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2024 Annual BONUS Reactor Radiological Survey Report

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This document is designed for online viewing.

Contents

Figures

Tables

Attachments

Abbreviations

BONUS	Boiling Nuclear Superheater
CFR	*Code of Federal Regulations*
cm^2	square centimeters
DOE	U.S. Department of Energy
dpm	disintegrations per minute
dpm/100 cm^2	disintegrations per minute per 100 square centimeters
LM	Office of Legacy Management
LMFSC	LM Field Support Center
LMS	Legacy Management Support
µrem	microrem per hour
mrem	millirem
PPE	personal protection equipment
PREPA	Puerto Rico Electric Power Authority
RCT	Radiological Control Technician

Executive Summary

In July 2024, Legacy Management Support (LMS) contractor radiological control technicians (RCTs) mobilized to the U.S. Department of Energy Office of Legacy Management Boiling Nuclear Superheater (BONUS), Puerto Rico, Decommissioned Reactor Site (site) and performed the annual radiological survey of the interior of the reactor containment building. The radiological survey was performed in accordance with the *Annual LMS Radiological Characterization Survey Plan for the BONUS, Puerto Rico, Decommissioned Reactor Site, LMS RadCon Survey Plan Number: 24-001* and LMS Radiological Control organization procedures, manuals, and plans.

A comparison of the 2023 and 2024 radiological survey results proved them to be very similar. Two previously identified contamination areas in the reactor containment building remain contamination areas and are radiologically posted as such. No new radiological areas were identified during the survey. No previously posted radiological areas were deposted.

The 2024 radiological survey results, along with the two radiologically posted and controlled contamination areas at the site, provide continued confidence that human health and the environment remain protected from radiological hazards at the site. Additionally, radiological survey results obtained in the nonposted areas are below regulatory surface contamination and radiation dose limits.

1.0 Introduction

The Boiling Nuclear Superheater (BONUS) Puerto Rico, Decommissioned Reactor Site (site), located northwest of Rincón, Puerto Rico, was developed as a prototype nuclear power plant to investigate the technical and economic feasibility of the integral boiling-superheating concept. Operation of the BONUS reactor was initiated in 1964 and terminated in 1968. Puerto Rico Electric Power Authority (PREPA) decommissioned the reactor between 1969 and 1970. During decommissioning, special nuclear materials (fuel) and certain highly activated components (e.g., control rods and shims) were removed and transported to the mainland and the piping systems were flushed. The reactor vessel and associated internal components within the biological shield were entombed in concrete. Many contaminated and activated materials were placed in the main circulation pump room beneath the pressure vessel and entombed in concrete.

The site falls under applicable portions of U.S. Department of Energy (DOE) regulations, specifically Title 10 *Code of Federal Regulations* Part 835 (10 CFR 835), "Occupational Radiation Protection." Radiological surveys conducted within the reactor containment building are performed annually to ensure continued worker and public health and environmental hazards remain below established regulatory limits.

1.1 Purpose and Scope

The purpose of this report is to present the radiological survey results obtained during the 2024 annual radiological survey (survey) of the site. Results from the survey are compared to the previous year's survey results to identify if radiological conditions at the site have changed by more than two sigma since the last survey performed (in 2023). Survey results are also compared against established regulatory radiological limits for the site.

The scope of this report is specific to the performance of various radiological surveys performed by Legacy Management Support (LMS) qualified radiological control technicians (RCTs) in the reactor's containment building (dome) and their outcomes. Surveys were performed in accordance with the *Annual LMS Radiological Characterization Survey Plan for the BONUS, Puerto Rico, Decommissioned Reactor Site, LMS RadCon Survey Plan Number: 24-001* (DOE 2024a), also called the survey plan, and LMS Radiological Control organization procedures, manuals, and plans. Radiological surveys were not performed outside of the dome.

1.2 Survey Limitations

The following survey limitations were identified in the survey plan and held true during the surveys:

- Beta-gamma contamination and gamma radiation surveys performed during the survey were used as described in the introduction section of the survey plan. Survey results obtained at the site were not used to make official radiological release decisions for the site. Two sets of used radiological personal protection equipment (PPE) (e.g., rubber shoe covers, disposable coveralls, and nitrile gloves) were radiologically surveyed and found to be free of surface contamination (below regulatory limits) and disposed of as office trash or put back into the radiological PPE inventory.

- Radiological surveys were performed by DOE-qualified LMS RCTs using functional and calibrated LMS radiological survey instruments and equipment.
- Radiological surveys, instrument preoperational checks, and recording of the survey results were performed in accordance with the LMS *Radiation Protection Program Plan* (DOE 2024f), *Radiological Control Manual* (DOE 2023a), Radiological Control implementing procedures, and the survey plan.

2.0 Radiological Surveys

2.1 Survey Instruments

In order to perform a removable and total surface contamination and general area gamma radiation dose rate survey of the dome, a Ludlum Model 3030 smear counter (serial no. 330877), Ludlum Model 26 Geiger–Müller pancake probe (serial no. PF009836), and ThermoScientific MicroRem meter instrument (serial no. 19288) were selected and used. The MicroRem meter and Ludlum Model 26 instruments were used in the dome to perform the total surface contamination and general area gamma radiation dose rate surveys. The Ludlum Model 3030 instrument (serial no. 330877) was used back at the Office of Legacy Management (LM) Field Support Center at Grand Junction, Colorado (LMFSC), to count loose surface contamination smears collected at the site.

LMS survey instruments shipped to the site arrived intact and operated as expected. Instruments were in calibration and passed their daily response checks prior to daily use, as required by the *Portable Radiation Survey Instrument Response Checks* (DOE 2024e) procedure and the *Counting Systems Daily Operation* (DOE 2024c) procedure. Surveys were performed in accordance with the *Contamination Surveys and Equipment and Material Release* (DOE 2024b) procedure and the survey plan.

Instrument annual calibration certificates, daily response check sheets, and other required instrumentation operational check and quality control documents are included in Attachment 4.

2.2 Contamination Survey

Direct beta-gamma removable and total surface contamination surveys were performed at the 73 identified survey locations (per the survey plan) and at 5 nonbiased survey locations (selected in real time by the RCT performing the survey) using the above-identified contamination survey instruments. Instruments were operated in accordance with LMS Radiological Control operating procedures, plans, and manuals, specifically the *Contamination Surveys and Equipment and Material Release* procedure. Surface contamination survey results were documented in accordance with the survey plan and the *Documenting Radiological Surveys* (DOE 2024d) procedure. Surface contamination smears were checked for radioactivity at the time of the survey using the Ludlum Model 26 Geiger–Müller pancake probe and then brought back to the LMFSC for nuclear counting on the Ludlum Model 3030 smear counter.

Direct beta-gamma surface contamination and transferable surface contamination surveys results were evaluated in real time using the below criteria, and additional confirmatory, biased beta-gamma surface contamination and transferable surface contamination smear surveys were performed when any of the following survey results or physical site conditions existed:

- The RCT observed excessive deterioration of the structure(s) during the survey when compared to the previous year's structural condition
- Survey results from the identified survey locations indicated contamination levels in excess of 1000 disintegrations per minute (dpm) (beta and gamma) per 100 square centimeters (cm^2) transferable contamination or 5000 dpm (beta and gamma) per 100 cm^2 total surface contamination
- The RCT observed any conditions that justify additional surface contamination surveys be performed, at their discretion

Only a single contamination survey result stood out to the RCTs performing the contamination surveys, which was at survey location L40. The remaining 77 contamination survey results were well within regulatory limits and appeared to be consistent with the 2023 contamination survey results.

Survey location L40 is identified as the Fuel Pool Purifier—Floor #1 location and is physically located inside one of two surface contamination areas in the dome (the contamination area located on the main level floor of the dome, inside the visitor-restricted area). Additional Ludlum Model 26 Geiger–Müller pancake probe surface scans were performed in and around survey location L40 to identify the extent of the contamination area. Scan values ranged from near background to tens of thousands of disintegrations per minute per 100 square centimeters (dpm/100 cm^2) for total surface contamination inside the contamination area. No surface contamination was identified outside of the contamination area boundary.

The original contamination area radiological posting (sign) and boundary string (Figure 1) were removed and replaced with a yellow and magenta radiological rope and with three contamination area postings hung from the new radiological rope (Figure 2 and Figure 3). This new rope boundary extended back to the walls of the fuel storage pool structure and "enclosed" the actual contamination area. The area (square feet) of contamination area did not change in size with the installation of the new radiological rope.

Figure 1. Original Main Level Contamination Area Posting and Boundary String

Figure 2. Updated Main Level Contamination Area Posting and Boundary Rope (looking west)

Figure 3. Updated Main Level Contamination Area Posting and Boundary Rope (looking southeast)

In the basement of the dome, a preexisting contamination area boundary and radiological posting was moved from its original location to inside the room where the contamination area existed. The movement of this boundary and radiological posting was performed at the request of the BONUS site lead. The RCT moved the boundary rope and radiological posting into the room roughly 15 feet and away from the main walkway in the basement (Figure 4 and Figure 5). The movement of this boundary and posting sign slightly reduced the square footage of the contamination area and better represents the contamination area boundary.

Within the basement contamination area, a single pump appeared to be the reason for the contamination area (the rust-colored material around the base of the pump in Figure 6).

Total surface contamination measurement readings ranged from near background to over 30,000 dpm/100 cm^2 on the areas where rust material existed (prior to applying fixative). As part of the 2024 radiological survey, a contamination fixative was sprayed onto the loose material around the base of the pump to reduce material from becoming loose surface contamination and prevent the spread of contamination in the area. The fixative applied was InstaCote Inc.'s CC Wet and CC Fix. CC Wet was applied first and then followed by CC Fix, per the manufacturer's instructions. The color of the CC Wet was fluorescent green while CC Fix was bright blue (Figure 7 and Figure 8).

Figure 4. Original Radiological Posting and Boundary Location, in the Basement Contamination Area

Figure 5. Moved Radiological Posting and Boundary, in the Basement Contamination Area

Figure 6. Basement Contamination Area—Offending Pump

Figure 7. Basement Contamination Area Pump with Fixative Applied, Front View

Figure 8. Basement Contamination Area Pump with Fixative Applied, Rear View

Survey locations were physically identified around the dome and then marked with an indelible marker (Figure 9) on floors and walls. These marking should remain visible and legible and aid in locating radiological survey locations in 2025. Survey locations identified in the survey plan were available and located during the survey. No survey locations had to be moved or relocated due to safety concerns or the unavailability of planned survey locations.

Contamination survey results are identified in Table 1 and on the *Radiological Survey Map* form (LMS 1553), radiological survey number 240722-002 (located in Attachment 3).

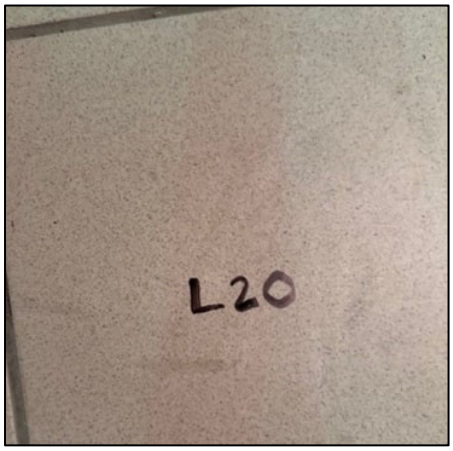

Figure 9. Survey Location Marking, Example of Survey Location 20 on Tile Floor

Table 1. 2024 Contamination Survey Results

Survey ID	Survey Location	Removable Contamination (dpm/100cm^2)	Total Contamination (dpm/100cm^2)	General Location
L1	Pipe Chase Face #1	26	< Sc	Monolith Top
L2	Pipe Chase Face #2	< Sc	< Sc	Monolith Top
L3	Pipe Chase Face #3	< Sc	< Sc	Monolith Top
L4	Pipe Chase Face #4	< Sc	495	Monolith Top
L5	Top Plug Face #1—Left	< Sc	< Sc	Monolith Top
L6	Top Plug Face #1—Center	< Sc	< Sc	Monolith Top
L7	Top Plug Face #1—Right	< Sc	495	Monolith Top
L8	Top Plug Face #2—Top	< Sc	730	Monolith Top
L9	Top Plug Face #2—Center	< Sc	1908	Monolith Top
L10	Top Plug Face #2—Bottom	< Sc	683	Monolith Top
L11	Top Plug Face #3—Right	< Sc	447	Monolith Top
L12	Top Plug Face #3—Center	< Sc	565	Monolith Top
L13	Top Plug Face #3—Left	< Sc	< Sc	Monolith Top
L14	Top Plug Face #4—Bottom	< Sc	< Sc	Monolith Top
L15	Top Plug Face #4—Center	< Sc	612	Monolith Top
L16	Top Plug Face #4—Top	< Sc	612	Monolith Top
L17	Top Plug Top Surface—Upper Left	< Sc	471	Monolith Top
L18	Top Plug Top Surface—Center Right	< Sc	< Sc	Monolith Top
L19	Top Plug Top Surface—Center Bottom	35	< Sc	Monolith Top
L20	Main Floor—Zone 1	< Sc	< Sc	Main Level—Public Access
L21	Main Floor—Zone 2	< Sc	< Sc	Main Level—Public Access
L22	Main Floor—Zone 3	< Sc	< Sc	Main Level—Public Access
L23	Main Floor—Zone 4	< Sc	707	Main Level—Public Access
L24	Main Floor—Zone 5	< Sc	777	Main Level—Public Access
L25	Main Floor—Zone 6	< Sc	942	Main Level—Public Access
L26	Main Floor—Zone 7	< Sc	< Sc	Main Level—Public Access
L27	Main Floor—Zone 8	< Sc	< Sc	Main Level—Public Access
L28	Main Floor—Zone 9	< Sc	< Sc	Main Level—Public Access

Table 1. 2024 Contamination Survey Results (continued)

Survey ID	Survey Location	Removable Contamination (dpm/100cm^2)	Total Contamination (dpm/100cm^2)	General Location
L29	Main Floor—Zone 10	28	683	Main Level—Public Access
L30	Main Floor—Zone 11	< Sc	< Sc	Main Level—Public Access
L31	Main Floor—Zone 12	< Sc	< Sc	Main Level—Public Access
L32	Main Floor—Zone 13	< Sc	542	Main Level—Public Access
L33	Main Floor—Zone 14	< Sc	777	Main Level—Public Access
L34	Main Floor Water Column—Center Bottom	28	542	Main Level—Controlled Area
L35	Main Floor Water Column—Right Middle	< Sc	< Sc	Main Level—Controlled Area
L36	Instrument Thimble #1	< Sc	< Sc	Main Level—Controlled Area
L37	Instrument Thimble #2	< Sc	< Sc	Main Level—Controlled Area
L38	Instrument Thimble #3	< Sc	< Sc	Main Level—Controlled Area
L39	Pipe Chase Exit Hatch	26	< Sc	Main Level—Controlled Area
L40	Fuel Pool Purifier—Floor #1	< Sc	18,699	Main Level—Contaminated Area
L41	Fuel Pool Purifier—Floor #2	< Sc	942	Main Level—Controlled Area
L42	Fuel Pool Purifier—Floor #3	< Sc	495	Main Level—Controlled Area
L43	Fuel Pool Purifier—Floor #4	< Sc	< Sc	Main Level—Controlled Area
L44	Basement Floor—Zone 1	< Sc	< Sc	Basement Level
L45	Basement Floor—Zone 2	< Sc	< Sc	Basement Level
L46	Basement Floor—Zone 3	< Sc	< Sc	Basement Level
L47	Basement Floor—Zone 4	35	< Sc	Basement Level
L48	Basement Floor—Zone 5	< Sc	< Sc	Basement Level
L49	Basement Floor—Zone 6	< Sc	< Sc	Basement Level
L50	Basement Floor—Zone 7	< Sc	< Sc	Basement Level
L51	Basement Floor—Zone 8	< Sc	< Sc	Basement Level
L52	Basement Floor—Zone 9	< Sc	< Sc	Basement Level
L53	Basement Floor—Zone 10	< Sc	< Sc	Basement Level
L54	Basement Floor—Zone 11	< Sc	< Sc	Basement Level
L55	Basement Floor—Zone 12	< Sc	< Sc	Basement Level
L56	Basement Floor—Zone 13	< Sc	< Sc	Basement Level

Table 1. 2024 Contamination Survey Results (continued)

Survey ID	Survey Location	Removable Contamination (dpm/100cm^2)	Total Contamination (dpm/100cm^2)	General Location
L57	Basement Floor—Zone 14	< Sc	< Sc	Basement Level
L58	Basement Floor—Zone 15	< Sc	< Sc	Basement Level
L59	Basement Floor—Zone 16	< Sc	495	Basement Level
L60	Basement Floor—Zone 17	< Sc	< Sc	Basement Level
L61	Basement Floor—Zone 18	< Sc	< Sc	Basement Level
L62	Side of Liquid Waste Tank #1	< Sc	< Sc	Basement Level
L63	Side of Liquid Waste Tank #2	< Sc	< Sc	Basement Level
L64	Column 4 and 5 Inside Room	< Sc	< Sc	Basement Level
L65	Heater Room (Wall)	< Sc	< Sc	Basement Level
L66	Vapor Sphere Room—Upper Left	< Sc	< Sc	Basement Level
L67	Vapor Sphere Room—Center Right	< Sc	< Sc	Basement Level
L68	Water Pump Room to the Right	< Sc	< Sc	Basement Level
L69	Condenser Room Entry Wall—Block	< Sc	< Sc	Basement Level
L70	Condenser Room Entry Wall—Concrete	< Sc	< Sc	Basement Level
L71	South Room with 2 pumps	< Sc	< Sc	Basement Level
L72	Under Stairs Near North Door—Floor #1	< Sc	471	Basement Level
L73	Under Stairs Near North Door—Floor #2	< Sc	< Sc	Basement Level
L74	Condensate Pump #2 Pedestal	< Sc	942	Basement Level
L75	Basement Floor—Zone 5	< Sc	< Sc	Basement Level
L76	Display Area	< Sc	< Sc	Main Level—Public Access
L77	RadCon Storage Area	< Sc	< Sc	Main Level—Public Access
L78	Building Airlock Main Entry	< Sc	< Sc	Main Level—Public Access

Abbreviations:
RadCon = radiological control
Sc = instrument critical value

2.3 Radiation Survey

General area gamma radiation dose rate surveys were performed at the 73 identified survey locations (per the survey plan) and at 5 nonbiased survey locations (selected real time by the RCT performing the survey) using the ThermoScientific MicroRem meter instrument (serial no. 19288). The instrument was operated in accordance with LMS Radiological Control operating procedures, plans, and manuals. General area gamma radiation dose rate results were documented in accordance with the survey plan and the *Documenting Radiological Surveys* procedure.

General area gamma radiation dose rate survey results were evaluated in real time using the criteria below. Additional confirmatory, biased general area gamma radiation dose rate surveys were performed when any of the following survey result or physical site conditions existed:

- The RCT observed excessive deterioration of the structure(s) during the survey when compared to the previous year's structural condition
- Survey results from the identified survey locations indicated a gamma radiation dose rate in excess of 0.4 millirem per hour (400 µrem/h)
- The RCT observed any conditions that justified an additional gamma radiation dose rate survey be performed, at their discretion

General area gamma radiation dose rate results appeared appropriate to the RCTs performing the surveys; survey results were well within regulatory limits and appeared to be consistent with 2023's general area gamma radiation dose rate survey results, taking into account the difference in the gamma radiation instruments used in 2023 and 2024 (a dose rate instrument that was used in 2024 versus an exposure rate instrument that was used in 2023) and the way the survey results were recorded and presented in the 2023 report, with the background exposure rate subtracted from the gross gamma exposure rate compared to the 2024 report, in which the dose rate was reported and recorded as a gross dose rate value (no background value was subtracted from the gross reading result). General area background dose rates were 17 µrem/h on the main level and mezzanine (monolith top), and 38 µrem/h in the basement level. No biased general area gamma radiation dose rate surveys were performed as none of the triggers to take biased general area gamma radiation dose rate surveys occurred.

Gamma radiation dose rate survey results are identified in Table 2 and on the *Radiological Survey Map* form, radiological survey number 240722-002 (located in Attachment 3).

