL

Table 5-3 provides a synopsis of the survey design for survey unit S2-011-101 B.

Table 5-3 – Synopsis of Survey Design

Feature	Design Criteria	Basis
Survey Unit Surface Area	20.42m^2 (204,293 cm^2)	84' of 10" ID PVC pipe
Number of Systematic Measurements (N)	21	25% coverage
Operational DCGLs (dpm/100 cm^2)	• Co-60: 1.57E+04 • Sr-90: 1.08E+05 • Cs-137: 6.68E+04 • Eu-152: 3.44E+04 • Eu-154: 3.20E+04	Operational DCGLs for buried pipe, LTP Table 5-8, Release Record Table 4-3
Action Level	4.37E+04 dpm/100 cm^2	Gross Gamma Operational DCGL, Equation 3
Investigation Level	>Operational DCGL	LTP, Table 5-16
Scan Areal Coverage	N/A	LTP, Section 5.7.1.8
Number of Judgmental Measurements	1	Per Sample Plan Actual Number Obtained
QC	2 replicate measurements	LTP, Section 5.9
Non-parametric Statistical Test	Sign Test	LTP, Section 5.6.4.2

6. SURVEY IMPLEMENTATION

FSS field activities were conducted under the FSS sample plan, which included DQOs, survey design, detailed FSS instructions, job safety analysis, and related procedures for reference. The survey unit was inspected and controlled in accordance with LC-FS-PR-010, *Isolation and Control for Final Status Survey* (Reference 14). A "Field Log" was used to document field activities and other information pertaining to the performance of the FSS. FSS field activities commenced on September 5, 2019.

FSS field activities were projected to take four (4) working days to complete. Daily briefings were conducted to discuss the expectations for job performance and to review safety aspects of the job. The survey-required field activities were performed during normal working hours and concluded on September 6, 2019.

Background measurements were acquired in the North Yard area of the site. These readings were found to be inconsistent with the activity measured in the pipe; a significant portion of the measurements were negative after subtracting background. It was determined that the backgrounds originally collected for Storm Drain 6 were not representative of true background levels. A background study was performed by collecting measurements on a buried piece of 10" ID PVC pipe. The result of the background study for the 10" ID PVC pipe was an average background value of 3,581 cpm. This is the value subtracted from each measurement for compliance.

Daily, prior to and following use, each detector was subjected to an Operational Response Check in accordance with procedure LC-FS-PR-018, *Radiation Surveys of Pipe Interiors Using Sodium/Cesium Iodide Detectors*. The Daily Operational Response Check compared the background response and the response to check source ranges established for normal background and detector source response to ensure that the detector was working properly.

The twenty-one (21) systematic 1-minute static measurements were collected using a Ludlum Model 2350-1 paired with a Model 44-10 NaI detector operated in the rate-meter mode and using audio response. The detector was fitted into a wheeled rig, which maintained fixed detector geometry, an area of detection of 2,434 cm^2. The static MDC was sufficient to detect residual radioactivity at the action level (adjusted gross gamma Operational DCGL of 4.37E+04 dpm/100 cm^2). Complete measurement results are provided in Attachment 2.

One (1) judgmental static measurement was collected during implementation of FSS, in accordance with the sample plan.

The implementation of survey specific QC measures included the collection of two (2) replicate static measurements for QC analysis.

7. SURVEY RESULTS

The SOF or "unity rule" is the mathematical test used to evaluate compliance with radiological criteria for license termination when more than one radionuclide has been determined to be potentially present. The equation for the unity rule is:

Equation 4

$$\frac{C_1}{DCGL_1} + \frac{C_2}{DCGL_2} + \ldots\ldots \frac{C_n}{DCGL_n} \leq 1$$

Where: C_n = concentration of radionuclide n

$DCGL_n$ = DCGL of radionuclide n.

The application of the unity rule serves to normalize the data to allow for an accurate comparison of the various data measurements to the release criteria. When the unity rule is applied, the $DCGL_W$ (used for the nonparametric statistical test) becomes one (1). The $DCGL_{BP}$ are directly analogous to the $DCGL_W$ as defined in MARSSIM. The use and application of the unity rule was performed in accordance with Section 4.3.3 of MARSSIM.

As described in LTP, Section 5.10.3.2, the Sign Test was used to evaluate the measured residual radioactivity against the dose criterion. The SOF for each measurement was used as the sum value for the Sign Test. The Sign Test then demonstrated that the mean activity for each ROC was less than the $OpDCGL_{BP}$ at a Type I decision error of 0.05. The results of the Sign Test are presented in Attachment 3.

For buried pipe, areas of elevated activity were defined as any area identified by measurement (systematic or judgmental) that exceeded the $OpDCGL_{BP}$ but was less than the $DCGL_{BP}$. The SOF (based on the $OpDCGL_B$) for a systematic or judgmental measurement can exceed one (1) without remediation as long as the survey unit passes the Sign Test, and the mean SOF (based on the $OpDCGL_{BP}$) for the survey unit does not exceed one (1). Once the survey data set passes the Sign Test (using Operational DCGLs), then the mean radionuclide activity for each ROC from systematic measurements along with any identified elevated areas from systematic and judgmental samples can be used with the Base Case DCGLs to perform a mean SOF_{BP} calculation. The dose from residual radioactivity assigned to the FSS unit is the mean SOF_{BP} multiplied by 25 mrem/yr.

The systematic measurement population consisted of twenty-one (21) static measurements that were acquired using the Ludlum Model 2350-1 paired to a Model 44-10 detector. In total, twenty-four (24) static measurements were collected, including the judgmental and QC measurements. A breakdown of the total static measurements and SOF for systematic measurements compared to the $OpDCGL_{BP}$ is provided in Table 7-1. A summary of the results of the systematic measurements taken for non-parametric statistical testing when compared to the $DCGL_{BP}$ is provided in Table 7-2. The complete results of the data assessment for survey unit S2-011-101 B are provided in Attachment 2.

Table 7-1 - Summary of Systematic and QC Measurements

Total Number of Systematic Measurements	21
Number of Quality Control Measurements	2
Number of Judgmental Measurements	1
Total Number of Measurements	24
Mean Systematic Measurement SOF (1)	0.2913
Max Individual Systematic Measurement SOF (1)	0.4149
Number of Systematic Measurements with SOF ≥ 1 (1)	0

(1) Based on the $OpDCGL_{BP}$

Table 7-2 - Basic Statistical Properties of the Systematic Measurement Population

ROC	Mean (dpm/100 cm^2)	Median (dpm/100 cm^2)	Max. (dpm/100 cm^2)	Min. (dpm/100 cm^2)	St. Dev. (dpm/100 cm^2)	BcDCGL (dpm/100 cm^2)	Avg. SOF per ROC	Avg. Dose per ROC (mrem/yr)
Co-60	9.10E+02	8.34E+02	1.30E+03	7.01E+02	1.77E+02	7.50E+04	0.0121	0.3034
Cs-137	1.17E+04	1.07E+04	1.67E+04	9.02E+03	2.28E+03	3.18E+05	0.0368	0.9211
Eu-152	7.76E+01	7.11E+01	1.11E+02	5.97E+01	1.51E+01	1.64E+05	0.0005	0.0118
Eu-154	3.97E+01	3.64E+01	5.66E+01	3.06E+01	7.72E+00	1.52E+05	0.0003	0.0065
Sr-90	5.88E+03	5.39E+03	8.38E+03	4.53E+03	1.14E+03	5.16E+05	0.0114	0.2850
						SUM	**0.0611**	**1.5278**

The mean SOF for the Storm Drain 6 pipe, based on the mean concentration for each ROC as measured by the systematic measurement population when compared against the $DCGL_{BP}$, is 0.0611. This SOF equates to a dose of 1.5278 mrem/yr.

8. QUALITY CONTROL

The implementation of survey specific QC measures included the collection of two (2) replicate static measurements for QC analysis. 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. The two (2) QC replicate measurements fell within the 20% criteria, and there is an acceptable agreement between standard and replicate results. Refer to Attachment 4 for QC analysis results.

9. INVESTIGATIONS AND RESULTS

No investigations were performed during the performance or analyses of the survey.

10. REMEDIATION AND RESULTS

No radiological remedial action as described by MARSSIM Section 5.4 was performed in this survey unit. Chapter 4 of the LTP determined that remediation beyond that required to meet the release criteria is unnecessary and that the remaining residual radioactivity in buried pipe was ALARA.

11. CHANGES FROM THE FINAL STATUS SURVEY PLAN

TSD LC-FS-TSD-005, *MCNP Modeling of Water Discharge Pipes for the LaCrosse Boiling Water Reactor*, was developed in response to the inaccurate efficiency calibration geometry originally assumed in the sample plan and during survey implementation. Additionally, as described in section 6 of this release record, background measurements collected for the background study were used instead of the original backgrounds collected for the survey.