Table 2. 2024 Dose Rate Survey Results

Survey ID	Survey Location	Dose Result (µrem/h)	General Location
L1	Pipe Chase Face #1	20	Monolith Top
L2	Pipe Chase Face #2	20	Monolith Top
L3	Pipe Chase Face #3	20	Monolith Top
L4	Pipe Chase Face #4	20	Monolith Top
L5	Top Plug Face #1—Left	12	Monolith Top
L6	Top Plug Face #1—Center	10	Monolith Top

Table 2. 2024 Dose Rate Survey Results (continued)

Survey ID	Survey Location	Dose Result (µrem/h)	General Location
L7	Top Plug Face #1—Right	10	Monolith Top
L8	Top Plug Face #2—Top	11	Monolith Top
L9	Top Plug Face #2—Center	12	Monolith Top
L10	Top Plug Face #2—Bottom	10	Monolith Top
L11	Top Plug Face #3—Right	10	Monolith Top
L12	Top Plug Face #3—Center	12	Monolith Top
L13	Top Plug Face #3—Left	13	Monolith Top
L14	Top Plug Face #4—Bottom	12	Monolith Top
L15	Top Plug Face #4—Center	12	Monolith Top
L16	Top Plug Face #4—Top	12	Monolith Top
L17	Top Plug Top Surface—Upper Left	12	Monolith Top
L18	Top Plug Top Surface—Center Right	12	Monolith Top
L19	Top Plug Top Surface—Center Bottom	14	Monolith Top
L20	Main Floor—Zone 1	14	Main Level—Public Access
L21	Main Floor—Zone 2	14	Main Level—Public Access
L22	Main Floor—Zone 3	15	Main Level—Public Access
L23	Main Floor—Zone 4	17	Main Level—Public Access
L24	Main Floor—Zone 5	17	Main Level—Public Access
L25	Main Floor—Zone 6	17	Main Level—Public Access
L26	Main Floor—Zone 7	18	Main Level—Public Access
L27	Main Floor—Zone 8	17	Main Level—Public Access
L28	Main Floor—Zone 9	17	Main Level—Public Access
L29	Main Floor—Zone 10	17	Main Level—Public Access
L30	Main Floor—Zone 11	15	Main Level—Public Access
L31	Main Floor—Zone 12	17	Main Level—Public Access
L32	Main Floor—Zone 13	18	Main Level—Public Access
L33	Main Floor—Zone 14	17	Main Level—Public Access
L34	Main Floor Water Column—Center Bottom	18	Main Level—Controlled Area
L35	Main Floor Water Column—Right Middle	15	Main Level—Controlled Area
L36	Instrument Thimble #1	22	Main Level—Controlled Area
L37	Instrument Thimble #2	20	Main Level—Controlled Area
L38	Instrument Thimble #3	16	Main Level—Controlled Area
L39	Pipe Chase Exit Hatch	22	Main Level—Controlled Area
L40	Fuel Pool Purifier—Floor #1	30	Main Level—Contaminated Area
L41	Fuel Pool Purifier—Floor #2	30	Main Level—Controlled Area
L42	Fuel Pool Purifier—Floor #3	30	Main Level—Controlled Area
L43	Fuel Pool Purifier—Floor #4	30	Main Level—Controlled Area
L44	Basement Floor—Zone 1	40	Basement Level
L45	Basement Floor—Zone 2	40	Basement Level
L46	Basement Floor—Zone 3	40	Basement Level
L47	Basement Floor—Zone 4	35	Basement Level

Table 2. 2024 Dose Rate Survey Results (continued)

Survey ID	Survey Location	Dose Result (µrem/h)	General Location
L48	Basement Floor—Zone 5	35	Basement Level
L49	Basement Floor—Zone 6	35	Basement Level
L50	Basement Floor—Zone 7	40	Basement Level
L51	Basement Floor—Zone 8	40	Basement Level
L52	Basement Floor—Zone 9	40	Basement Level
L53	Basement Floor—Zone 10	35	Basement Level
L54	Basement Floor—Zone 11	35	Basement Level
L55	Basement Floor—Zone 12	40	Basement Level
L56	Basement Floor—Zone 13	35	Basement Level
L57	Basement Floor—Zone 14	35	Basement Level
L58	Basement Floor—Zone 15	35	Basement Level
L59	Basement Floor—Zone 16	40	Basement Level
L60	Basement Floor—Zone 17	35	Basement Level
L61	Basement Floor—Zone 18	40	Basement Level
L62	Side of Liquid Waste Tank #1	40	Basement Level
L63	Side of Liquid Waste Tank #2	40	Basement Level
L64	Column 4 and 5 Inside Room	40	Basement Level
L65	Heater Room (wall)	40	Basement Level
L66	Vapor Sphere Room—Upper Left	40	Basement Level
L67	Vapor Sphere Room—Center Right	35	Basement Level
L68	Water Pump Room to the Right	40	Basement Level
L69	Condenser Room Entry Wall—Block	40	Basement Level
L70	Condenser Room Entry Wall—Concrete	40	Basement Level
L71	South Room with 2 pumps	40	Basement Level
L72	Under Stairs Near North Door—Floor #1	40	Basement Level
L73	Under Stairs Near North Door—Floor #2Under stairs near north door Floor #2	40	Basement Level
L74	Condensate Pump #2 Pedestal	40	Basement Level
L75	Basement Floor—Zone 5	35	Basement Level
L76	Display Area	19	Main Level—Public Access
L77	RadCon Storage Area	20	Main Level—Public Access
L78	Building Airlock Main Entry	18	Main Level—Public Access

2.4 Survey Quality

The quality of a radiological survey (and its results) can be demonstrated in several ways and is predominately based on the type of survey being performed (NRC 2020). For unrestricted release surveys or Final Status Surveys, high-quality data is needed to ensure that the surveyed item being released truly meets the release criteria. While survey data quality is still necessary for characterization and routine-type radiological surveys, the level of the data quality process is not as rigorous as the process needed for an unrestricted release survey.

For the surveys performed in 2024, radiological survey and results quality is obtained and demonstrated through several methods and techniques, including using senior-level DOE-qualified RCTs to perform the survey, using approved survey procedures, using an approved plan, using industry standard calibrated and daily response checked survey instruments, calculating counting instrument critical values, and performing peer-reviews and senior health physics reviews of the survey results.

For the 2024 survey, two senior LMS RCTs mobilized to the site and performed the identified radiological surveys in accordance with the approved survey plan and LMS Radiological Control organization procedures. Instrument daily response checks were performed at both the beginning of the day and then at the end of the day, ensuring the instruments were functioning properly during the daily surveys. *Daily Instrument Response* forms (LMS 1974a) were used to record the morning's response checks and are included in Attachment 4. In addition to the *Daily Instrument Response* forms, instrument *After-Calibration Source Response Checks Data Sheet* forms (LMS 1974) and instrument calibration certificates are also included in Attachment 4 for the instruments used during the surveys. Survey results were recorded on an LMS *Radiological Survey Map* form and are included in Attachment 3. This form has been in use for numerous years by LMS staff and is an electronic form that automatically performs the complex calculations required to convert raw instrument results data (i.e., counts per unit time) into disintegrations per unit time and survey area results data (i.e., dpm/100 cm^2) that can then be comparted against established regulatory limits for the surveys. The *Radiological Survey Map* form also automatically calculates the critical values of the instruments used, given the instrument's background values. Using an electronic-based form like the *Radiological Survey Map* helps ensure the accuracy of required calculations and adds an additional level of survey results quality.

Lastly, the survey results are formally reviewed by a senior-level LMS health physicist and signed off as reviewed and proved on the *Radiological Survey Map* form. If errors are identified on the *Radiological Survey Map* form, then it is returned to the RCT that performed the survey and corrections to the results are requested.

2.5 Survey Regulatory Limits

Radiological survey results were compared against the established regulatory limits of 10 CFR 835 Appendix D, "Surface Contamination Values," for surface radioactive contamination (for both removable and total, Table 3) and against the radiation levels identified in 10 CFR 835 for a radiation area (i.e., any area, accessible to individuals, in which radiation levels could result in an individual receiving an equivalent dose to the whole body in excess of 5 millirem [mrem] in 1 hour at 30 centimeters from the source or from any surface that the radiation penetrates).

Only a single survey location (L40) exceeded the total surface contamination limit of 5000 dpm/100 cm^2, with a value of 18,699 dpm/100 cm^2. This survey location is inside an identified and posted contamination area and is therefore not a radiological control concern and there is not an exceedance of regulatory limits.

No survey locations exceeded 5 mrem in 1 hour at 30 centimeters from the source or from any surface.

Table 3. Summary of Surface Contamination Values[a] in dpm/100 cm^2 (10 CFR 835 Appendix D)

Radionuclide	Removable[b,d]	Total (Fixed + Removable)[b,c]
U-natural, U-235, U-238, and associated decay products	1,000[g]	5,000[g]
Transuranic elements, radium-226, radium-228, thorium-230, thorium-228, protactinium-231, actinium-227, iodine-125, iodine-129	20	500
Th-natural, thorium-232, strontium-90, radium-223, radium-224, U-232, iodine-126, iodine-131, iodine-133	200	1,000
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except strontium-90 and others noted above[e]	1,000	5,000
Tritium and STCs[f]	10,000	See Note f

Notes:

[a] The values in this appendix, with the exception noted in footnote f, apply to radioactive contamination deposited on, but not incorporated into the interior or matrix of, the contaminated item. Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides apply independently.

[b] As used in this table, dpm means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[c] The levels may be averaged over 1 square meter provided the maximum surface activity in any area of 100 cm^2 is less than three times the value specified. For purposes of averaging, any square meter of surface shall be considered to be above the surface contamination value if: (1) by using measurements of a representative number of sections it is determined that the average contamination level exceeds the applicable value; or (2) it is determined that the sum of the activity of all isolated spots or particles in any 100 cm^2 area exceeds three times the applicable value.

[d] The amount of removable radioactive material per 100 cm^2 of surface area should be determined by swiping the area with dry filter or soft absorbent paper, applying moderate pressure, and then assessing the amount of radioactive material on the swipe with an appropriate instrument of known efficiency. (Note: The use of dry material may not be appropriate for tritium.) When removable contamination on objects of surface area less than 100 cm^2 is determined, the activity per unit area shall be based on the actual area and the entire surface shall be wiped. It is not necessary to use swiping techniques to measure removable contamination levels if direct scan surveys indicate that the total residual surface contamination levels are within the limits for removable contamination.

[e] This category of radionuclides includes mixed fission products, including the strontium-90 which is present in them. It does not apply to strontium-90 which has been separated from the other fission products or mixtures where the strontium-90 has been enriched.

[f] Tritium contamination including STCs may diffuse into the volume or matrix of materials. Evaluation of surface contamination shall consider the extent to which such contamination may migrate to the surface in order to ensure the surface contamination value provided in this appendix is not exceeded. Once this contamination migrates to the surface, it may be removable, not fixed; therefore, a "total" value does not apply. In certain cases, a “total” value of 10,000 dpm/100 cm^2 may be applicable either to metals of the types from which insoluble special tritium compounds are formed, that have been exposed to tritium, or to bulk materials to which insoluble special tritium compound particles are fixed to a surface.

[g] These limits apply only to the alpha emitters within the respective decay series.

Abbreviations:

STC= special tritium compound
Th = thorium
U = uranium

2.6 Survey Results Comparisons (2024 to 2023)

In accordance with the survey plan, results from the 2024 survey are to be compared to the previous year's survey results to identify if radiological conditions at the site have changed (by more than two sigma) since the last survey performed.

2.6.1 Removable Surface Contamination Comparison

The 2024 removable surface contamination results are very similar to the 2023 removable surface contamination results (Table 4). Given the insignificance of the survey results greater than either the 2024 instrument's critical value or the 2023 instrument's minimum detectable activity for the survey instruments used, a two sigma value was not determined for the survey result populations nor used as a comparison tool (to understand if removable surface contamination values had changed with any statistical significance). The highest removable surface contamination result identified for the comparison was 215 dpm/100 cm^2 (from the 2023 survey). When compared to the removable surface contamination limit of 1000 dpm/100 cm^2, surface contamination levels of 215 dpm/100 cm^2 or less already provide a solid indication that surface contamination levels are not changing in a given area.

One 2024 survey location (L43) did not have a matching 2023 survey location. During development of the 2024 survey plan, the plan's author was unsure of the location of the 2023 survey location. During the physical survey, it was determined that the 2023 L43 survey location was inside the contamination area while the 2024 survey location was outside of the contamination area. Hence, no 2023 radiological data was available for the 2024 comparison.

It can be concluded (for both years 2024 and 2023) that removable surface contamination is not migrating from one area to another area and that removable surface contamination levels are significantly below regulatory removable surface contamination limit values and do not pose human health concerns or environmental risks.

2.6.2 Total Surface Contamination Comparison

The 2024 total surface contamination survey results compare favorably to the 2023 total surface contamination survey results (Table 5), excluding one survey result (at survey location L40).

The standard deviation (sigma) value calculated for all of the 2023 total surface contamination results is 1354 dpm/100 cm^2. The sigma value calculated for all of the 2024 total surface contamination results is 3764 dpm/100 cm^2. These sigma results differ by more than two times. However, when survey location L40 results are removed from the sigma calculations, the 2023 sigma value is 286 dpm/100 cm^2 and the 2024 sigma value is 309 dpm/100 cm^2. These two sigma results (when the L40 survey location results are excluded) are well within the two sigma range of each other, suggesting that the 2023 and 2024 total surface contamination results are very similar. The highest total surface contamination result (excluding survey location L40) identified for the comparison was 1908 dpm/100 cm^2, from the 2024 survey.

Table 4. 2024 Versus 2023 Removable Contamination Survey Results

Survey ID	Survey Location	2024 Removable Contamination (dpm/100cm^2)	2023 Removable Contamination (dpm/100cm^2)	General Location
L1	Pipe Chase Face #1	26	< MDA	Monolith Top
L2	Pipe Chase Face #2	< Sc	< MDA	Monolith Top
L3	Pipe Chase Face #3	< Sc	< MDA	Monolith Top
L4	Pipe Chase Face #4	< Sc	< MDA	Monolith Top
L5	Top Plug Face #1—Left	< Sc	< MDA	Monolith Top
L6	Top Plug Face #1—Center	< Sc	< MDA	Monolith Top
L7	Top Plug Face #1—Right	< Sc	< MDA	Monolith Top
L8	Top Plug Face #2—Top	< Sc	< MDA	Monolith Top
L9	Top Plug Face #2—Center	< Sc	< MDA	Monolith Top
L10	Top Plug Face #2—Bottom	< Sc	< MDA	Monolith Top
L11	Top Plug Face #3—Right	< Sc	< MDA	Monolith Top
L12	Top Plug Face #3—Center	< Sc	122	Monolith Top
L13	Top Plug Face #3—Left	< Sc	< MDA	Monolith Top
L14	Top Plug Face #4—Bottom	< Sc	149	Monolith Top
L15	Top Plug Face #4—Center	< Sc	< MDA	Monolith Top
L16	Top Plug Face #4—Top	< Sc	< MDA	Monolith Top
L17	Top Plug Top Surface—Upper Left	< Sc	< MDA	Monolith Top
L18	Top Plug Top Surface—Center Right	< Sc	< MDA	Monolith Top
L19	Top Plug Top Surface—Center Bottom	35	< MDA	Monolith Top
L20	Main Floor—Zone 1	< Sc	< 200	Main Level—Public Access
L21	Main Floor—Zone 2	< Sc	< MDA	Main Level—Public Access
L22	Main Floor—Zone 3	< Sc	122	Main Level—Public Access
L23	Main Floor—Zone 4	< Sc	< MDA	Main Level—Public Access
L24	Main Floor—Zone 5	< Sc	< MDA	Main Level—Public Access
L25	Main Floor—Zone 6	< Sc	< 200	Main Level—Public Access
L26	Main Floor—Zone 7	< Sc	< 200	Main Level—Public Access
L27	Main Floor—Zone 8	< Sc	< 200	Main Level—Public Access
L28	Main Floor—Zone 9	< Sc	< 200	Main Level—Public Access

Table 4. 2024 Versus 2023 Removable Contamination Survey Results (continued)

Survey ID	Survey Location	2024 Removable Contamination (dpm/100cm^2)	2023 Removable Contamination (dpm/100cm^2)	General Location
L29	Main Floor—Zone 10	28	< 200	Main Level—Public Access
L30	Main Floor—Zone 11	< Sc	< 200	Main Level—Public Access
L31	Main Floor—Zone 12	< Sc	< 200	Main Level—Public Access
L32	Main Floor—Zone 13	< Sc	< 200	Main Level—Public Access
L33	Main Floor—Zone 14	< Sc	< 200	Main Level—Public Access
L34	Main Floor Water Column—Center Bottom	28	< MDA	Main Level—Controlled Area
L35	Main Floor Water Column—Right Middle	< Sc	< MDA	Main Level—Controlled Area
L36	Instrument Thimble #1	< Sc	< MDA	Main Level—Controlled Area
L37	Instrument Thimble #2	< Sc	< MDA	Main Level—Controlled Area
L38	Instrument Thimble #3	< Sc	127	Main Level—Controlled Area
L39	Pipe Chase Exit Hatch	26	< MDA	Main Level—Controlled Area
L40	Fuel Pool Purifier—Floor #1	< Sc	138	Main Level—Contaminated Area
L41	Fuel Pool Purifier—Floor #2	< Sc	< MDA	Main Level—Controlled Area
L42	Fuel Pool Purifier—Floor #3	< Sc	215	Main Level—Controlled Area
L43	Fuel Pool Purifier—Floor #4	< Sc	NA	Main Level—Controlled Area
L44	Basement Floor—Zone 1	< Sc	< 200	Basement Level
L45	Basement Floor—Zone 2	< Sc	< 200	Basement Level
L46	Basement Floor—Zone 3	< Sc	< 200	Basement Level
L47	Basement Floor—Zone 4	35	< 200	Basement Level
L48	Basement Floor—Zone 5	< Sc	< 200	Basement Level
L49	Basement Floor—Zone 6	< Sc	< 200	Basement Level
L50	Basement Floor—Zone 7	< Sc	< 200	Basement Level
L51	Basement Floor—Zone 8	< Sc	< 200	Basement Level
L52	Basement Floor—Zone 9	< Sc	< 200	Basement Level
L53	Basement Floor—Zone 10	< Sc	< 200	Basement Level
L54	Basement Floor—Zone 11	< Sc	< 200	Basement Level
L55	Basement Floor—Zone 12	< Sc	< 200	Basement Level
L56	Basement Floor—Zone 13	< Sc	< 200	Basement Level

Table 4. 2024 Versus 2023 Removable Contamination Survey Results (continued)

Survey ID	Survey Location	2024 Removable Contamination (dpm/100cm^2)	2023 Removable Contamination (dpm/100cm^2)	General Location
L57	Basement Floor—Zone 14	< Sc	< 200	Basement Level
L58	Basement Floor—Zone 15	< Sc	< 200	Basement Level
L59	Basement Floor—Zone 16	< Sc	< 200	Basement Level
L60	Basement Floor—Zone 17	< Sc	< 200	Basement Level
L61	Basement Floor—Zone 18	< Sc	< 200	Basement Level
L62	Side of Liquid Waste Tank #1	< Sc	< MDA	Basement Level
L63	Side of Liquid Waste Tank #2	< Sc	< MDA	Basement Level
L64	Column 4 and 5 Inside Room	< Sc	< MDA	Basement Level
L65	Heater Room (wall)	< Sc	< MDA	Basement Level
L66	Vapor Sphere Room—Upper Left	< Sc	< MDA	Basement Level
L67	Vapor Sphere Room—Center Right	< Sc	< MDA	Basement Level
L68	Water Pump Room to the Right	< Sc	< MDA	Basement Level
L69	Condenser Room Entry Wall, block	< Sc	< MDA	Basement Level
L70	Condenser Room Entry Wall, concrete	< Sc	< MDA	Basement Level
L71	South Room with 2 pumps	< Sc	< MDA	Basement Level
L72	Under Stairs Near North Door—Floor #1	< Sc	< MDA	Basement Level
L73	Under Stairs Near North Door—Floor #2	< Sc	177	Basement Level
L74	Condensate Pump #2 Pedestal	< Sc	See Note a	Basement Level
L75	Basement Floor—Zone 5	< Sc	See Note a	Basement Level
L76	Display Area	< Sc	See Note a	Main Level—Public Access
L77	RadCon Storage Area	< Sc	See Note a	Main Level—Public Access
L78	Building Airlock Main Entry	< Sc	See Note a	Main Level—Public Access

Note:
[a] 2024 RCT-selected survey locations, did not exist in 2023.