12. DATA QUALITY ASSESSMENT

The DQO survey design and data were reviewed in accordance with LC-FS-PR-008, *Final Status Survey Data Assessment* (Reference 15) for completeness and consistency. Documentation was complete and legible. Surveys were consistent with the DQOs and were sufficient to ensure that the survey unit was properly designated as Class 2. The survey design had adequate power as indicated by the Retrospective Power Curve (see Attachment 5).

All measurements were less than a SOF of one (1) when compared to the $OpDCGL_{BP}$.

The Sign Test was performed on the data and compared to the original assumptions of the DQOs. The evaluation of the Sign Test results clearly demonstrates that the survey unit passes the unrestricted release criteria, thus, the null hypothesis is rejected.

The preliminary data review consisted of calculating basic statistical quantities (e.g., mean, median, standard deviation). All data was considered valid including negative values, zeros, values reported below the MDC, and values with uncertainties that exceeded two standard deviations. The mean and median values for each ROC were well below the respective

Operational DCGLs. Also, the retrospective power curve shows that a sufficient number of measurements were collected to achieve the desired power. Therefore, the survey unit meets the unrestricted release criteria with adequate power as required by the DQOs.

13. ANOMALIES

No anomalies were observed during the performance or analyses of the survey.

14. CONCLUSION

Survey unit S2-011-101B has met the DQOs of the FSS plan. The ALARA criteria as specified in Chapter 4 of the LTP were achieved.

The sample data passed the Sign Test. The null hypothesis was rejected. The Retrospective Power Curve showed that adequate power was achieved. The survey unit is properly classified as Class 1. Therefore, in accordance with the LTP, Section 5.11, the survey unit meets the release criteria.

The dose contribution from survey unit S2-011-101 B is 1.5278 mrem/yr TEDE, based on the average concentration of the ROC in measurements used for non-parametric statistical testing (mean SOF).

Survey unit S2-011-101 B is acceptable for unrestricted release.

15. REFERENCES

1. LC-FS-PR-009, *Final Status Survey Data Reporting*
2. *La Crosse Boiling Water Reactor License Termination Plan*
3. LC-FS-PR-002, *Final Status Survey Package Development*
4. LC-FS-PR-018, *Radiation Surveys of Pipe Interiors Using Sodium/Cesium Iodide Detectors*
5. NUREG-1575, Revision 1, *Multi-Agency Radiation Survey and Site Investigation Manual*
6. *La Crosse Boiling Water Reactor Historical Site Assessment*
7. LC-FS-PR-006, *Survey Unit Classification*
8. RS-TD-313196-001, *Radionuclides of Concern during LACBWR Decommissioning*
9. NUREG-1757, Volume 2, Revision 1, *Consolidated Decommissioning Guidance – Characterization, Survey, and Determination of Radiological Criteria, Final Report*
10. LC-FS-TSD-002, *Operational Derived Concentration Guideline Levels for Final Status Survey DCGL*
11. RS-TD-313196-004, *LACBWR Soil DCGL, Basement Concrete DCGL, and Buried Pipe*

12. LC-FS-TSD-005, *MCNP Modeling of Water Discharge Pipes for the LaCrosse Boiling Water Reactor*
13. LC-QA-PN-001, *Final Status Survey Quality Assurance Project Plan*
14. LC-FS-PR-010, *Isolation and Control for Final Status Survey*
15. LC-FS-PR-008, *Final Status Survey Data Assessment*

16. ATTACHMENTS

Attachment 1 – Figures and Maps

Attachment 2 – Measurement Data

Attachment 3 – Sign Test

Attachment 4 – Quality Control Assessment

Attachment 5 – Graphical Presentations

ATTACHMENT 1
FIGURES AND MAPS

Figure 16-1 – Survey Unit S2-011-101 B Drawing

ATTACHMENT 2
MEASUREMENT DATA

LACROSSE SOLUTIONS

Table 16-1 – Survey Unit S2-011-101 B Static Measurements Data Assessment

Measurement Population	Measurement ID	Gamma Result	Activity[1] (dpm/100 cm^2)					Fraction of OpDCGL					Measurement OpSOF
		dpm/100 cm^2	Co-60	Cs-137	Eu-152	Eu-154	Sr-90	Co-60	Cs-137	Eu-152	Eu-154	Sr-90	
S	1	14103	1.01E+03	1.30E+04	8.59E+01	4.39E+01	6.51E+03	0.0642	0.1941	0.0025	0.0014	0.0603	0.3224
S	2	14668	1.05E+03	1.35E+04	8.93E+01	4.57E+01	6.77E+03	0.0667	0.2019	0.0026	0.0014	0.0627	0.3353
S	3	18112	1.29E+03	1.67E+04	1.10E+02	5.64E+01	8.36E+03	0.0824	0.2493	0.0032	0.0018	0.0774	0.4140
S	4	15292	1.09E+03	1.41E+04	9.31E+01	4.77E+01	7.06E+03	0.0696	0.2105	0.0027	0.0015	0.0653	0.3496
S	5	16241	1.16E+03	1.49E+04	9.89E+01	5.06E+01	7.50E+03	0.0739	0.2235	0.0029	0.0016	0.0694	0.3713
S	6	18150	1.30E+03	1.67E+04	1.11E+02	5.66E+01	8.38E+03	0.0826	0.2498	0.0032	0.0018	0.0776	0.4149
S	7	13308	9.50E+02	1.22E+04	8.10E+01	4.15E+01	6.14E+03	0.0605	0.1832	0.0024	0.0013	0.0569	0.3042
S	8	10920	7.80E+02	1.00E+04	6.65E+01	3.40E+01	5.04E+03	0.0497	0.1503	0.0019	0.0011	0.0467	0.2496
S	9	11351	8.11E+02	1.04E+04	6.91E+01	3.54E+01	5.24E+03	0.0516	0.1562	0.0020	0.0011	0.0485	0.2595
S	10	12711	9.08E+02	1.17E+04	7.74E+01	3.96E+01	5.87E+03	0.0578	0.1749	0.0022	0.0012	0.0543	0.2906
S	11	12770	9.12E+02	1.17E+04	7.77E+01	3.98E+01	5.89E+03	0.0581	0.1758	0.0023	0.0012	0.0546	0.2919
S	12	11330	8.09E+02	1.04E+04	6.90E+01	3.53E+01	5.23E+03	0.0515	0.1559	0.0020	0.0011	0.0484	0.2590
S	13	11053	7.89E+02	1.02E+04	6.73E+01	3.44E+01	5.10E+03	0.0503	0.1521	0.0020	0.0011	0.0472	0.2527
S	14	9811	7.01E+02	9.02E+03	5.97E+01	3.06E+01	4.53E+03	0.0446	0.1350	0.0017	0.0010	0.0419	0.2243
S	15	10925	7.80E+02	1.00E+04	6.65E+01	3.40E+01	5.04E+03	0.0497	0.1504	0.0019	0.0011	0.0467	0.2497
S	16	12327	8.80E+02	1.13E+04	7.51E+01	3.84E+01	5.69E+03	0.0561	0.1697	0.0022	0.0012	0.0527	0.2818
S	17	11682	8.34E+02	1.07E+04	7.11E+01	3.64E+01	5.39E+03	0.0531	0.1608	0.0021	0.0011	0.0499	0.2671
S	18	10754	7.68E+02	9.89E+03	6.55E+01	3.35E+01	4.96E+03	0.0489	0.1480	0.0019	0.0010	0.0460	0.2458
S	19	11021	7.87E+02	1.01E+04	6.71E+01	3.43E+01	5.09E+03	0.0501	0.1517	0.0020	0.0011	0.0471	0.2519
S	20	10765	7.69E+02	9.90E+03	6.55E+01	3.35E+01	4.97E+03	0.0490	0.1482	0.0019	0.0010	0.0460	0.2461
S	21	10328	7.38E+02	9.50E+03	6.29E+01	3.22E+01	4.77E+03	0.0470	0.1421	0.0018	0.0010	0.0441	0.2361
J	22	10573	7.55E+02	9.72E+03	6.44E+01	3.29E+01	4.88E+03	0.0481	0.1455	0.0019	0.0010	0.0452	0.2417
Q	QC 10	12093	8.64E+02	1.11E+04	7.36E+01	3.77E+01	5.58E+03	0.0550	0.1664	0.0021	0.0012	0.0517	0.2764
Q	QC 20	10690	7.64E+02	9.83E+03	6.51E+01	3.33E+01	4.93E+03	0.0486	0.1471	0.0019	0.0010	0.0457	0.2444

(1) Sr-90 activity inferred from Cs-137.