Abbreviations:
MDA = minimum detectable activity
NA = not available
RadCon = radiological control
Sc = instrument critical value

Table 5. 2024 Versus 2023 Total Contamination Survey Results

Survey ID	Survey Location	2024 Total Contamination (dpm/100cm^2)	2023 Total Contamination (dpm/100cm^2)	General Location
L1	Pipe Chase Face #1	< Sc	< MDA	Monolith Top
L2	Pipe Chase Face #2	< Sc	< MDA	Monolith Top
L3	Pipe Chase Face #3	< Sc	< MDA	Monolith Top
L4	Pipe Chase Face #4	495	< MDA	Monolith Top
L5	Top Plug Face #1—Left	< Sc	737	Monolith Top
L6	Top Plug Face #1—Center	< Sc	558	Monolith Top
L7	Top Plug Face #1—Right	495	759	Monolith Top
L8	Top Plug Face #2—Top	730	714	Monolith Top
L9	Top Plug Face #2—Center	1,908	1,696	Monolith Top
L10	Top Plug Face #2—Bottom	683	1,339	Monolith Top
L11	Top Plug Face #3—Right	447	871	Monolith Top
L12	Top Plug Face #3—Center	565	536	Monolith Top
L13	Top Plug Face #3—Left	< Sc	759	Monolith Top
L14	Top Plug Face #4—Bottom	< Sc	603	Monolith Top
L15	Top Plug Face #4—Center	612	737	Monolith Top
L16	Top Plug Face #4—Top	612	781	Monolith Top
L17	Top Plug Top Surface—Upper Left	471	603	Monolith Top
L18	Top Plug Top Surface—Center Right	< Sc	647	Monolith Top
L19	Top Plug Top Surface—Center Bottom	< Sc	848	Monolith Top
L20	Main Floor—Zone 1	< Sc	See Note a	Main Level—Public Access
L21	Main Floor—Zone 2	< Sc	1,205	Main Level—Public Access
L22	Main Floor—Zone 3	< Sc	<MDA	Main Level—Public Access
L23	Main Floor—Zone 4	707	<MDA	Main Level—Public Access
L24	Main Floor—Zone 5	777	<MDA	Main Level—Public Access
L25	Main Floor—Zone 6	942	See Note a	Main Level—Public Access
L26	Main Floor—Zone 7	< Sc	See Note a	Main Level—Public Access
L27	Main Floor—Zone 8	< Sc	See Note a	Main Level—Public Access
L28	Main Floor—Zone 9	< Sc	See Note a	Main Level—Public Access

Table 5. 2024 Versus 2023 Total Contamination Survey Results (continued)

Survey ID	Survey Location	2024 Total Contamination (dpm/100cm^2)	2023 Total Contamination (dpm/100cm^2)	General Location
L29	Main Floor—Zone 10	683	See Note a	Main Level—Public Access
L30	Main Floor—Zone 11	< Sc	See Note a	Main Level—Public Access
L31	Main Floor—Zone 12	< Sc	See Note a	Main Level—Public Access
L32	Main Floor—Zone 13	542	See Note a	Main Level—Public Access
L33	Main Floor—Zone 14	777	See Note a	Main Level—Public Access
L34	Main Floor Water Column—Center Bottom	542	< MDA	Main Level—Controlled Area
L35	Main Floor Water Column—Right Middle	< Sc	647	Main Level—Controlled Area
L36	Instrument Thimble #1	< Sc	< MDA	Main Level—Controlled Area
L37	Instrument Thimble #2	< Sc	< MDA	Main Level—Controlled Area
L38	Instrument Thimble #3	< Sc	< MDA	Main Level—Controlled Area
L39	Pipe Chase Exit Hatch	< Sc	< MDA	Main Level—Controlled Area
L40	Fuel Pool Purifier—Floor #1	18,699	7,590	Main Level—Contaminated Area
L41	Fuel Pool Purifier—Floor #2	942	1,250	Main Level—Controlled Area
L42	Fuel Pool Purifier—Floor #3	495	848	Main Level—Controlled Area
L43	Fuel Pool Purifier—Floor #4	< Sc	NA	Main Level—Controlled Area
L44	Basement Floor—Zone 1	< Sc	See Note a	Basement Level
L45	Basement Floor—Zone 2	< Sc	See Note a	Basement Level
L46	Basement Floor—Zone 3	< Sc	See Note a	Basement Level
L47	Basement Floor—Zone 4	< Sc	See Note a	Basement Level
L48	Basement Floor—Zone 5	< Sc	See Note a	Basement Level
L49	Basement Floor—Zone 6	< Sc	See Note a	Basement Level
L50	Basement Floor—Zone 7	< Sc	See Note a	Basement Level
L51	Basement Floor—Zone 8	< Sc	See Note a	Basement Level
L52	Basement Floor—Zone 9	< Sc	See Note a	Basement Level
L53	Basement Floor—Zone 10	< Sc	See Note a	Basement Level
L54	Basement Floor—Zone 11	< Sc	See Note a	Basement Level
L55	Basement Floor—Zone 12	< Sc	See Note a	Basement Level
L56	Basement Floor—Zone 13	< Sc	See Note a	Basement Level

Table 5. 2024 Versus 2023 Total Contamination Survey Results (continued)

Survey ID	Survey Location	2024 Total Contamination (dpm/100cm^2)	2023 Total Contamination (dpm/100cm^2)	General Location
L57	Basement Floor—Zone 14	< Sc	See Note a	Basement Level
L58	Basement Floor—Zone 15	< Sc	See Note a	Basement Level
L59	Basement Floor—Zone 16	495	See Note a	Basement Level
L60	Basement Floor—Zone 17	< Sc	See Note a	Basement Level
L61	Basement Floor—Zone 18	< Sc	See Note a	Basement Level
L62	Side of Liquid Waste Tank #1	< Sc	938	Basement Level
L63	Side of Liquid Waste Tank #2	< Sc	1,116	Basement Level
L64	Column 4 and 5 Inside Room	< Sc	< MDA	Basement Level
L65	Heater Room (wall)	< Sc	< MDA	Basement Level
L66	Vapor Sphere Room—Upper Left	< Sc	< MDA	Basement Level
L67	Vapor Sphere Room—Center Right	< Sc	< MDA	Basement Level
L68	Water Pump Room to the Right	< Sc	625	Basement Level
L69	Condenser Room Entry Wall—Block	< Sc	< MDA	Basement Level
L70	Condenser Room Entry Wall—Concrete	< Sc	603	Basement Level
L71	South Room with 2 pumps	< Sc	< MDA	Basement Level
L72	Under Stairs Near North Door—Floor #1	471	< MDA	Basement Level
L73	Under Stairs Near North Door—Floor #2	< Sc	558	Basement Level
L74	Condensate Pump #2 Pedestal	942	See Note b	Basement Level
L75	Basement Floor—Zone 5	< Sc	See Note b	Basement Level
L76	Display Area	< Sc	See Note b	Main Level—Public Access
L77	RadCon Storage Area	< Sc	See Note b	Main Level—Public Access
L78	Building Airlock Main Entry	< Sc	See Note b	Main Level—Public Access

Notes:
[a] 2023 total contamination was not collected or reported in the 2023 BONUS Survey Report.
[b] 2024 RCT-selected survey locations, did not exist in 2023.

Abbreviations:
MDA = minimum detectable activity
NA = not available
Sc = instrument critical value

At survey location L40, the total surface contamination result for 2023 was 7590 dpm/100 cm^2 while the 2024 result was 18699 dpm/100 cm^2 (both above the 5000 dpm/100 cm^2 regulatory total surface contamination limit). The L40 survey location is the single survey location at the site that is located within a radiological posted contamination area. Regardless, it is unknown why the total surface contamination level at survey location L40 increased almost 2.5 times from 2023's survey result. Removable contamination levels at survey location L40 (and around L40) were well below regulatory removable surface contamination limits and below the critical value for the instrument used to count that smear in 2024. It is doubtful that the floor at survey location L40 was additionally contaminated between the two survey events, as no removable surface contamination was identified during either the 2023 or 2024 surveys at that location. Special attention to survey location L40 will be implemented during the planning phase of the 2025 survey at the site to better understand possible and likely causes for an increase in total contamination levels in that area. Because the L40 survey location is already identified, posted, and controlled as an LMS contamination area; is also within another physical barrier area (a plexiglass half-wall) that prevents unauthorized personal (visitor) access; and is physically identified as fixed contamination (contamination that is not easily removed or transferred from one location to another), the surface contamination at survey location L40 does not pose human health concerns or environmental risks.

One 2024 survey location (L43) did not have a matching 2023 survey location. During development of the 2024 survey plan, the plan's author was unsure of the location of the 2023 survey location. During the physical survey, it was determined that the 2023 L43 survey location was inside the contamination area while the 2024 survey location was outside of the contamination area. Hence, no 2023 radiological data was available for the 2024 comparison.

When compared to the total surface contamination limit of 5000 dpm/100 cm^2, total surface contamination levels at the site are well within regulatory limits and do not pose human health concerns or environmental risks.

2.6.3 Radiation Dose and Exposure Rate Comparison

Comparison of 2024 gamma radiation dose rate results to the 2023 gamma radiation exposure rate results (as recorded) initially proves to be confusing (Table 6). In Table 6, none of the radiation dose rate results are shown with the instrument's background level removed from the instrument's gross reading, which is the correct way to document general area radiation dose rate survey results. However, once instrument-specific radiation dose rate background values are removed from the instrument's gross reading, comparison of 2024 to 2023 gamma radiation survey results become clearer (Table 7). The 2024 gamma radiation dose rate survey results compare favorably to the 2023 gamma radiation dose rate survey results, excluding five survey results: L41, L42, L62, L63, and L65 (Table 8).

Different gamma radiation dose rate instruments were used in 2023 and 2024. Specifically, a dose rate instrument was used in 2024 versus an exposure rate instrument in 2023. It is acceptable to use either type of gamma radiation dose or exposure rate survey instrument for performing the annual BONUS gamma radiation survey (e.g., a dose rate versus exposure rate survey) so long as background radiation dose rates are subtracted from the instrument's gross gamma radiation rate readings. The only real difference between the two instruments when measuring gamma radiation from cesium 137 is the instrument's manufacturer and its readout units (i.e., exposure rate versus dose rate).

Table 6. 2024 Versus 2023 Gamma Radiation Survey Results

Survey ID	Survey Location	2024 Dose Result (µrem/h)	2023 Exposure Result (µR/h)	General Location
L1	Pipe Chase Face #1	20	4	Monolith Top
L2	Pipe Chase Face #2	20	4	Monolith Top
L3	Pipe Chase Face #3	20	4	Monolith Top
L4	Pipe Chase Face #4	20	4	Monolith Top
L5	Top Plug Face #1—Left	12	6	Monolith Top
L6	Top Plug Face #1—Center	10	6	Monolith Top
L7	Top Plug Face #1—Right	10	6	Monolith Top
L8	Top Plug Face #2—Top	11	6	Monolith Top
L9	Top Plug Face #2—Center	12	7	Monolith Top
L10	Top Plug Face #2—Bottom	10	6	Monolith Top
L11	Top Plug Face #3—Right	10	5	Monolith Top
L12	Top Plug Face #3—Center	12	5	Monolith Top
L13	Top Plug Face #3—Left	13	5	Monolith Top
L14	Top Plug Face #4—Bottom	12	7	Monolith Top
L15	Top Plug Face #4—Center	12	5	Monolith Top
L16	Top Plug Face #4—Top	12	5	Monolith Top
L17	Top Plug Top Surface—Upper Left	12	4	Monolith Top
L18	Top Plug Top Surface—Center Right	12	4	Monolith Top
L19	Top Plug Top Surface—Center Bottom	14	4	Monolith Top
L20	Main Floor—Zone 1	14	5	Main Level—Public Access
L21	Main Floor—Zone 2	14	5	Main Level—Public Access
L22	Main Floor—Zone 3	15	6	Main Level—Public Access
L23	Main Floor—Zone 4	17	4	Main Level—Public Access
L24	Main Floor—Zone 5	17	5	Main Level—Public Access
L25	Main Floor—Zone 6	17	5	Main Level—Public Access
L26	Main Floor—Zone 7	18	5	Main Level—Public Access
L27	Main Floor—Zone 8	17	5	Main Level—Public Access
L28	Main Floor—Zone 9	17	6	Main Level—Public Access
L29	Main Floor—Zone 10	17	6	Main Level—Public Access

Table 6. 2024 Versus 2023 Gamma Radiation Survey Results (continued)

Survey ID	Survey Location	2024 Dose Result (µrem/h)	2023 Exposure Result (µR/h)	General Location
L30	Main Floor—Zone 11	15	7	Main Level—Public Access
L31	Main Floor—Zone 12	17	6	Main Level—Public Access
L32	Main Floor—Zone 13	18	6	Main Level—Public Access
L33	Main Floor—Zone 14	17	6	Main Level—Public Access
L34	Main Floor Water Column—Center Bottom	18	5	Main Level—Controlled Area
L35	Main Floor Water Column—Right Middle	15	5	Main Level—Controlled Area
L36	Instrument Thimble #1	22	5	Main Level—Controlled Area
L37	Instrument Thimble #2	20	5	Main Level—Controlled Area
L38	Instrument Thimble #3	16	5	Main Level—Controlled Area
L39	Pipe Chase Exit Hatch	22	5	Main Level—Controlled Area
L40	Fuel Pool Purifier—Floor #1	30	15	Main Level—Contaminated Area
L41	Fuel Pool Purifier—Floor #2	30	4	Main Level—Controlled Area
L42	Fuel Pool Purifier—Floor #3	30	4	Main Level—Controlled Area
L43	Fuel Pool Purifier—Floor #4	30	NA	Main Level—Controlled Area
L44	Basement Floor—Zone 1	40	5	Basement Level
L45	Basement Floor—Zone 2	40	5	Basement Level
L46	Basement Floor—Zone 3	40	5	Basement Level
L47	Basement Floor—Zone 4	35	5	Basement Level
L48	Basement Floor—Zone 5	35	4	Basement Level
L49	Basement Floor—Zone 6	35	7	Basement Level
L50	Basement Floor—Zone 7	40	5	Basement Level
L51	Basement Floor—Zone 8	40	4	Basement Level
L52	Basement Floor—Zone 9	40	5	Basement Level
L53	Basement Floor—Zone 10	35	4	Basement Level
L54	Basement Floor—Zone 11	35	5	Basement Level
L55	Basement Floor—Zone 12	40	5	Basement Level
L56	Basement Floor—Zone 13	35	4	Basement Level
L57	Basement Floor—Zone 14	35	5	Basement Level
L58	Basement Floor—Zone 15	35	5	Basement Level

Table 6. 2024 Versus 2023 Gamma Radiation Survey Results (continued)

Survey ID	Survey Location	2024 Dose Result (µrem/h)	2023 Exposure Result (µR/h)	General Location
L59	Basement Floor—Zone 16	40	5	Basement Level
L60	Basement Floor—Zone 17	35	5	Basement Level
L61	Basement Floor—Zone 18	40	4	Basement Level
L62	Side of Liquid Waste Tank #1	40	30	Basement Level
L63	Side of Liquid Waste Tank #2	40	28	Basement Level
L64	Column 4 and 5 Inside Room	40	7	Basement Level
L65	Heater Room (wall)	40	18	Basement Level
L66	Vapor Sphere Room—Upper Left	40	4	Basement Level
L67	Vapor Sphere Room—Center Right	35	5	Basement Level
L68	Water Pump Room to the Right	40	7	Basement Level
L69	Condenser Room Entry Wall—Block	40	5	Basement Level
L70	Condenser Room Entry Wall—Concrete	40	5	Basement Level
L71	South Room with 2 pumps	40	6	Basement Level
L72	Under Stairs Near North Door—Floor #1	40	5	Basement Level
L73	Under Stairs Near North Door—Floor #2	40	5	Basement Level
L74	Condensate Pump #2 Pedestal	40	See Note a	Basement Level
L75	Basement Floor—Zone 5	35	See Note a	Basement Level
L76	Display Area	19	See Note a	Main Level—Public Access
L77	RadCon Storage Area	20	See Note a	Main Level—Public Access
L78	Building Airlock Main Entry	18	See Note a	Main Level—Public Access

Note:
[a] 2024 RCT-selected survey locations, did not exist in 2023.

Abbreviations:
µR/h = microroentgens per hour
NA = not available

Table 7. 2024 Versus 2023 Gamma Radiation Survey Results with Background Removed

Survey ID	Survey Location	2024 Dose Result—Bkgd (µrem/h)	2023 Exposure Result—Bkgd (µR/h)	General Location
L1	Pipe Chase Face #1	3	−1	Monolith Top
L2	Pipe Chase Face #2	3	−1	Monolith Top
L3	Pipe Chase Face #3	3	−1	Monolith Top
L4	Pipe Chase Face #4	3	−1	Monolith Top
L5	Top Plug Face #1—Left	−5	1	Monolith Top
L6	Top Plug Face #1—Center	−7	1	Monolith Top
L7	Top Plug Face #1—Right	−7	1	Monolith Top
L8	Top Plug Face #2—Top	−6	1	Monolith Top
L9	Top Plug Face #2—Center	−5	2	Monolith Top
L10	Top Plug Face #2—Bottom	−7	1	Monolith Top
L11	Top Plug Face #3—Right	−7	0	Monolith Top
L12	Top Plug Face #3—Center	−5	0	Monolith Top
L13	Top Plug Face #3—Left	−4	0	Monolith Top
L14	Top Plug Face #4—Bottom	−5	2	Monolith Top
L15	Top Plug Face #4—Center	−5	0	Monolith Top
L16	Top Plug Face #4—Top	−5	0	Monolith Top
L17	Top Plug Top Surface—Upper Left	−5	−1	Monolith Top
L18	Top Plug Top Surface—Center Right	−5	−1	Monolith Top
L19	Top Plug Top Surface—Center Bottom	−3	−1	Monolith Top
L20	Main Floor—Zone 1	−3	0	Main Level—Public Access
L21	Main Floor—Zone 2	−3	0	Main Level—Public Access
L22	Main Floor—Zone 3	−2	1	Main Level—Public Access
L23	Main Floor—Zone 4	0	−1	Main Level—Public Access
L24	Main Floor—Zone 5	0	0	Main Level—Public Access
L25	Main Floor—Zone 6	0	0	Main Level—Public Access
L26	Main Floor—Zone 7	1	0	Main Level—Public Access
L27	Main Floor—Zone 8	0	0	Main Level—Public Access
L28	Main Floor—Zone 9	0	1	Main Level—Public Access
L29	Main Floor—Zone 10	0	1	Main Level—Public Access

Table 7. 2024 Versus 2023 Gamma Radiation Survey Results with Background Removed (continued)

Survey ID	Survey Location	2024 Dose Result—Bkgd (µrem/h)	2023 Exposure Result—Bkgd (µR/h)	General Location
L30	Main Floor—Zone 11	−2	2	Main Level—Public Access
L31	Main Floor—Zone 12	0	1	Main Level—Public Access
L32	Main Floor—Zone 13	1	1	Main Level—Public Access
L33	Main Floor—Zone 14	0	1	Main Level—Public Access
L34	Main Floor Water Column—Center Bottom	1	0	Main Level—Controlled Area
L35	Main Floor Water Column—Right Middle	−2	0	Main Level—Controlled Area
L36	Instrument Thimble #1	5	0	Main Level—Controlled Area
L37	Instrument Thimble #2	3	0	Main Level—Controlled Area
L38	Instrument Thimble #3	−1	0	Main Level—Controlled Area
L39	Pipe Chase Ext Hatch	5	0	Main Level—Controlled Area
L40	Fuel Pool Purifier—Floor #1	13	10	Main Level—Contaminated Area
L41	Fuel Pool Purifier—Floor #2	13	−1	Main Level—Controlled Area
L42	Fuel Pool Purifier—Floor #3	13	−1	Main Level—Controlled Area
L43	Fuel Pool Purifier—Floor #4	13	NA	Main Level—Controlled Area
L44	Basement Floor—Zone 1	2	0	Basement Level
L45	Basement Floor—Zone 2	2	0	Basement Level
L46	Basement Floor—Zone 3	2	0	Basement Level
L47	Basement Floor—Zone 4	−3	0	Basement Level
L48	Basement Floor—Zone 5	−3	−1	Basement Level
L49	Basement Floor—Zone 6	−3	2	Basement Level
L50	Basement Floor—Zone 7	2	0	Basement Level
L51	Basement Floor—Zone 8	2	−1	Basement Level
L52	Basement Floor—Zone 9	2	0	Basement Level
L53	Basement Floor—Zone 10	−3	−1	Basement Level
L54	Basement Floor—Zone 11	−3	0	Basement Level
L55	Basement Floor—Zone 12	2	0	Basement Level
L56	Basement Floor—Zone 13	−3	−1	Basement Level
L57	Basement Floor—Zone 14	−3	0	Basement Level
L58	Basement Floor—Zone 15	−3	0	Basement Level

Table 7. 2024 Versus 2023 Gamma Radiation Survey Results with Background Removed (continued)

Survey ID	Survey Location	2024 Dose Result—Bkgd (µrem/h)	2023 Exposure Result—Bkgd (µR/h)	General Location
L59	Basement Floor—Zone 16	2	0	Basement Level
L60	Basement Floor—Zone 17	−3	0	Basement Level
L61	Basement Floor—Zone 18	2	−1	Basement Level
L62	Side of Liquid Waste Tank #1	2	25	Basement Level
L63	Side of Liquid Waste Tank #2	2	23	Basement Level
L64	Column 4 and 5 Inside Room	2	2	Basement Level
L65	Heater Room (wall)	2	13	Basement Level
L66	Vapor Sphere Room—Upper Left	2	−1	Basement Level
L67	Vapor Sphere Room—Center Right	−3	0	Basement Level
L68	Water Pump Room to the Right	2	2	Basement Level
L69	Condenser Room Entry Wall—Block	2	0	Basement Level
L70	Condenser Room Entry Wall—Concrete	2	0	Basement Level
L71	South Room with 2 pumps	2	1	Basement Level
L72	Under Stairs Near North Door—Floor #1	2	0	Basement Level
L73	Under Stairs Near North Door—Floor #2	2	0	Basement Level
L74	Condensate Pump #2 Pedestal	2	See Note a	Basement Level
L75	Basement Floor—Zone 5	−3	See Note a	Basement Level
L76	Display Area	2	See Note a	Main Level—Public Access
L77	RadCon Storage Area	3	See Note a	Main Level—Public Access
L78	Building Airlock Main Entry	1	See Note a	Main Level—Public Access

Note:
[a] 2024 RCT-selected survey locations, did not exist in 2023.

Abbreviations:
Bkgd = Background
µrem/h = microrems per hour
µR/h = microroentgens per hour
NA = not available

Table 8. 2024 Versus 2023 Gamma Radiation Survey Results For Comparison (with Background Removed)

Survey ID	Survey Location	2024 Dose Result—Bkgd (µrem/h)	2023 Exposure Result—Bkgd (µR/h)	General Location
L41	Fuel Pool Purifier—Floor #2	13	−1	Main Level—Controlled Area
L42	Fuel Pool Purifier—Floor #3	13	−1	Main Level—Controlled Area
L62	Side of Liquid Waste Tank #1	2	25	Basement Level
L63	Side of Liquid Waste Tank #2	2	23	Basement Level
L65	Heater Room (Wall)	2	13	Basement Level

Abbreviations:
Bkgd = background
µrem/h = microrems per hour
µR/h = microroentgens per hour

Similar to survey location L40 for the total surface contamination comparison, it is unsure why the 2024 survey identified five areas with radiation dose rate results that are greater or less than 10 µrem/h when compared to the 2023 radiation dose rate results. It is doubtful that those five areas have been impacted in a way that would increase or decrease general area radiation dose rates between the December 2023 and August 2024 gamma radiation dose rate surveys. Similar to survey location L40 for the total surface contamination comparison, special attention to survey locations L41, L42, L62, L63, and L65 will be implemented during the planning phase of the 2025 survey at the site in an attempt to better understand a likely cause for an increase or decrease in gamma radiation dose rates in those survey areas. While the five survey locations showed slight changes in gamma radiation dose rate levels between the two surveys, none of the gamma dose rate survey results (2024 or 2023) are anywhere near the 5 mrem/h (5000 µrem/h) regulatory dose limit that would require posting the area as a radiation area and maintaining entry control. The maximum increase in gamma radiation dose rates during the 2024 survey was 14 µrem/h in two areas (L41 and L42), the other three survey locations showed a decrease in their general area gamma radiation dose rates (decreasing up to 23 µrem/h at survey location L62).

One 2024 survey location (L43) did not have a matching 2023 survey location. During development of the 2024 survey plan, the plan's author was unsure of the location of the 2023 survey location. During the physical survey, it was determined that the 2023 L43 survey location was inside the contamination area while the 2024 survey location was outside of the contamination area. Hence, no 2023 radiological data was available for the 2024 comparison.

Gamma radiation dose rate levels at the site are significantly below regulatory radiation dose rate limit values and do not pose human health concerns or environmental risks.

2.7 Remaining Survey and Safety Supplies

At the conclusion of the 2024 radiological survey, survey and safety supplies as well as some equipment were packaged in lockable totes (Figure 10) and left at the site in a lockable fenced area. The notable survey and safety items remaining at the site include an LMS trauma kit, pulse-oximeter monitor, digital thermometer, a selection of radiological and safety PPE, two sprayer bottles, and the remaining InstaCote surface fixative (approximately ¼ gallon of CC Fix and ½ gallon of CC Wet). The combination to the locks on the totes is 6-4-5-3. LMS radiological survey instruments and radioactive check sources were sent back to the LMFSC at the end of the survey.

Figure 10. Remaining Survey and Safety Supplies

3.0 2024 Survey Conclusion

LMS RCTs mobilized to the BONUS site and performed the annual radiological survey of the interior of the reactor containment building. The radiological survey was performed in accordance with the survey plan and LMS Radiological Control organization procedures, manuals, and plans.

In accordance with the survey plan, it was determined that:

1. Noncontamination area accessible site surfaces are below established regulatory limits of 10 CFR 835 Appendix D for surface contamination.
2. General area radiation levels are below established regulatory limits of 10 CFR 835.2.
3. The two surface contamination areas at the site are properly controlled and posted in accordance with *Radiological Control Manual*.
4. The 2024 radiological conditions at the site compare favorably to the 2023 conditions, and where there was a difference, a review and evaluation of the change(s) were performed and documented in this survey report.

Two previously identified contamination areas in the reactor containment building remain contamination areas and are radiologically posted as such. No new radiological areas were identified during the survey. No previously posted radiological areas were deposted.

The 2024 radiological survey results, along with the two radiologically posted and controlled contamination areas at the site, provide continued confidence that human health and the environment remain protected from radiological hazards at the site.

4.0 References

10 CFR 835. U.S. Nuclear Regulatory Commission, "Occupational Radiation Protection," *Code of Federal Regulations*.

DOE (U.S. Department of Energy), 2023a. *Radiological Control Manual*, LMS/POL/S04322-7.0, Office of Legacy Management, August.

DOE (U.S. Department of Energy), 2023b. *Radiological Control Technician (RCT) Training and Qualification Program Description*, LMS/PRO/S08621-5.0, Office of Legacy Management, March.

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DOE (U.S. Department of Energy), 2024b. *Contamination Surveys and Equipment and Material Release*, LMS/PRO/S20079-2.0, Office of Legacy Management, August.

DOE (U.S. Department of Energy), 2024c. *Counting Systems Daily Operation*, LMS/PRO/S20076-2.0, Office of Legacy Management, May.

DOE (U.S. Department of Energy), 2024d. *Documenting Radiological Surveys*, LMS/PRO/S20073-2.0, Office of Legacy Management, August.

DOE (U.S. Department of Energy), 2024e. *Portable Radiation Survey Instrument Response Checks*, LMS/PRO/S20074-2.0, Office of Legacy Management, July.

DOE (U.S. Department of Energy), 2024f. *Radiation Protection Program Plan*, LMS/POL/S04373-10.0, Office of Legacy Management, June.

DOE Order 435.1 Chg 2 (Admin Chg), *Radioactive Waste Management*, U.S. Department of Energy, January 11, 2021.

NRC (U.S. Nuclear Regulatory Commission), 2020. *Multi-Agency Radiation Survey and Site Investigation Manual*, NUREG-1557, Rev. 1, August.

Attachment 1

***Annual LMS Radiological Characterization Survey Plan for the BONUS, Puerto Rico, Decommissioned Reactor Site LMS RadCon Survey Plan Number: 24-001*,**
June 2024, LMS/BON/48092

RSI ENTECH
In Partnership with Amentum and TFE
United for the Legacy Management Mission

LMS/BON/48092-0.0
Level 4
Issue Date: 06/11/2024
Effective Date: 07/11/2024

Annual LMS Radiological Characterization Survey Plan for the BONUS, Puerto Rico, Decommissioned Reactor Site LMS RadCon Survey Plan Number: 24-001

June 2024

Work performed under DOE contract number 89303020DLM000001
for the U.S. Department of Energy Office of Legacy Management.

This document is designed for online viewing.

Annual LMS Radiological Characterization Survey Plan for the BONUS, Puerto Rico, Decommissioned Reactor Site
LMS RadCon Survey Plan Number: 24-001
Document History

Version No./ Revision No.	Revised	Description of Change
0.0	June 2024	Initial issue.

Approved:

MICHAEL MCDONALD (Affiliate)

Digitally signed by MICHAEL MCDONALD (Affiliate)
Date: 2024.06.11 14:44:24 -06'00'

Michael McDonald
Radiological Control Manager
RSI EnTech, LLC

Date

Contents

Figures

Attachment

Abbreviations

BONUS	Boiling Nuclear Superheater
dpm/100 cm^2	disintegrations per minute per 100 centimeters squared
LMS	Legacy Management Support
µR/h	microroentgens per hour
RadCon	Radiological Control
RCT	radiological control technician
S&H	Safety and Health

Forms Referenced in This Manual

LMS forms are accessible on the **Document Management** homepage > **LMS Forms**.

Radiological Survey Map	LMS 1553

1.0 Introduction

Legacy Management Support (LMS) contractor personnel are responsible for performing the annual LMS radiological characterization survey (characterization survey) at the BONUS, Puerto Rico, Decommissioned Reactor Site in Rincon, Puerto Rico.

This Annual LMS Radiological Characterization Survey Plan provides information and guidance necessary for an LMS qualified radiological control technician (RCT) to perform the survey. The results of the survey will be used to verify that:

1. Accessible site surfaces are below established regulatory limits of Title 10 *Code of Federal Regulations* Section 835 (10 CFR 835) Appendix D, "Surface Contamination Values," for surface radioactive contamination.
2. Accessible area radiation levels are below established regulatory limits of 10 CFR 835.2, "Definitions," for a radiation area.
3. Accessible areas or surfaces that exceed regulatory radiological limits are properly controlled and posted in accordance with *Radiological Control Manual* (LMS/POL/S04322).
4. Survey results have not changed by more than 2 sigma (standard deviations) when compared to the previous year's survey results, and if they have changed by more than 2 sigma, a review and evaluation of the change(s) will be performed and documented by an LMS senior health physicist and the evaluation results shared with the LMS site lead.

1.1 Purpose and Scope

1. The purpose of this survey plan is to provide guidance to the RCT conducting the characterization survey. It also provides the requirements associated with the evaluation of the characterization survey results, including the comparison of the current characterization survey results to the previous year's survey results and to the regulatory limits associated with both surface contamination and general area gamma radiation exposure rates.
2. The scope of the plan pertains only to the characterization survey performed at the site (specifically the internal parts of the enclosed domed building).

1.2 Limitations

- Beta-gamma contamination and gamma radiation surveys performed during this survey should only be used as described in the introduction section of this plan. Survey results shall not be used to make release decisions for the site.
- The characterization survey shall be performed by a qualified LMS RCT using functional and calibrated LMS radiological survey instruments and equipment or appropriate and acceptable vendor-supplied radiological instrumentation.
- Characterization surveys, instrument preoperational checks, and recording of the survey results shall be performed in accordance with the *Radiation Protection Program Plan* (LMS/POL/S04373), *Radiological Control Manual* (LMS/POL/S04322), and Radiological Control (RadCon) implementing procedures. If a conflict exists between this plan and the *Radiation Protection Program Plan*, *Radiological Control Manual*, or the RadCon

implementing procedures, then the RCT shall follow the requirements and guidance identified in the *Radiation Protection Program Plan*, *Radiological Control Manual*, and the RadCon implementing procedures.

- As of 2024, the enclosed domed building is not ventilated or heated or cooled, and ambient outside temperatures likely drive internal dome temperatures. During the summer months, it is expected that internal dome temperatures will reach temperatures at which heat stress monitoring and controls will be required and implemented. During the winter months, it is expected that internal dome temperatures will reach temperatures at which cold stress monitoring and controls will be required and implemented. Work restrictions and controls for heat or cold stress will be identified on the site's job safety analysis and shall be followed in accordance with appropriate LMS Safety and Health (S&H) procedure and requirements.

2.0 Survey and S&H Equipment and Supplies

Knowing that the site is located out of the country and that necessary LMS S&H and RadCon supplies and equipment might be limited or not available in San Juan or Rincón, Puerto Rico, it is necessary to identify needed equipment and supplies and then purchase them in the United States and have the equipment and supplies shipped to the site (if equipment and supplies are not already there) along with other LMS radiological instrumentation.

Recommended S&H and RadCon supplies and equipment include the following:

- 2 each: Bicron/ThermoScientific Microrem Meter instrument or equivalent
- 2 each: Ludlum Model 26 instrument or equivalent
- 200 Rad Dawg smears or equivalent
- 5 radiological waste plastic bags
- 3 each: Radioactive Material Area and Contamination Area signs and attachment mechanisms
- 10 pairs of Tyvek coveralls (appropriate sizes) or equivalent
- 2 boxes of nitrile gloves (appropriate sizes) or equivalent
- 1 roll of duct tape
- 2 pairs of rubber overshoes
- 10 pairs of plastic liners
- 2 one-gallon pump-sprayer bottles
- 4 pairs of clear safety glasses
- 1 Wet Bulb Globe Temperature thermometer or equivalent thermometer

3.0 Survey Requirements

In accordance with the *Long-Term Surveillance and Maintenance Plan for the Boiling Nuclear Superheater (BONUS) Reactor Facility, Rincón, Puerto Rico* (LMS/BON/S01091); *Radiation Protection Program Plan*; and the *Radiological Control Manual*, several different characterization surveys are required for the site and are included as part of this plan.

3.1 Gamma Radiation Exposure Rate Survey

General area gamma radiation exposure rate surveys will be obtained at the 73 defined locations (Figure 1 through Figure 6) to determine the radiation level (in microroentgens per hour [μR/h] or similar dose rate result units) associated with the entombment structure and the accessible enclosed domed building. Additionally, five nonbiased gamma radiation exposure rate surveys will be performed in accessible areas commonly permitted for public access.

Results of the gamma radiation exposure rate surveys will be evaluated in real time and confirmatory, biased gamma radiation exposure rate surveys performed when any of the following survey result or physical site conditions exist:

- The RCT observes excessive deterioration of the structure(s) during the survey when compared to the previous year's structural condition
- Survey results from the identified survey locations indicate a gamma radiation exposure rate in excess of 0.4 milliroentgen per hour (400 μR/h)
- The RCT observes any conditions that justify an additional gamma radiation exposure rate survey be performed, at their discretion

Gamma radiation exposure rate survey results will be reported on the *BONUS Annual Survey Location and Results Data Sheet* (Attachment 1). In addition, gamma radiation exposure rate survey results will be recorded on a *Radiological Survey Map* form (LMS 1553) and be considered the official record of the characterization survey and its results.

If additional gamma radiation exposure rate surveys are performed, then identify the following information on the *BONUS Annual Survey Location and Results Data Sheet* (Attachment 1) and on the *Radiological Survey Map* form in the comments section:

- The reason for performing the additional survey(s)
- The location of the additional survey(s)
- Observations and conclusions relative to the survey(s), such as site conditions or equipment or item physical condition (e.g., extreme rust, paint chipping)

3.2 Contamination Level Survey

Direct beta-gamma surface contamination and transferable surface contamination smear surveys will be obtained at the 73 defined locations (Figure 1 through Figure 6) to determine the surface's contamination levels (in disintegrations per minute per 100 centimeters squared [dpm/100 cm^2] or similar surface contamination result units) for both transferable and total surface activity associated with the entombment structure and the accessible enclosed domed building. Additionally, five nonbiased direct beta-gamma surface contamination and transferable

surface contamination smear surveys will be performed in accessible areas commonly permitted for public access.

Results of the direct beta-gamma surface contamination and transferable surface contamination smear surveys will be evaluated in real-time and confirmatory, biased beta-gamma surface contamination and transferable surface contamination smear surveys will be performed when any of the following survey result or physical site conditions exist:

- The RCT observes excessive deterioration of the structure(s) during the survey when compared to the previous year's structural condition
- Survey results from the identified survey locations indicate contamination levels in excess of 1000 dpm (beta/gamma)/100 cm^2 transferable contamination or 5000 dpm (beta/gamma)/100 cm^2 total surface contamination
- The RCT observes any conditions that justify additional surface contamination surveys be performed, at their discretion

Results of direct beta-gamma surface contamination and transferable surface contamination smear surveys will be reported on the *BONUS Annual Survey Location and Results Data Sheet* (Attachment 1). In addition, the same results will be recorded on a *Radiological Survey Map* form and be considered the official record of the characterization survey and its results.

If additional direct beta-gamma surface contamination and transferable surface contamination smear surveys are performed, then identify the following information on the *BONUS Annual Survey Location and Results Data Sheet* (Attachment 1) and on the *Radiological Survey Map* form in the comments section:

- The reason for performing the additional survey(s)
- The location of the additional survey(s)
- Observations and conclusions relative to the survey result(s), such as site conditions or equipment or item physical condition (e.g., extreme rust, paint chipping)

4.0 Survey Instrumentation

Calibrated and functional radiological survey instruments shall be used to perform the characterization survey at the site. Appropriate beta-gamma surface contamination survey instruments include Ludlum Model 26, Ludlum Model 3000 with 44-9 Geiger Mueller (GM) probe, and Thermo Scientific FH40 Geiger (G) with FHZ 732 GM probe. Appropriate gamma radiation exposure rate survey instruments include Thermo Scientific or Bicron microrem meter, ThermoScientific FH 40 G, and Ludlum ion chamber meters. Instruments shall be operated in accordance with the instrument's operating manual and LMS RadCon implementing procedures.

Knowing that the site is located out of the country and that radiological survey instrumentation is likely not available in San Juan or Rincón, it is recommended that two of each instrument type (gamma radiation exposure rate and surface contamination) be acquired (either from the LMS radiological instrument inventory or from an acceptable radiological instrument vendor), packaged for shipment, and then shipped to the site (if radiological instrumentation is not already there).

5.0 Survey Documentation

Characterization surveys shall be documented on a *Radiological Survey Map* in accordance with the *Radiological Control Manual* and the *Documenting Radiological Surveys* (LMS/PRO/S20073) procedure. In addition, characterization survey results shall be recorded on the *BONUS Annual Survey Location and Results Data Sheet* (Attachment 1).

6.0 Survey Result Evaluation

Characterization survey results shall be evaluated initially for correctness and completeness. This is accomplished by submitting the completed survey documentation (e.g., *Radiological Survey Map*) to an LMS senior health physicist for review and approval.

7.0 Survey Result Comparison

Reviewed and approved characterization survey results shall be compared against regulatory limits and also against the previous year's characterization survey results.

7.1 Regulatory Limit Comparison

[1] Using reviewed and approved characterization survey results, compare surface contamination values against Table 2, "Summary of Surface Contamination Values in dpm/100 cm2 (10 CFR 835 Appendix D)," in the *Radiological Control Manual*.

[a] If removable or fixed surface contamination characterization survey results exceed *Radiological Control Manual* limits for areas at the site that are not currently radiologically controlled, then contact the RadCon manager immediately.

[b] If removable or fixed surface contamination characterization survey results are equal to or below *Radiological Control Manual* limits for areas at the site that are not currently radiologically controlled, then inform the site lead that surface contamination is within regulatory limits.

[2] Using reviewed and approved characterization survey results, compare gamma radiation exposure rate values against 400 µR/h (above background).

[a] If gamma radiation exposure rate characterization survey results exceed 400 µR/h (above background) for areas at the site that are not currently radiologically controlled, then contact the RadCon manager immediately.

[b] If gamma radiation exposure rate characterization survey results are equal to or less than 400 µR/h (above background) for areas at the site that are not currently radiologically controlled, then inform the site lead that gamma radiation exposure rates are equal to or below 400 µR/h (above background).

7.2 Previous Year's Results Comparison

Using the characterization survey results recorded on the *BONUS Annual Survey Location and Results Data Sheet* (Attachment 1), compare them against the previous year's characterization survey results.

If current characterization survey results are different by more than 2 sigma of the previous year's characterization survey results, then an LMS senior health physicist shall perform a review of the difference(s), document the review, and submit the review to the LMS site lead.