ATTACHMENT 3
SIGN TEST

Table 16-2 – Survey Unit S2-011-101 B Sign Test

#	SOF (Ws)	1-Ws	Sign
1	0.3224	0.68	+1
2	0.3353	0.66	+1
3	0.4140	0.59	+1
4	0.3496	0.65	+1
5	0.3713	0.63	+1
6	0.4149	0.59	+1
7	0.3042	0.70	+1
8	0.2496	0.75	+1
9	0.2595	0.74	+1
10	0.2906	0.71	+1
11	0.2919	0.71	+1
12	0.2590	0.74	+1
13	0.2527	0.75	+1
14	0.2243	0.78	+1
15	0.2497	0.75	+1
16	0.2818	0.72	+1
17	0.2671	0.73	+1
18	0.2458	0.75	+1
19	0.2519	0.75	+1
20	0.2461	0.75	+1
21	0.2361	0.76	+1

Number of positive differences (S+) 21

Critical Value 14

Survey Unit Meets the Acceptance Criteria

ATTACHMENT 4
QUALITY CONTROL ASSESSMENT

Table 16-3 – Survey Unit S2-011-101 B QC Assessment

Standard Measurement				Replicate		
ID	Activity Value	+20%	-20%	ID	Activity Value	Acceptable (Y/N)
10	12711	15253	10169	QC 10	12093	Y
20	10765	12918	8612	QC 20	10690	Y
Comments/Corrective Actions: The replicate measurement results are in acceptable agreement				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.		