8.0 Figures

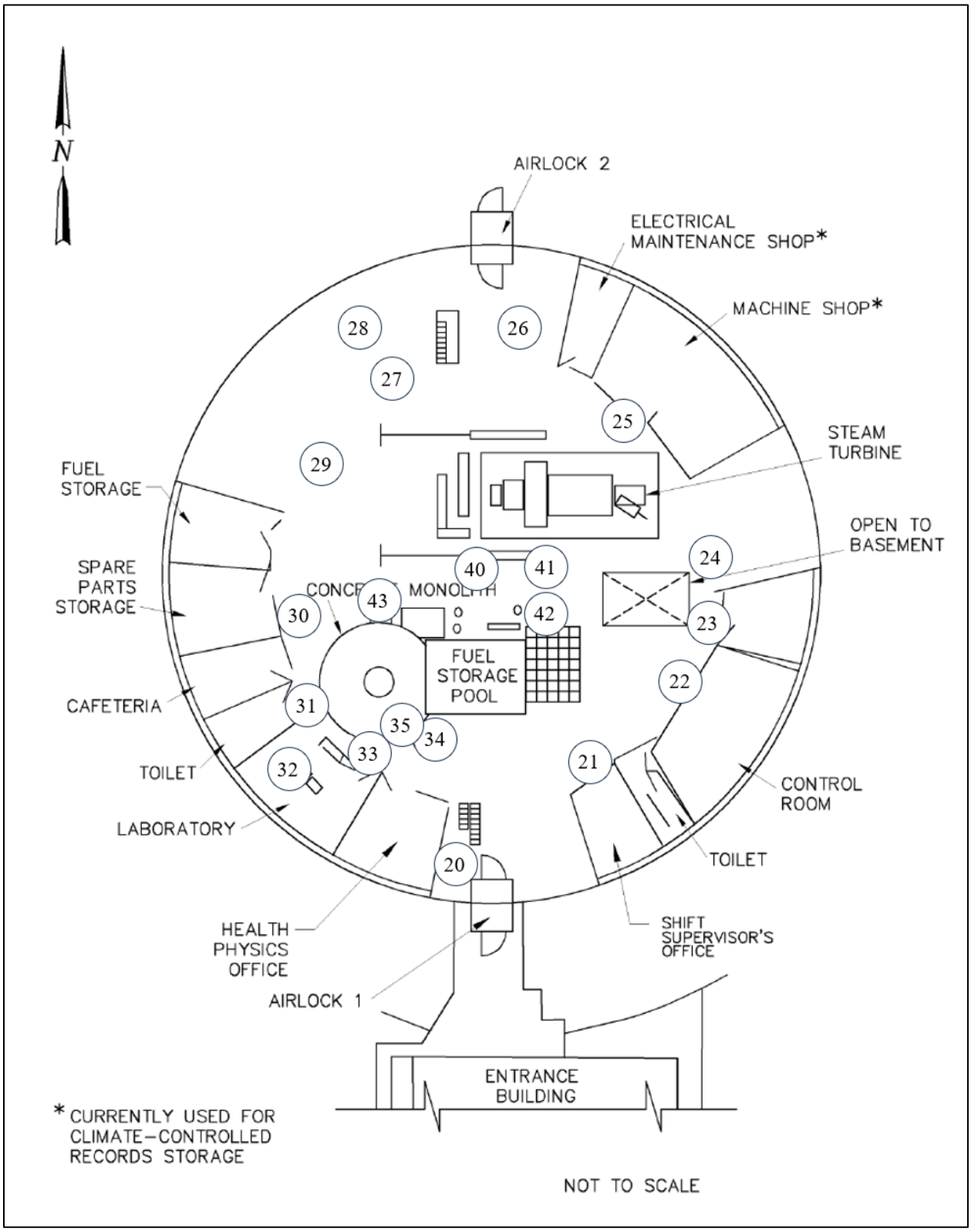


Figure 1. Main Floor Survey Locations

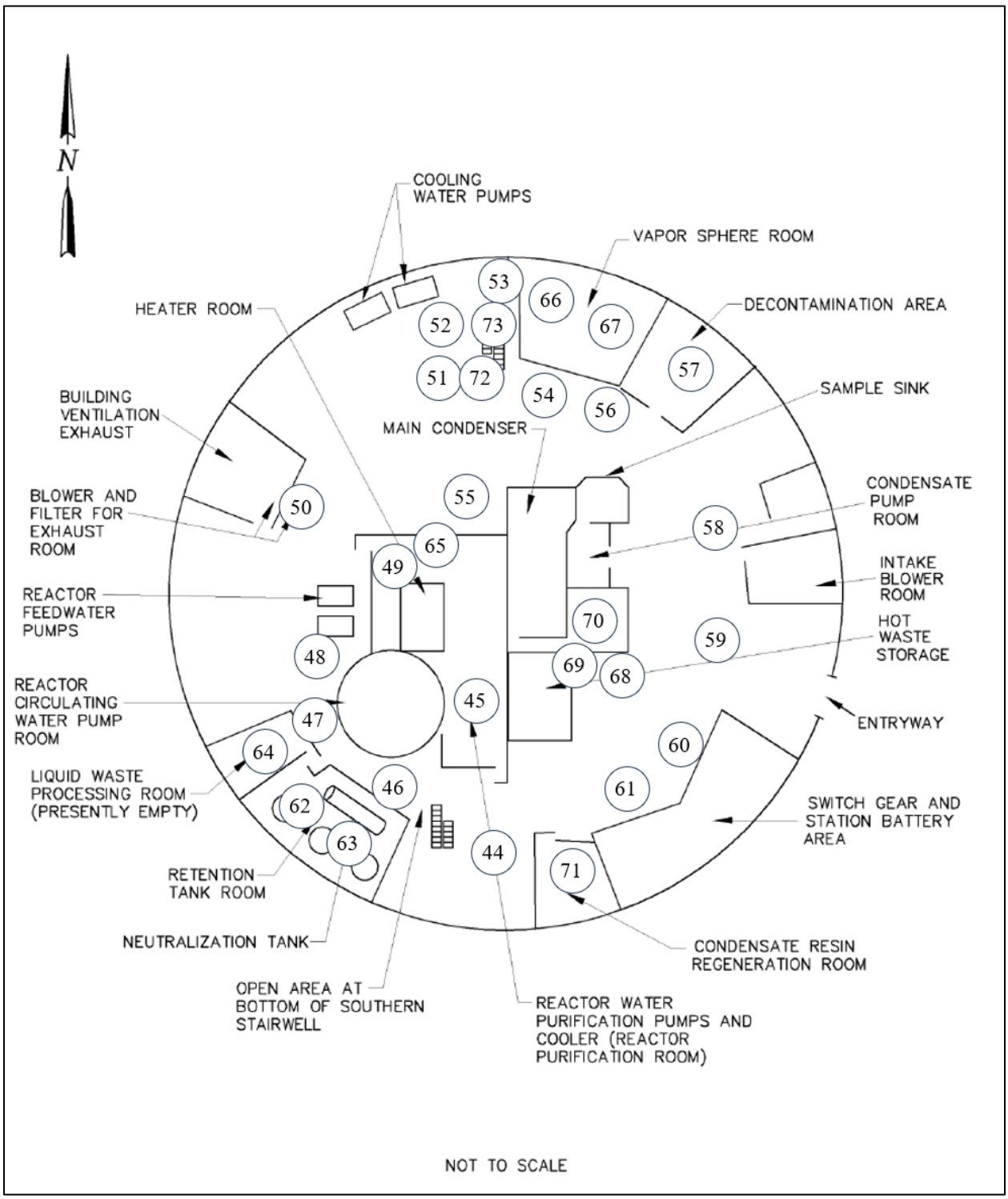


Figure 2. Basement Floor Survey Locations

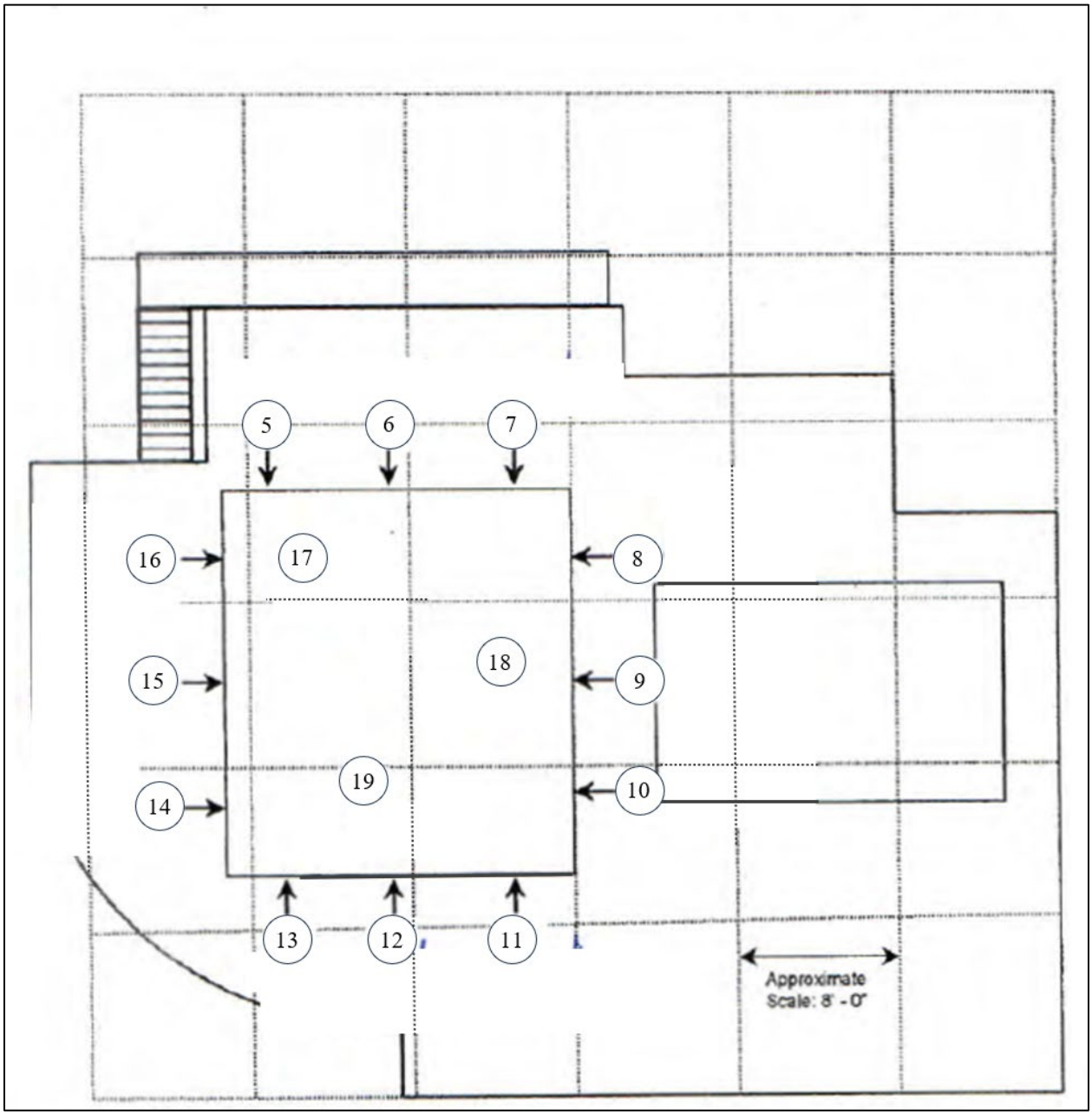


Figure 3. Monolith Top Plug Structure

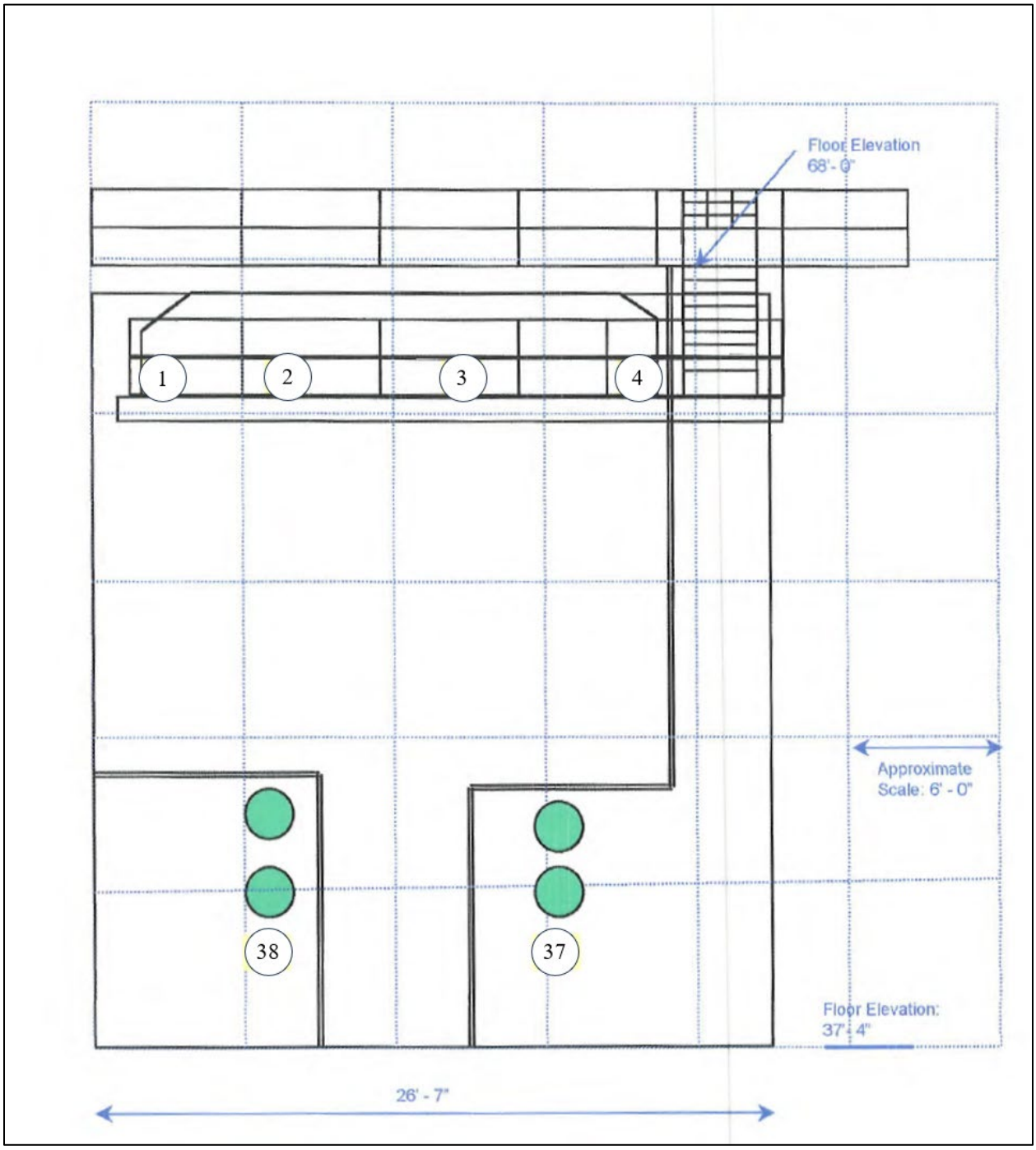


Figure 4. Entombment System—North View

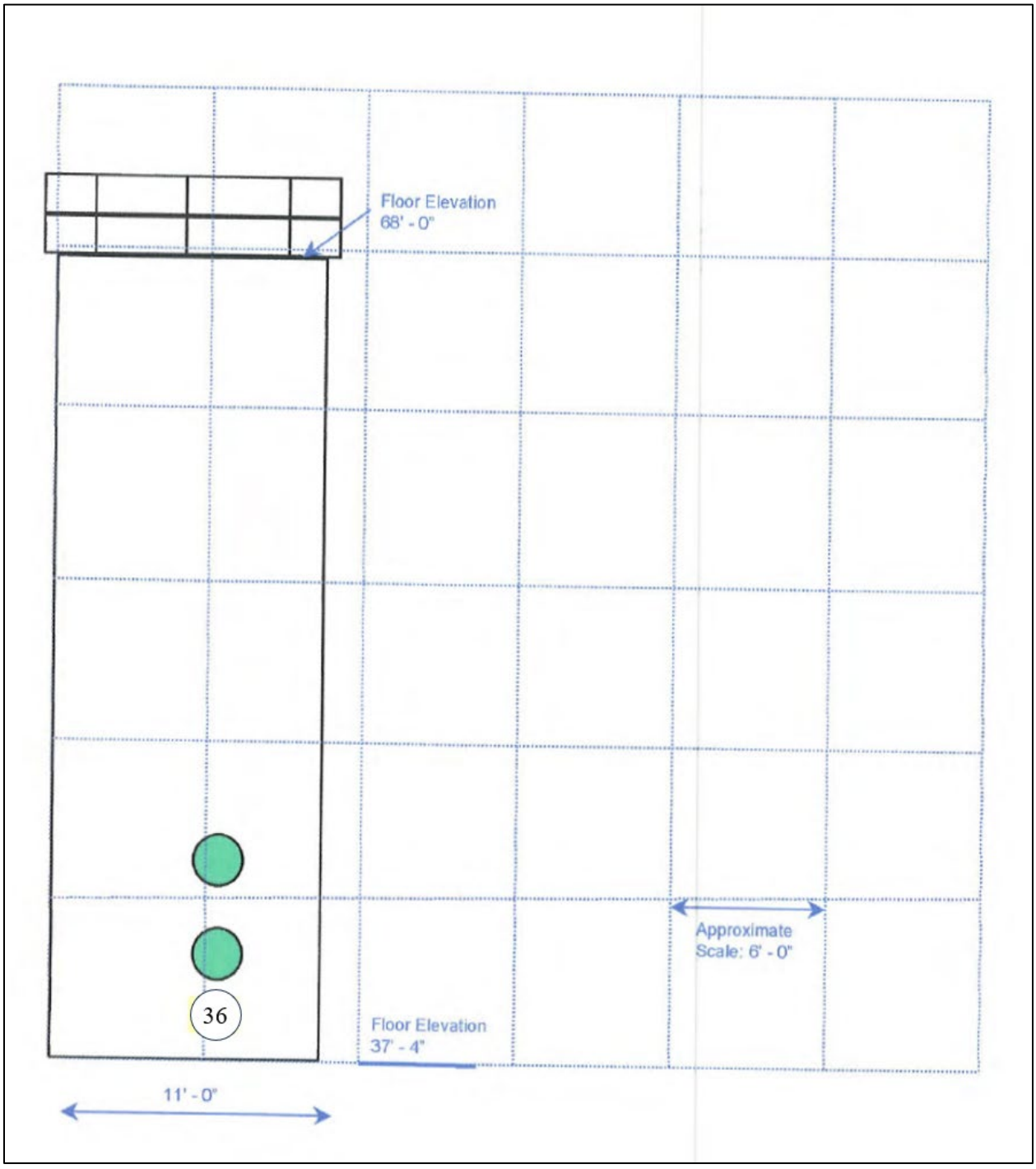


Figure 5. Entombment System—South View

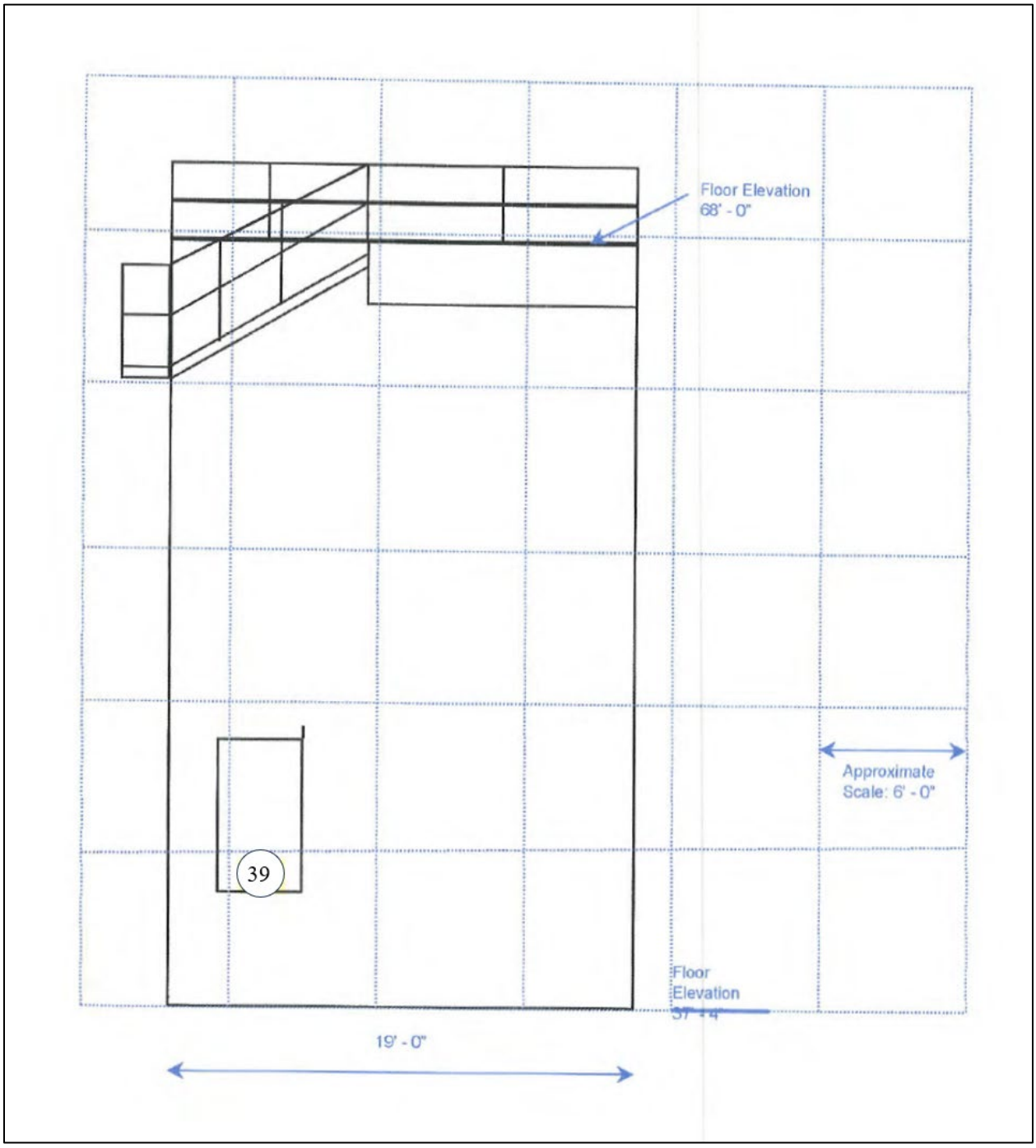


Figure 6. Entombment System—North View

9.0 References

10 CFR 835. "Occupational Radiation Protection," *Code of Federal Regulations*.

Documenting Radiological Surveys, LMS/PRO/S20073, continually updated, prepared by the LMS contractor for the U.S. Department of Energy Office of Legacy Management.

Long-Term Surveillance and Maintenance Plan for the Boiling Nuclear Superheater (BONUS) Reactor Facility, Rincón, Puerto Rico, LMS/BON/S01091, continually updated, prepared by the LMS contractor for the U.S. Department of Energy Office of Legacy Management.

Radiation Protection Program Plan, LMS/POL/S04373, continually updated, prepared by the LMS contractor for the U.S. Department of Energy Office of Legacy Management.

Radiological Control Manual, LMS/POL/S04322, continually updated, prepared by the LMS contractor for the U.S. Department of Energy Office of Legacy Management.

Records and Information Management, LM-Policy-1-11-1.0, continually updated, prepared by the Office of Legacy Management, March.

Attachment 1

BONUS Annual Survey Location and Results Data Sheet

RCT Name: _____ **Survey Date:** _____

Exposure Rate Instrument Information

Survey Instrument Model: _____
Instrument Serial Number: _____
Calibration Due Date: _____
Time of Daily Response Check: _____
Background Exposure Rate (μR/h): _____

Surface Contamination Instrument Information

Survey Instrument Model: _____
Instrument Serial Number: _____
Calibration Due Date: _____
Time of Daily Response Check: _____

Survey ID	Survey Location	Exposure Result (μR/h)	Removable Contamination (dpm/100cm^2)	Total Contamination (dpm/100cm^2)	Comment
1	Pipe Chase Face #1				Monolith Top
2	Pipe Chase Face #2				Monolith Top
3	Pipe Chase Face #3				Monolith Top
4	Pipe Chase Face #4				Monolith Top
5	Top Plug Face #1—Left				Monolith Top
6	Top Plug Face #1—Center				Monolith Top
7	Top Plug Face #1—Right				Monolith Top
8	Top Plug Face #2—Top				Monolith Top
9	Top Plug Face #2—Center				Monolith Top
10	Top Plug Face #2—Bottom				Monolith Top
11	Top Plug Face #3—Right				Monolith Top
12	Top Plug Face #3—Center				Monolith Top
13	Top Plug Face #3—Left				Monolith Top
14	Top Plug Face #4—Bottom				Monolith Top
15	Top Plug Face #4—Center				Monolith Top
16	Top Plug Face #4—Top				Monolith Top
17	Top Plug Top Surface—Upper Left				Monolith Top
18	Top Plug Top Surface—Center Right				Monolith Top
19	Top Plug Top Surface—Center Bottom				Monolith Top
20	Main Floor—Zone 1				Main Level—Public Access
21	Main Floor—Zone 2				Main Level—Public Access
22	Main Floor—Zone 3				Main Level—Public Access
23	Main Floor—Zone 4				Main Level—Public Access
24	Main Floor—Zone 5				Main Level—Public Access
25	Main Floor—Zone 6				Main Level—Public Access

Survey ID	Survey Location	Exposure Result (μR/h)	Removable Contamination (dpm/100cm^2)	Total Contamination (dpm/100cm^2)	Comment
26	Main Floor—Zone 7				Main Level—Public Access
27	Main Floor—Zone 8				Main Level—Public Access
28	Main Floor—Zone 9				Main Level—Public Access
29	Main Floor—Zone 10				Main Level—Public Access
30	Main Floor—Zone 11				Main Level—Public Access
31	Main Floor—Zone 12				Main Level—Public Access
32	Main Floor—Zone 13				Main Level—Public Access
33	Main Floor—Zone 14				Main Level—Public Access
34	Main Floor Water Column #1				Main Level—Controlled Area
35	Main Floor Water Column #2				Main Level—Controlled Area
36	Instrument Thimble #1				Main Level—Controlled Area
37	Instrument Thimble #2				Main Level—Controlled Area
38	Instrument Thimble #3				Main Level—Controlled Area
39	Pipe Chase Exit Hatch				Main Level—Controlled Area
40	Fuel Pool Purifier—Floor #1				Main Level—Contaminated Area
41	Fuel Pool Purifier—Floor #2				Main Level—Controlled Area
42	Fuel Pool Purifier—Floor #3				Main Level—Controlled Area
43	Fuel Pool Purifier—Floor #4				Main Level—Controlled Area
44	Basement Floor—Zone 1				Basement Level
45	Basement Floor—Zone 2				Basement Level
46	Basement Floor—Zone 3				Basement Level
47	Basement Floor—Zone 4				Basement Level
48	Basement Floor—Zone 5				Basement Level
49	Basement Floor—Zone 6				Basement Level
50	Basement Floor—Zone 7				Basement Level
51	Basement Floor—Zone 8				Basement Level
52	Basement Floor—Zone 9				Basement Level
53	Basement Floor—Zone 10				Basement Level
54	Basement Floor—Zone 11				Basement Level
55	Basement Floor—Zone 12				Basement Level
56	Basement Floor—Zone 13				Basement Level
57	Basement Floor—Zone 14				Basement Level

Survey ID	Survey Location	Exposure Result (µR/h)	Removable Contamination (dpm/100cm^2)	Total Contamination (dpm/100cm^2)	Comment
58	Basement Floor—Zone 15				Basement Level
59	Basement Floor—Zone 16				Basement Level
60	Basement Floor—Zone 17				Basement Level
61	Basement Floor—Zone 18				Basement Level
62	Side of Liquid Waste Tank #1				Basement Level
63	Side of Liquid Waste Tank #2				Basement Level
64	Column 4 and 5 Inside Room				Basement Level
65	Heater Room (Wall)				Basement Level
66	Vapor Sphere Room—Upper Left				Basement Level
67	Vapor Sphere Room—Center Right				Basement Level
68	Water Pump Room to the Right, Enter 50A				Basement Level
69	Condenser Room Entry Wall—Block				Basement Level
70	Condenser Room Entry Wall—Concrete				Basement Level
71	South Room with 2 pumps				Basement Level
72	Under Stairs Near North Door—Floor #1				Basement Level
73	Under Stairs Near North Door—Floor #2				Basement Level
74					
75					
76					
77					
78					

Abbreviations: dpm/100cm^2 = disintegrations per minute per 100 square centimeters, ID = identifier, µR/h = microroentgens per hour, RCT = radiological control technician

Attachment 2

Completed BONUS Annual Survey Location and Results Data Sheet, from the *Annual LMS Radiological Characterization Survey Plan for the BONUS, Puerto Rico, Decommissioned Reactor Site LMS RadCon Survey Plan Number: 24-001*, June 2024, LMS/BON/48092

Radiological Survey Number: 240722-002

RCT Name: Larry Oeffner/Mike McDonald **Survey Date:** 7-16/17-2024

Exposure Rate Instrument Info

Survey Instrument Model: Thermo Microrem
Instrument Serial Number: 19288
Calibration Due Date: 8/17/2024
Time of Daily Response Check: 0947/0830
Background Exposure Rate (μR/h): 17/38 (main/basement)

Surface Contamination Instrument Info

Survey Instrument Model: Ludlum 26
Instrument Serial Number: PF009836
Calibration Due Date: 2/6/2025
Time of Daily Response Check: 0947/0830

Survey ID	Survey Location	2024 Exposure Result (μrem/hr)	2024 Removable Contamination (dpm/100cm^2)	2024 Total Contamination (dpm/100cm^2)	General Location	Comment
L1	Pipe Chase Face #1	20	26	< Sc	Monolith Top	
L2	Pipe Chase Face #2	20	< Sc	< Sc	Monolith Top	
L3	Pipe Chase Face #3	20	< Sc	< Sc	Monolith Top	
L4	Pipe Chase Face #4	20	< Sc	495	Monolith Top	
L5	Top Plug Face #1 - left	12	< Sc	< Sc	Monolith Top	
L6	Top Plug Face #1 - center	10	< Sc	< Sc	Monolith Top	
L7	Top Plug Face #1 - right	10	< Sc	495	Monolith Top	
L8	Top Plug Face #2 - top	11	< Sc	730	Monolith Top	
L9	Top Plug Face #2 - center	12	< Sc	1908	Monolith Top	
L10	Top Plug Face #2 - bottom	10	< Sc	683	Monolith Top	
L11	Top Plug Face #3 - right	10	< Sc	447	Monolith Top	
L12	Top Plug Face #3 - center	12	< Sc	565	Monolith Top	
L13	Top Plug Face #3 - left	13	< Sc	< Sc	Monolith Top	
L14	Top Plug Face #4 - bottom	12	< Sc	< Sc	Monolith Top	
L15	Top Plug Face #4 - center	12	< Sc	612	Monolith Top	
L16	Top Plug Face #4 - top	12	< Sc	612	Monolith Top	
L17	Top Plug Top Surface - upper left	12	< Sc	471	Monolith Top	
L18	Top Plug Top Surface - center right	12	< Sc	< Sc	Monolith Top	
L19	Top Plug Top Surface - center bottom	14	35	< Sc	Monolith Top	
L20	Main Floor Zone 1	14	< Sc	< Sc	Main Level-Public Access	
L21	Main Floor Zone 2	14	< Sc	< Sc	Main Level-Public Access	
L22	Main Floor Zone 3	15	< Sc	< Sc	Main Level-Public Access	
L23	Main Floor Zone 4	17	< Sc	707	Main Level-Public Access	
L24	Main Floor Zone 5	17	< Sc	777	Main Level-Public Access	
L25	Main Floor-Zone 6	17	< Sc	942	Main Level-Public Access	
L26	Main Floor-Zone 7	18	< Sc	< Sc	Main Level-Public Access	
L27	Main Floor-Zone 8	17	< Sc	< Sc	Main Level-Public Access	
L28	Main Floor-Zone 9	17	< Sc	< Sc	Main Level-Public Access	
L29	Main Floor-Zone 10	17	28	683	Main Level-Public Access	
L30	Main Floor-Zone 11	15	< Sc	< Sc	Main Level-Public Access	
L31	Main Floor-Zone 12	17	< Sc	< Sc	Main Level-Public Access	
L32	Main Floor-Zone 13	18	< Sc	542	Main Level-Public Access	
L33	Main Floor-Zone 14	17	< Sc	777	Main Level-Public Access	
L34	Main Floor Water Column - center bottom	18	28	542	Main Level-Controlled Area	
L35	Main Floor Water Column - right middle	15	< Sc	< Sc	Main Level-Controlled Area	
L36	Instrument Thimble #1	22	< Sc	< Sc	Main Level-Controlled Area	
L37	Instrument Thimble #2	20	< Sc	< Sc	Main Level-Controlled Area	
L38	Instrument Thimble #3	16	< Sc	< Sc	Main Level-Controlled Area	
L39	Pipe Chase Ext Hatch	22	26	< Sc	Main Level-Controlled Area	
L40	Fuel Pool Purifier. Floor #1	30	< Sc	18699	Main Level-Contaminated Area	
L41	Fuel Pool Purifier. Floor #2	30	< Sc	942	Main Level-Controlled Area	
L42	Fuel Pool Purifier. Floor #3	30	< Sc	495	Main Level-Controlled Area	

Radiological Survey Number: 240722-002

RCT Name: Larry Oeffner/Mike McDonald **Survey Date:** 7-16/17-2024

Exposure Rate Instrument Info

Survey Instrument Model: Thermo Microrem
Instrument Serial Number: 19288
Calibration Due Date: 8/17/2024
Time of Daily Response Check: 0947/0830
Background Exposure Rate (μR/h): 17/38 (main/basement)

Surface Contamination Instrument Info

Survey Instrument Model: Ludlum 26
Instrument Serial Number: PF009836
Calibration Due Date: 2/6/2025
Time of Daily Response Check: 0947/0830

Survey ID	Survey Location	2024 Exposure Result (μrem/hr)	2024 Removable Contamination (dpm/100cm^2)	2024 Total Contamination (dpm/100cm^2)	General Location	Comment
L43	Fuel Pool Purifier. Floor #4	30	< Sc	< Sc	Main Level-Controlled Area	
L44	Basement Floor-Zone 1	40	< Sc	< Sc	Basement Level	
L45	Basement Floor-Zone 2	40	< Sc	< Sc	Basement Level	
L46	Basement Floor-Zone 3	40	< Sc	< Sc	Basement Level	
L47	Basement Floor-Zone 4	35	35	< Sc	Basement Level	
L48	Basement Floor-Zone 5	35	< Sc	< Sc	Basement Level	
L49	Basement Floor-Zone 6	35	< Sc	< Sc	Basement Level	
L50	Basement Floor-Zone 7	40	< Sc	< Sc	Basement Level	
L51	Basement Floor-Zone 8	40	< Sc	< Sc	Basement Level	
L52	Basement Floor-Zone 9	40	< Sc	< Sc	Basement Level	
L53	Basement Floor-Zone 10	35	< Sc	< Sc	Basement Level	
L54	Basement Floor-Zone 11	35	< Sc	< Sc	Basement Level	
L55	Basement Floor-Zone 12	40	< Sc	< Sc	Basement Level	
L56	Basement Floor-Zone 13	35	< Sc	< Sc	Basement Level	
L57	Basement Floor-Zone 14	35	< Sc	< Sc	Basement Level	
L58	Basement Floor-Zone 15	35	< Sc	< Sc	Basement Level	
L59	Basement Floor-Zone 16	40	< Sc	495	Basement Level	
L60	Basement Floor-Zone 17	35	< Sc	< Sc	Basement Level	
L61	Basement Floor-Zone 18	40	< Sc	< Sc	Basement Level	
L62	Side of Liq. Waste Ret. Tank #1	40	< Sc	< Sc	Basement Level	
L63	Side of Liq. Waste Ret. Tank #2	40	< Sc	< Sc	Basement Level	
L64	Column 4 and 5 inside room	40	< Sc	< Sc	Basement Level	
L65	F.W. Heater Room (Wall)	40	< Sc	< Sc	Basement Level	
L66	Vapor Sphere Room - upper left	40	< Sc	< Sc	Basement Level	
L67	Vapor Sphere Room - center right	35	< Sc	< Sc	Basement Level	
L68	Water pump room to the right, enter 50A	40	< Sc	< Sc	Basement Level	
L69	Condenser Room Entry Wall - block	40	< Sc	< Sc	Basement Level	
L70	Condenser Room Entry Wall - concrete	40	< Sc	< Sc	Basement Level	
L71	South room with 2 pumps	40	< Sc	< Sc	Basement Level	
L72	Under stairs near north door. Floor #1	40	< Sc	471	Basement Level	
L73	Under stairs near north door. Floor #2	40	< Sc	< Sc	Basement Level	
L74	Condensate Pump #2 Pedestal	40	< Sc	942	Basement Level	Nonbiased survey location chosen by the RCT
L75	Basement Floor-Zone 5	35	< Sc	< Sc	Basement Level	Nonbiased survey location chosen by the RCT
L76	Display Area	19	< Sc	< Sc	Main Level-Public Access	Nonbiased survey location chosen by the RCT
L77	RadCon Storage Area	20	< Sc	< Sc	Main Level-Public Access	Nonbiased survey location chosen by the RCT
L78	Building Airlock Main Entry	18	< Sc	< Sc	Main Level-Public Access	Nonbiased survey location chosen by the RCT

Attachment 3

Radiological Survey Map Form (LMS 1553) for the BONUS, Puerto Rico, Decommissioned Reactor Site, July 16–17, 2024, Radiological Survey Number 240722-002

Radiological Survey Map

Radiological Survey Number: 240722-002 **Page** 1 **of** 6

Purpose: BONUS Reactor 2024 Annual Radiological Survey Truck #: Trailer #:

RWP number: Time: 9:50 AM Date: July 16 & 17, 2024

Site name: BONUS, PR, Decommissioned Reactor Site Location: Rincon, Puerto Rico

RCT (printed): Larry Oeffner, Mike McDonald Reviewer signature: SCOTT NEWSOM (Affiliate) Digitally signed by SCOTT NEWSOM (Affiliate) Date: 2024.08.12 08:20:56 -06'00' Date:

Counting Instruments:	Instrument 1	Instrument 2	Instrument 3	Radiation Instruments:	Instrument 4
Instrument/probe model:	Ludlum Model 3030		Ludlum Model 26	Instrument/probe model:	ThermoScient Microrem
Instrument serial number:	330877		PF009836	Instrument serial number:	19288
Probe serial number:				Probe serial number:	
Calibration due:	8/17/2024		2/6/2025	Calibration due:	8/17/2024
Efficiency:	α 0.34 β 0.43	α β	α β 0.276	Background (dose rate):	17/38 µrem/hr
Background (cpm):	α 0.10 β 39	α β	α β 46	Other info (as needed):	
S_C (dpm/100cm^2):	α 2 β 24	α β	α β 406	Dose rate background main level - 17 µrem/hr	
Area probe correction factor:	1.0		6.5	Dose rate background basement level - 38 µrem/hr	

Surface Contamination and Radiation Survey Results

Item Surveyed / Map Location	Counting Inst. No. Used	Smear Survey (Instrument 1 or 2)						Direct Survey (Instrument 3)						Exposure Rate Survey
		Gross Counts		Net Counts		Activity		Gross Counts		Net Counts		Activity		
		Alpha cpm	Beta/gamma cpm	Alpha cpm	Beta/gamma cpm	Alpha dpm/100cm^2	Beta/gamma dpm/100cm^2	Alpha cpm	Beta/gamma cpm	Alpha cpm	Beta/gamma cpm	Alpha dpm/100cm^2	Beta/gamma dpm/100cm^2	
L1	1	1	50	0.9	11.0	3	26		37		-9.0		< Sc	20
L2	1	1	40	0.9	1.0	3	< Sc		55		9.0		< Sc	20
L3	1	0	38	-0.1	-1.0	< Sc	< Sc		55		9.0		< Sc	20
L4	1	0	40	-0.1	1.0	< Sc	< Sc		67		21.0		495	20
L5	1	1	37	0.9	-2.0	3	< Sc		61		15.0		< Sc	12
L6	1	1	42	0.9	3.0	3	< Sc		60		14.0		< Sc	10
L7	1	0	30	-0.1	-9.0	< Sc	< Sc		67		21.0		495	10
L8	1	0	42	-0.1	3.0	< Sc	< Sc		77		31.0		730	11
L9	1	0	37	-0.1	-2.0	< Sc	< Sc		127		81.0		1908	12
L10	1	1	39	0.9	0.0	3	< Sc		75		29.0		683	10
L11	1	1	45	0.9	6.0	3	< Sc		65		19.0		447	10
L12	1	1	43	0.9	4.0	3	< Sc		70		24.0		565	12
L13	1	2	40	1.9	1.0	6	< Sc		41		-5.0		< Sc	13
L14	1	0	38	-0.1	-1.0	< Sc	< Sc		51		5.0		< Sc	12
L15	1	0	37	-0.1	-2.0	< Sc	< Sc		72		26.0		612	12
L16	1	1	32	0.9	-7.0	3	< Sc		72		26.0		612	12

RCT signature: LAWRENCE OEFFNER (Affiliate) Digitally signed by LAWRENCE OEFFNER (Affiliate) Date: 2024.08.01 13:17:12 -04'00' MICHAEL MCDONALD (Affiliate) Digitally signed by MICHAEL MCDONALD (Affiliate) Date: 2024.08.01 08:57:43 -06'00'

Radiological Survey Map

Radiological Survey Number: 240722-002 **Page** 2 **of** 6

Surface Contamination and Radiation Survey Results

Item Surveyed / Map Location	Counting Inst. No. Used	Smear Survey (Instrument 1 or 2)						Direct Survey (Instrument 3)						Exposure Rate Survey
		Gross Counts		Net Counts		Activity		Gross Counts		Net Counts		Activity		
		Alpha cpm	Beta/gamma cpm	Alpha cpm	Beta/gamma cpm	Alpha dpm/100cm^2	Beta/gamma dpm/100cm^2	Alpha cpm	Beta/gamma cpm	Alpha cpm	Beta/gamma cpm	Alpha dpm/100cm^2	Beta/gamma dpm/100cm^2	
L17	1	0	39	-0.1	0.0	< Sc	< Sc		66		20.0		471	12
L18	1	0	39	-0.1	0.0	< Sc	< Sc		62		16.0		< Sc	12
L19	1	1	54	0.9	15.0	3	35		42		-4.0		< Sc	14
L20	1	1	48	0.9	9.0	3	< Sc		46		0.0		< Sc	14
L21	1	1	42	0.9	3.0	3	< Sc		51		5.0		< Sc	14
L22	1	0	47	-0.1	8.0	< Sc	< Sc		47		1.0		< Sc	15
L23	1	0	39	-0.1	0.0	< Sc	< Sc		76		30.0		707	17
L24	1	1	44	0.9	5.0	3	< Sc		79		33.0		777	17
L25	1	0	49	-0.1	10.0	< Sc	< Sc		86		40.0		942	17
L26	1	0	40	-0.1	1.0	< Sc	< Sc		55		9.0		< Sc	18
L27	1	0	45	-0.1	6.0	< Sc	< Sc		62		16.0		< Sc	17
L28	1	2	40	1.9	1.0	6	< Sc		57		11.0		< Sc	17
L29	1	0	51	-0.1	12.0	< Sc	28		75		29.0		683	17
L30	1	0	45	-0.1	6.0	< Sc	< Sc		61		15.0		< Sc	15
L31	1	0	31	-0.1	-8.0	< Sc	< Sc		40		-6.0		< Sc	17
L32	1	0	39	-0.1	0.0	< Sc	< Sc		69		23.0		542	18
L33	1	0	42	-0.1	3.0	< Sc	< Sc		79		33.0		777	17
L34	1	1	51	0.9	12.0	3	28		69		23.0		542	18
L35	1	0	35	-0.1	-4.0	< Sc	< Sc		54		8.0		< Sc	15
L36	1	0	36	-0.1	-3.0	< Sc	< Sc		54		8.0		< Sc	22
L37	1	0	42	-0.1	3.0	< Sc	< Sc		48		2.0		< Sc	20
L38	1	0	26	-0.1	-13.0	< Sc	< Sc		46		0.0		< Sc	16
L39	1	1	50	0.9	11.0	3	26		58		12.0		< Sc	22
L40	1	1	37	0.9	-2.0	3	< Sc		840		794.0		18699	30
L41	1	1	37	0.9	-2.0	3	< Sc		86		40.0		942	30
L42	1	0	38	-0.1	-1.0	< Sc	< Sc		67		21.0		495	30
L43	1	2	33	1.9	-6.0	6	< Sc		60		14.0		< Sc	30
L44	1	0	25	-0.1	-14.0	< Sc	< Sc		43		-3.0		< Sc	40
L45	1	0	41	-0.1	2.0	< Sc	< Sc		38		-8.0		< Sc	40
L46	1	1	47	0.9	8.0	3	< Sc		43		-3.0		< Sc	40
L47	1	0	54	-0.1	15.0	< Sc	35		39		-7.0		< Sc	35
L48	1	0	41	-0.1	2.0	< Sc	< Sc		38		-8.0		< Sc	35

Radiological Survey Map

Radiological Survey Number: 240722-002 **Page** 3 **of** 6

Surface Contamination and Radiation Survey Results

Item Surveyed / Map Location	Counting Inst. No. Used	Smear Survey (Instrument 1 or 2)						Direct Survey (Instrument 3)						Exposure Rate Survey
		Gross Counts		Net Counts		Activity		Gross Counts		Net Counts		Activity		
		Alpha cpm	Beta/gamma cpm	Alpha cpm	Beta/gamma cpm	Alpha dpm/100cm^2	Beta/gamma dpm/100cm^2	Alpha cpm	Beta/gamma cpm	Alpha cpm	Beta/gamma cpm	Alpha dpm/100cm^2	Beta/gamma dpm/100cm^2	
L49	1	1	46	0.9	7.0	3	< Sc		49		3.0		< Sc	35
L50	1	1	39	0.9	0.0	3	< Sc		34		-12.0		< Sc	40
L51	1	0	38	-0.1	-1.0	< Sc	< Sc		54		8.0		< Sc	40
L52	1	0	39	-0.1	0.0	< Sc	< Sc		31		-15.0		< Sc	40
L53	1	0	44	-0.1	5.0	< Sc	< Sc		43		-3.0		< Sc	35
L54	1	0	42	-0.1	3.0	< Sc	< Sc		44		-2.0		< Sc	35
L55	1	0	41	-0.1	2.0	< Sc	< Sc		30		-16.0		< Sc	40
L56	1	0	31	-0.1	-8.0	< Sc	< Sc		43		-3.0		< Sc	35
L57	1	0	37	-0.1	-2.0	< Sc	< Sc		34		-12.0		< Sc	35
L58	1	0	37	-0.1	-2.0	< Sc	< Sc		33		-13.0		< Sc	35
L59	1	1	35	0.9	-4.0	3	< Sc		67		21.0		495	40
L60	1	1	32	0.9	-7.0	3	< Sc		51		5.0		< Sc	35
L61	1	0	42	-0.1	3.0	< Sc	< Sc		36		-10.0		< Sc	40
L62	1	2	33	1.9	-6.0	6	< Sc		34		-12.0		< Sc	40
L63	1	0	33	-0.1	-6.0	< Sc	< Sc		46		0.0		< Sc	40
L64	1	0	29	-0.1	-10.0	< Sc	< Sc		45		-1.0		< Sc	40
L65	1	1	39	0.9	0.0	3	< Sc		46		0.0		< Sc	40
L66	1	0	36	-0.1	-3.0	< Sc	< Sc		32		-14.0		< Sc	40
L67	1	0	44	-0.1	5.0	< Sc	< Sc		37		-9.0		< Sc	35
L68	1	0	46	-0.1	7.0	< Sc	< Sc		40		-6.0		< Sc	40
L69	1	0	36	-0.1	-3.0	< Sc	< Sc		43		-3.0		< Sc	40
L70	1	1	47	0.9	8.0	3	< Sc		23		-23.0		< Sc	40
L71	1	0	37	-0.1	-2.0	< Sc	< Sc		41		-5.0		< Sc	40
L72	1	0	34	-0.1	-5.0	< Sc	< Sc		66		20.0		471	40
L73	1	1	39	0.9	0.0	3	< Sc		62		16.0		< Sc	40
L74	1	0	31	-0.1	-8.0	< Sc	< Sc		86		40.0		942	40
L75	1	2	23	1.9	-16.0	6	< Sc		55		9.0		< Sc	35
L76	1	0	36	-0.1	-3.0	< Sc	< Sc		47		1.0		< Sc	19
L77	1	1	34	0.9	-5.0	3	< Sc		55		9.0		< Sc	20

Radiological Survey Map

Radiological Survey Number: 240722-002 **Page** 4 **of** 6

Surface Contamination and Radiation Survey Results

Item Surveyed / Map Location	Counting Inst. No. Used	Smear Survey (Instrument 1 or 2)						Direct Survey (Instrument 3)						Exposure Rate Survey
		Gross Counts		Net Counts		Activity		Gross Counts		Net Counts		Activity		
		Alpha cpm	Beta/gamma cpm	Alpha cpm	Beta/gamma cpm	Alpha dpm/100cm^2	Beta/gamma dpm/100cm^2	Alpha cpm	Beta/gamma cpm	Alpha cpm	Beta/gamma cpm	Alpha dpm/100cm^2	Beta/gamma dpm/100cm^2	
L78	1	0	39	-0.1	0.0	< Sc	< Sc		36		-10.0		< Sc	18

Applicable Surface Contamination Limits

Check one for alpha, one for beta.