ATTACHMENT 5
GRAPHICAL PRESENTATIONS

Figure 16-2 – Quantile Plot for Gross Gamma Activity

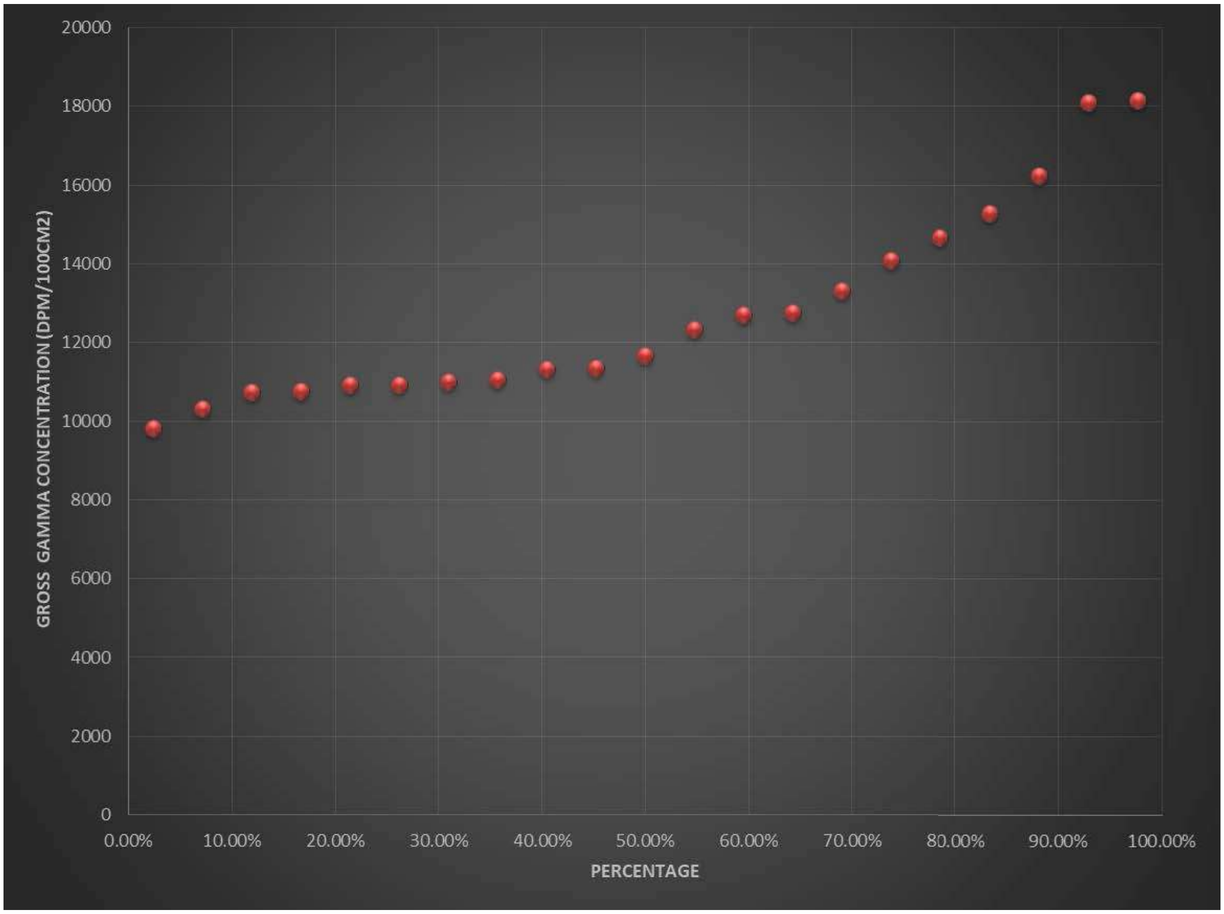

Figure 16-3 - Histogram for Gross Gamma Activity

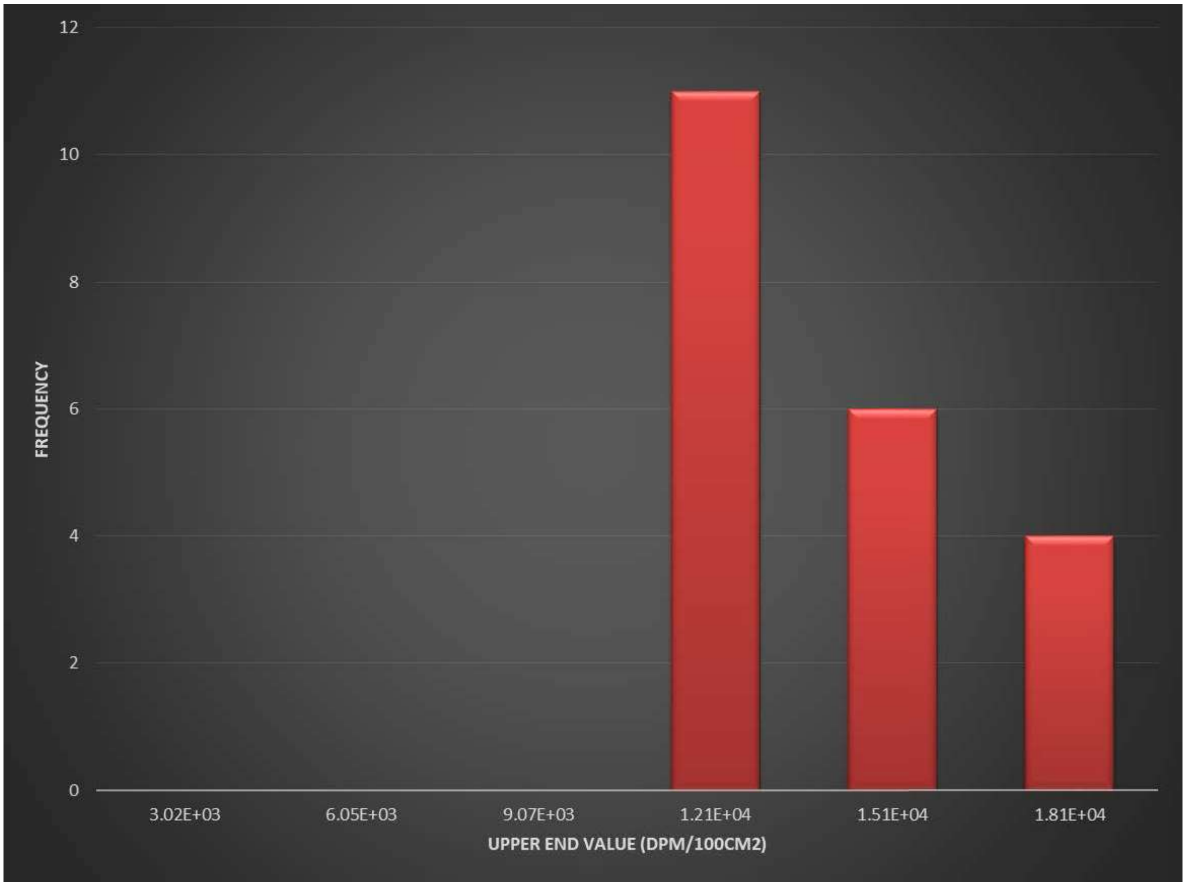

Figure 16-4 - Retrospective Power Curve for Survey Unit S2-011-101 B