Alpha (removable/total)	☐	1000/5000	☐ 200/1000	☐ 20/500
Beta (removable/total)	☑	1000/5000	☐ 200/1000	

Activity Equation

Gross count minus BKGD count = Net count

Net count/Eff = dpm

Dpm x Area Probe Correction Factor (APCF) = dpm/100cm^2

APCE

44-9 = 6.5

FHZ 732 (GM) = 6.5

43-10-1 = 1

Remarks:

- See attached survey location maps and gross instrument reading results table.
- 1 minute background verification counts were performed on the Ludlum 3030 after smear numbers 20, 40, 60 and 78. Verification counts were appropriate and showed no instrument contamination during smear counting.

Radiological Survey Map

Radiological Survey Number: 240722-002 **Page** 5 **of** 6

Contamination and Radiation Survey Figure

Standardized Map Symbols

○ = Smear/wipe (no. inside)
△ = Air sample (no. inside)
6.3 = General area exposure rate (result in µR/hr)
✱ = Contact exposure rate (result beside, in µR/hr)
\# = Direct frisk (count rate) (result beside)
☆ = Direct gamma (count rate) (e.g., 2"x2" NaI) (result beside)

Note: Note units used if not identified above.

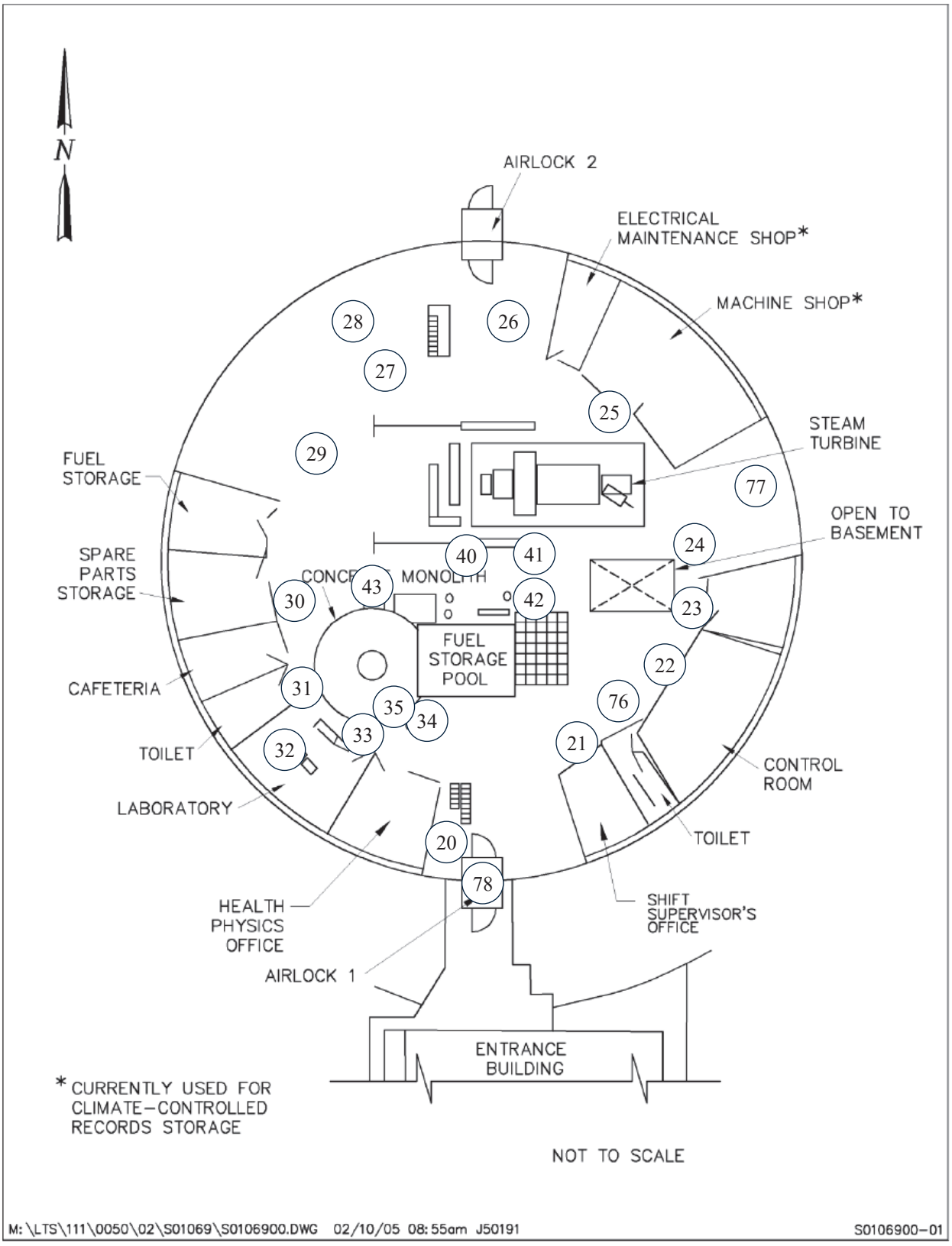
(Place figure in this area.)

Remarks:

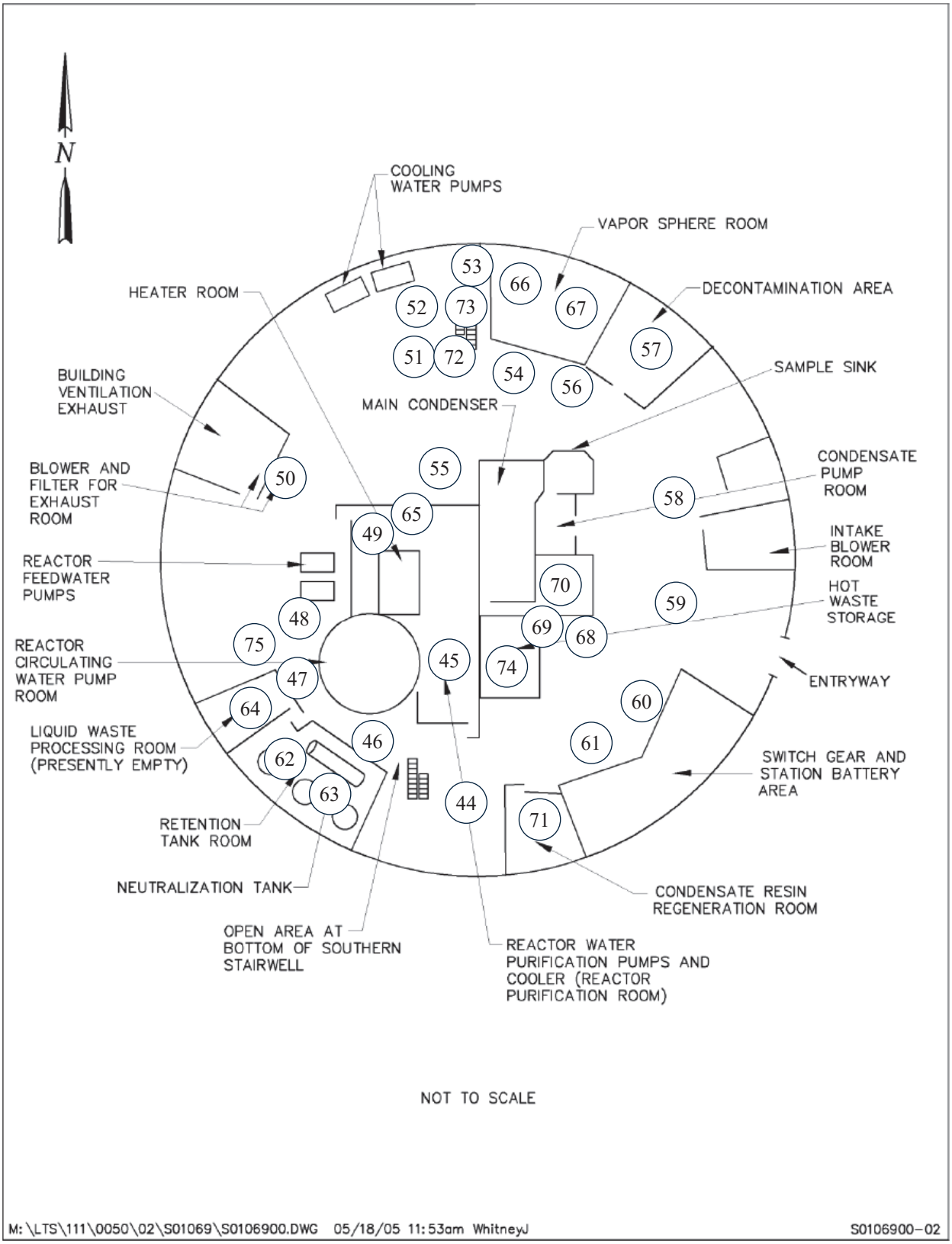
Radiological Survey Map

Radiological Survey Number: 240722-002 **Page** 6 **of** 6

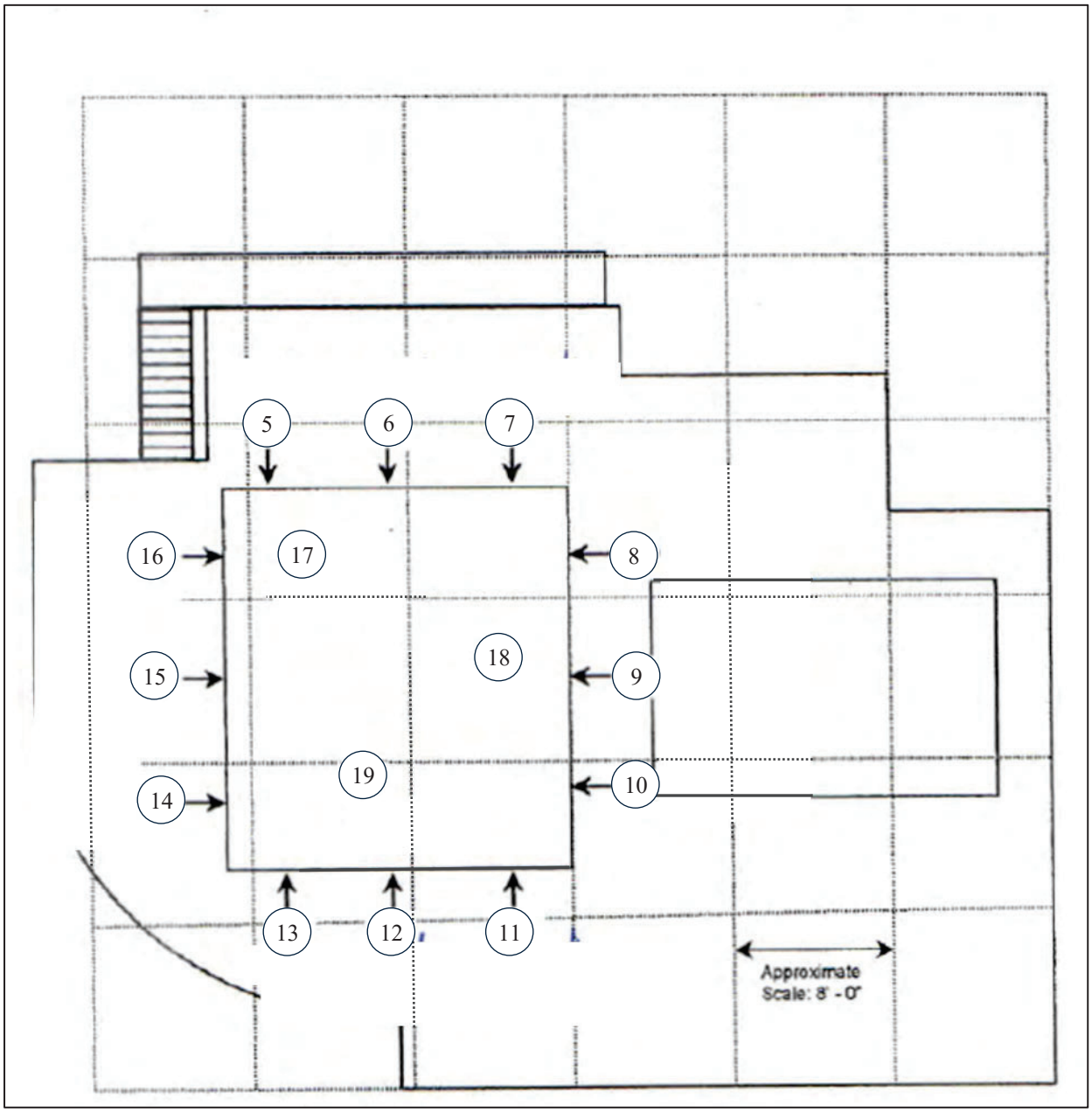
Contamination and Radiation Survey Continuation Sheet
Use this sheet to document or record radiological survey information (in addition to page 1 of the form)



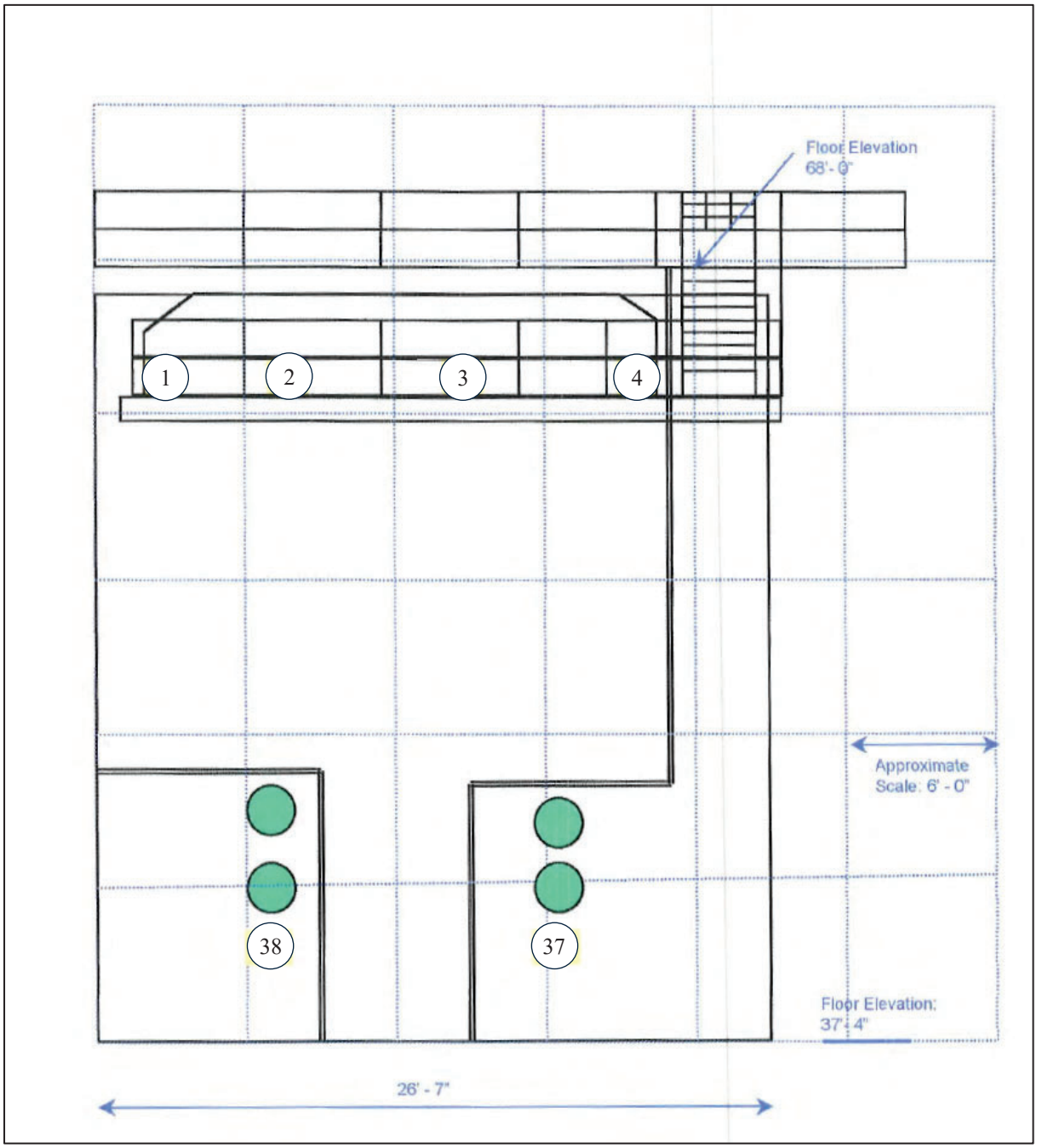
Main Floor Survey Locations



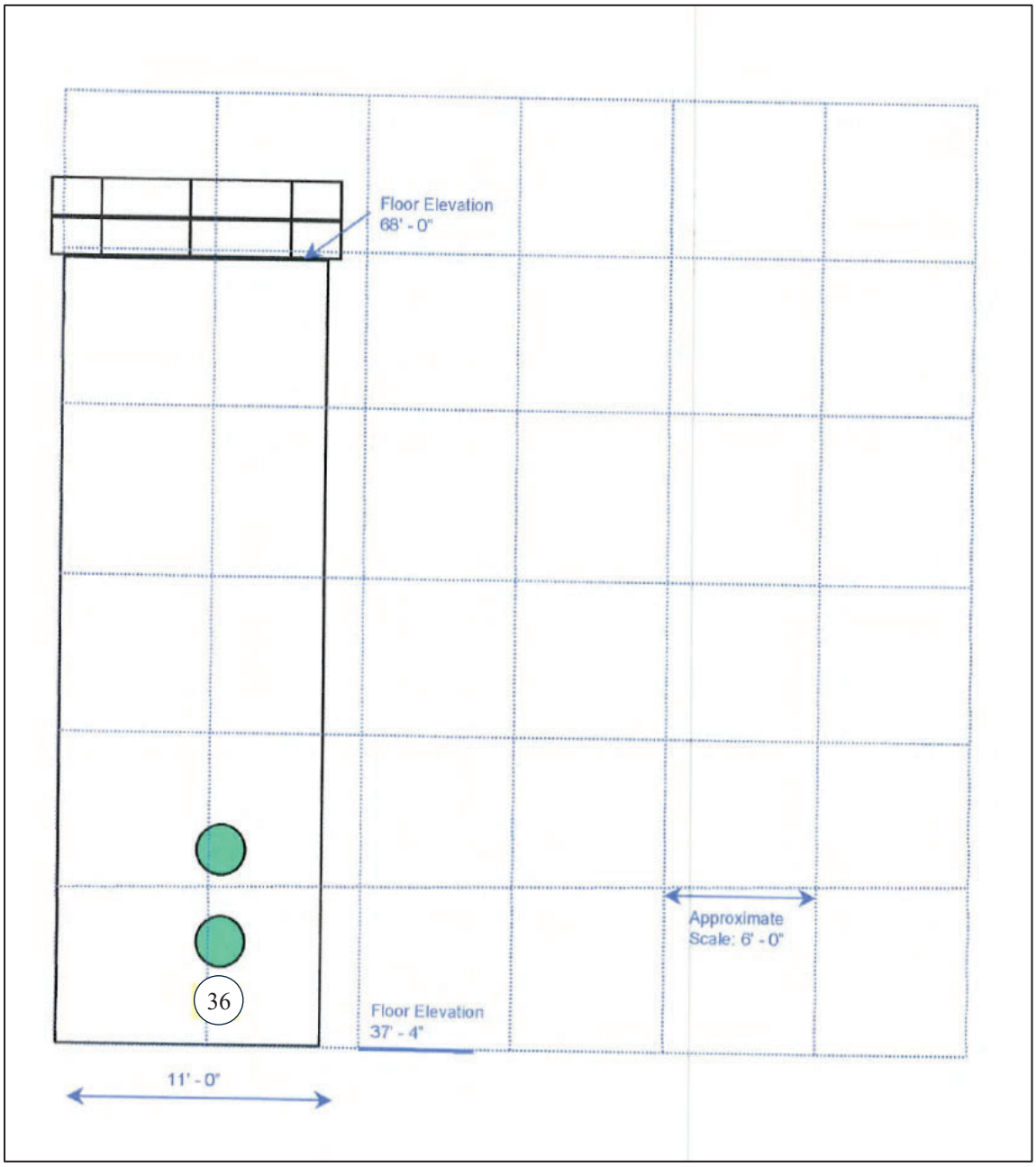
Basement Floor Survey Locations



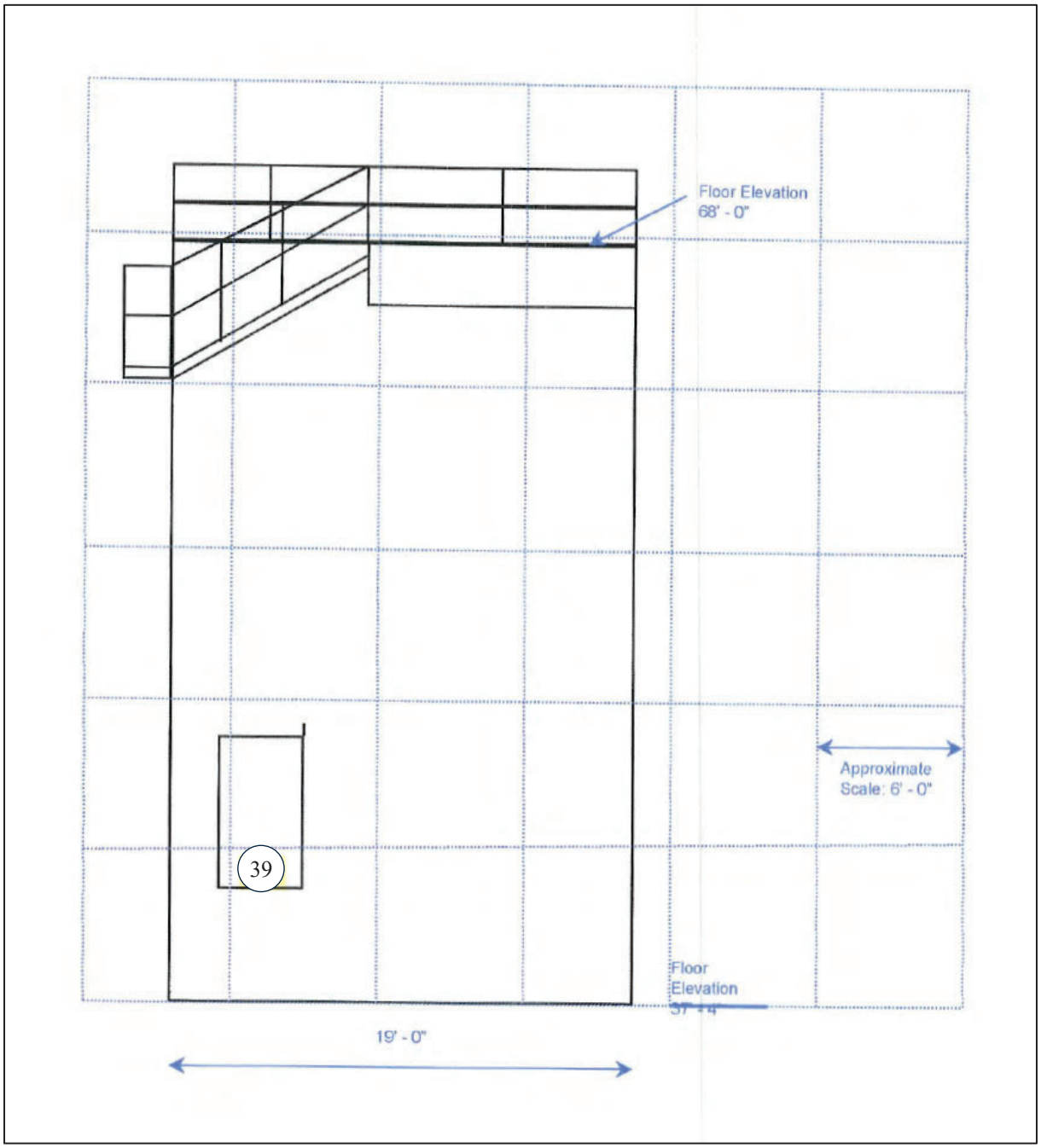
Monolith Top Plug Structure - Mezzanine



Entombment System - North View



Entombment System - South View



Entombment System - North View

Radiological Survey Number: 240722-002

RCT Name: Larry Oeffner/Mike McDonald **Survey Date:** 7-16/17-2024

Exposure Rate Instrument Info

Survey Instrument Model: Thermo Microrem
Instrument Serial Number: 19288
Calibration Due Date: 8/17/2024
Time of Daily Response Check: 0947/0830
Background Exposure Rate (μR/h): 17/38 (main/basement)

Surface Contamination Instrument Info

Survey Instrument Model: Ludlum 26
Instrument Serial Number: PF009836
Calibration Due Date: 2/6/2025
Time of Daily Response Check: 0947/0830

Survey ID	Survey Location	2024 Exposure Result (μrem/hr)	2024 Removable Contamination (dpm/100cm^2)	2024 Total Contamination (dpm/100cm^2)	General Location	Comment
L1	Pipe Chase Face #1	20	26	< Sc	Monolith Top	
L2	Pipe Chase Face #2	20	< Sc	< Sc	Monolith Top	
L3	Pipe Chase Face #3	20	< Sc	< Sc	Monolith Top	
L4	Pipe Chase Face #4	20	< Sc	495	Monolith Top	
L5	Top Plug Face #1 - left	12	< Sc	< Sc	Monolith Top	
L6	Top Plug Face #1 - center	10	< Sc	< Sc	Monolith Top	
L7	Top Plug Face #1 - right	10	< Sc	495	Monolith Top	
L8	Top Plug Face #2 - top	11	< Sc	730	Monolith Top	
L9	Top Plug Face #2 - center	12	< Sc	1908	Monolith Top	
L10	Top Plug Face #2 - bottom	10	< Sc	683	Monolith Top	
L11	Top Plug Face #3 - right	10	< Sc	447	Monolith Top	
L12	Top Plug Face #3 - center	12	< Sc	565	Monolith Top	
L13	Top Plug Face #3 - left	13	< Sc	< Sc	Monolith Top	
L14	Top Plug Face #4 - bottom	12	< Sc	< Sc	Monolith Top	
L15	Top Plug Face #4 - center	12	< Sc	612	Monolith Top	
L16	Top Plug Face #4 - top	12	< Sc	612	Monolith Top	
L17	Top Plug Top Surface - upper left	12	< Sc	471	Monolith Top	
L18	Top Plug Top Surface - center right	12	< Sc	< Sc	Monolith Top	
L19	Top Plug Top Surface - center bottom	14	35	< Sc	Monolith Top	
L20	Main Floor Zone 1	14	< Sc	< Sc	Main Level-Public Access	
L21	Main Floor Zone 2	14	< Sc	< Sc	Main Level-Public Access	
L22	Main Floor Zone 3	15	< Sc	< Sc	Main Level-Public Access	
L23	Main Floor Zone 4	17	< Sc	707	Main Level-Public Access	
L24	Main Floor Zone 5	17	< Sc	777	Main Level-Public Access	
L25	Main Floor-Zone 6	17	< Sc	942	Main Level-Public Access	
L26	Main Floor-Zone 7	18	< Sc	< Sc	Main Level-Public Access	
L27	Main Floor-Zone 8	17	< Sc	< Sc	Main Level-Public Access	
L28	Main Floor-Zone 9	17	< Sc	< Sc	Main Level-Public Access	
L29	Main Floor-Zone 10	17	28	683	Main Level-Public Access	
L30	Main Floor-Zone 11	15	< Sc	< Sc	Main Level-Public Access	
L31	Main Floor-Zone 12	17	< Sc	< Sc	Main Level-Public Access	
L32	Main Floor-Zone 14	18	< Sc	542	Main Level-Public Access	
L33	Main Floor-Zone 13	17	< Sc	777	Main Level-Public Access	
L34	Main Floor Water Column - center bottom	18	28	542	Main Level-Controlled Area	
L35	Main Floor Water Column - right middle	15	< Sc	< Sc	Main Level-Controlled Area	
L36	Instrument Thimble #1	22	< Sc	< Sc	Main Level-Controlled Area	
L37	Instrument Thimble #2	20	< Sc	< Sc	Main Level-Controlled Area	
L38	Instrument Thimble #3	16	< Sc	< Sc	Main Level-Controlled Area	
L39	Pipe Chase Ext Hatch	22	26	< Sc	Main Level-Controlled Area	
L40	Fuel Pool Purifier. Floor #1	30	< Sc	18699	Main Level-Contaminated Area	
L41	Fuel Pool Purifier. Floor #2	30	< Sc	942	Main Level-Controlled Area	
L42	Fuel Pool Purifier. Floor #3	30	< Sc	495	Main Level-Controlled Area	
L43	Fuel Pool Purifier. Floor #4	30	< Sc	< Sc	Main Level-Controlled Area	

Radiological Survey Number: 240722-002

RCT Name: Larry Oeffner/Mike McDonald **Survey Date:** 7-16/17-2024

Exposure Rate Instrument Info

Survey Instrument Model: Thermo Microrem
Instrument Serial Number: 19288
Calibration Due Date: 8/17/2024
Time of Daily Response Check: 0947/0830
Background Exposure Rate (μR/h): 17/38 (main/basement)

Surface Contamination Instrument Info

Survey Instrument Model: Ludlum 26
Instrument Serial Number: PF009836
Calibration Due Date: 2/6/2025
Time of Daily Response Check: 0947/0830

Survey ID	Survey Location	2024 Exposure Result (μrem/hr)	2024 Removable Contamination (dpm/100cm^2)	2024 Total Contamination (dpm/100cm^2)	General Location	Comment
L44	Basement Floor-Zone 1	40	< Sc	< Sc	Basement Level	
L45	Basement Floor-Zone 2	40	< Sc	< Sc	Basement Level	
L46	Basement Floor-Zone 3	40	< Sc	< Sc	Basement Level	
L47	Basement Floor-Zone 4	35	35	< Sc	Basement Level	
L48	Basement Floor-Zone 5	35	< Sc	< Sc	Basement Level	
L49	Basement Floor-Zone 6	35	< Sc	< Sc	Basement Level	
L50	Basement Floor-Zone 7	40	< Sc	< Sc	Basement Level	
L51	Basement Floor-Zone 8	40	< Sc	< Sc	Basement Level	
L52	Basement Floor-Zone 9	40	< Sc	< Sc	Basement Level	
L53	Basement Floor-Zone 10	35	< Sc	< Sc	Basement Level	
L54	Basement Floor-Zone 11	35	< Sc	< Sc	Basement Level	
L55	Basement Floor-Zone 12	40	< Sc	< Sc	Basement Level	
L56	Basement Floor-Zone 13	35	< Sc	< Sc	Basement Level	
L57	Basement Floor-Zone 14	35	< Sc	< Sc	Basement Level	
L58	Basement Floor-Zone 15	35	< Sc	< Sc	Basement Level	
L59	Basement Floor-Zone 16	40	< Sc	495	Basement Level	
L60	Basement Floor-Zone 17	35	< Sc	< Sc	Basement Level	
L61	Basement Floor-Zone 18	40	< Sc	< Sc	Basement Level	
L62	Side of Liq. Waste Ret. Tank #1	40	< Sc	< Sc	Basement Level	
L63	Side of Liq. Waste Ret. Tank #2	40	< Sc	< Sc	Basement Level	
L64	Column 4 and 5 inside room	40	< Sc	< Sc	Basement Level	
L65	F.W. Heater Room (Wall)	40	< Sc	< Sc	Basement Level	
L66	Vapor Sphere Room - upper left	40	< Sc	< Sc	Basement Level	
L67	Vapor Sphere Room - center right	35	< Sc	< Sc	Basement Level	
L68	Water pump room to the right, enter 50A	40	< Sc	< Sc	Basement Level	
L69	Condenser Room Entry Wall - block	40	< Sc	< Sc	Basement Level	
L70	Condenser Room Entry Wall - concrete	40	< Sc	< Sc	Basement Level	
L71	South room with 2 pumps	40	< Sc	< Sc	Basement Level	
L72	Under stairs near north door. Floor #1	40	< Sc	471	Basement Level	
L73	Under stairs near north door. Floor #2	40	< Sc	< Sc	Basement Level	
L74	Condensate Pump #2 Pedestal	40	< Sc	942	Basement Level	Nonbiased survey location chosen by the RCT
L75	Basement Floor-Zone 5	35	< Sc	< Sc	Basement Level	Nonbiased survey location chosen by the RCT
L76	Display Area	19	< Sc	< Sc	Main Level-Public Access	Nonbiased survey location chosen by the RCT
L77	RadCon Storage Area	20	< Sc	< Sc	Main Level-Public Access	Nonbiased survey location chosen by the RCT
L78	Building Airlock Main Entry	18	< Sc	< Sc	Main Level-Public Access	Nonbiased survey location chosen by the RCT

Attachment 4

Radiological Instrument Calibration Certificates, *After-Calibration Source Response Checks Data Sheet* Forms (LMS 1974), and *Daily Instrument Response* Forms (LMS 1974a)

After-Calibration Source Response Checks Data Sheet

Location:	LM Field Support Center at Grand Junction, Colorado	**Date:**	7/3/2024

Survey Instrument Data		**Detector/Probe Data (if applicable)**	
Manufacturer:	Ludlum Measurements Inc.	**Manufacturer:**	
Model No.:	26	**Model No.:**	
Serial No.:	PF009836	**Serial No.:**	
Calibration Due Date:	2/6/2025	**Calibration Due Date:**	
Instrument Units:	cpm	**Source/Detector Distance:**	~0.5 cm
		Shielding/Geometry:	Source in jig on contact

Check Source Data

#1 Isotope:	Cl-36	**Source ID No.:**	W1-932	**Activity & Units:**	2.762 nCi
#2 Isotope:		**Source ID No.:**		**Activity & Units:**	

Source Response #1 Isotope

1st Reading	2nd Reading	3rd Reading	4th Reading	5th Reading	Total
1148	1187	1162	1129	1166	5792
Average:	1158.4	**–20% of Avg:**	926.72	**+20% of Avg:**	1390.08

Source Response #2 Isotope

1st Reading	2nd Reading	3rd Reading	4th Reading	5th Reading	Total
Average:		**–20% of Avg:**		**+20% of Avg:**	

Comments

Performed by (print name)	Performed by (signature)	Date
Jessica Uglesich	JESSICA UGLESICH (Affiliate) Digitally signed by JESSICA UGLESICH (Affiliate) Date: 2024.07.03 15:11:00 -06'00'	7/3/2024
Reviewed by (print name)	**Reviewed by (signature)**	**Date**
Mike McDonald	[redacted]	7-3-2024

Daily Instrument Response

Instrument model: 26 **Serial number:** PF009836 **Detector model:** _____ **Serial number:** _____

Source ID number: W1-932 **Isotope:** Cl-36 **Scale units:** cpm

Calibration due date: 02/06/2025 **Acceptable range (± 20%):** 927 - 1390

Month July **Year** 2024

Initial if daily response check is satisfactory										
Day	Response (Scale or Decade)						Battery Check	Physical Inspection	In Calibration	Initials
	cpm		Satisfactory	Unsatisfactory	2nd Check	Sat/Failed				
1										
2										
3	1100		X				SAT	SAT	YES	JU
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16	1360		X				✓	✓	✓	LO
17	1296		X				✓	✓	✓	LO
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										
31										

Reviewed by the LMS Radiological Control Manager or designee (print and sign) _____ Date

After-Calibration Source Response Checks Data Sheet

Location:	LM Field Support Center at Grand Junction, Colorado	**Date:**	7/3/2024

Survey Instrument Data		**Detector/Probe Data (if applicable)**	
Manufacturer:	Thermo Scientific	**Manufacturer:**	
Model No.:	Micro Rem	**Model No.:**	
Serial No.:	19288	**Serial No.:**	
Calibration Due Date:	8/17/2024	**Calibration Due Date:**	

Instrument Units:	µrem/hr	**Source/Detector Distance:**	On contact	**Shielding/Geometry:**	On contact with + on front

Check Source Data

#1 Isotope:	Cs-137	**Source ID No.:**	248	**Activity & Units:**	0.25 µCi
#2 Isotope:		**Source ID No.:**		**Activity & Units:**	

Source Response #1 Isotope

1st Reading	2nd Reading	3rd Reading	4th Reading	5th Reading	Total
128	125	132	126	131	642
Average:	128.4	**–20% of Avg:**	102.72	**+20% of Avg:**	154.08

Source Response #2 Isotope

1st Reading	2nd Reading	3rd Reading	4th Reading	5th Reading	Total
Average:		**–20% of Avg:**		**+20% of Avg:**	

Comments

Performed by (print name)	**Performed by (signature)**	**Date**
Jessica Uglesich	JESSICA UGLESICH (Affiliate) Digitally signed by JESSICA UGLESICH (Affiliate) Date: 2024.07.03 15:42:13 -06'00'	7/3/2024
Reviewed by (print name)	**Reviewed by (signature)**	**Date**
Mike McDonald	[redacted]	7-3-2024

Daily Instrument Response

Instrument model: Micro Rem **Serial number:** 19288 **Detector model:** _____ **Serial number:** _____

Source ID number: 248 **Isotope:** Cs-137 **Scale units:** µrem/hr

Calibration due date: 08/17/2024 **Acceptable range (± 20%):** 103 - 154

Month July **Year** 2024

Day	Initial if daily response check is satisfactory									
	Response (Scale or Decade)						Battery Check	Physical Inspection	In Calibration	Initials
	µrem/hr		Satisfactory	Unsatisfactory	2nd Check	Sat/Failed				
1										
2										
3	129		X				SAT	SAT	YES	JU
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16	115		X				SAT	SAT	Yes	LO
17	130		X				Sat	Sat	Yes	LO
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										
31										

_____ _____

Reviewed by the LMS Radiological Control Manager or designee (print and sign) Date

Scaler Chi-Squared (x2) Test Data Sheet

Scaler model	3030		Serial No.	330877	Calibration due date
Detector model	N/A		Serial No.	N/A	8/17/2024
α Source ID no.	FR 693		βγ Source ID no.	FR 706	
α Source isotope	Th-230		βγ Source isotope	Cl-36	
α Source activity	19400	dpm	βγ Source activity	5060	dpm
α Source diameter	47	mm	βγ Source diameter	47	mm
α Source assay date	9/1/1997		βγ Source assay date	8/29/1997	
Date performed	7/1/2024		Location performed at	GJO-B810, RM 163	

Chi-Squared (χ^2) Test

Alpha

n	x_i	$(x_i)-(\bar{x})$	$[(x_i)-(\bar{x})]^2$
1	6510	-28.65	820.8
2	6518	-20.65	426.4
3	6554	15.35	235.6
4	6615	76.35	5829.3
5	6367	-171.65	29463.7
6	6633	94.35	8901.9
7	6505	-33.65	1132.3
8	6696	157.35	24759.0
9	6622	83.35	6947.2
10	6455	-83.65	6997.3
11	6484	-54.65	2986.6
12	6464	-74.65	5572.6
13	6687	148.35	22007.7
14	6585	46.35	2148.3
15	6388	-150.65	22695.4
16	6568	29.35	861.4
17	6415	-123.65	15289.3
18	6608	69.35	4809.4
19	6586	47.35	2242.0
20	6513	-25.65	657.9
Totals	130773	na	164784.6
$\bar{x}$ =	6538.7	σ =	93.1
2σ =	186.3	3σ =	279.4

Beta

n	x_i	$(x_i)-(\bar{x})$	$[(x_i)-(\bar{x})]^2$
1	2214	-12.3	151.3
2	2215	-11.3	127.7
3	2180	-46.3	2143.7
4	2264	37.7	1421.3
5	2196	-30.3	918.1
6	2183	-43.3	1874.9
7	2217	-9.3	86.5
8	2261	34.7	1204.1
9	2286	59.7	3564.1
10	2315	88.7	7867.7
11	2239	12.7	161.3
12	2219	-7.3	53.3
13	2239	12.7	161.3
14	2242	15.7	246.5
15	2313	86.7	7516.9
16	2176	-50.3	2530.1
17	2242	15.7	246.5
18	2175	-51.3	2631.7
19	2176	-50.3	2530.1
20	2174	-52.3	2735.3
Totals	44526	na	38172.2
$\bar{x}$ =	2226.3	σ =	44.8
2σ =	89.6	3σ =	134.5

Mean

$$\bar{x} = \frac{\sum x_i}{20}$$

Sigma

$$\sigma = \sqrt{\frac{\Sigma(x_i - \bar{x})^2}{(n-1)}}$$

Chi-Squared

$$x^2 = \frac{\sum (x_i - \bar{x})^2}{\bar{x}}$$

Alpha Values

mean +2σ =	6724.9	mean -2σ =	6352.4
mean +3σ =	6818.0	mean -3σ =	6259.3
Chi-squared range: 8.91 to 32.85			
x^2 =	25.2	Test result	Pass

Beta Values

mean +2σ =	2315.9	mean -2σ =	2136.7
mean +3σ =	2360.8	mean -3σ =	2091.8
Chi-squared range: 8.91 to 32.85			
x^2 =	17.1	Test result	Pass

Performed: Chad Goodrich — Date: 7/1/2024

Printed Name and Signature

Reviewed: _____ — Date: _____

Printed Name and Signature

Scaler Post-Calibration Test Data Sheet

Scaler model	3030		Serial No.	330877	Calibration due date		
Detector model	N/A		Serial No.	N/A		8/17/2024	
α Source ID no.	FR 693		β-γ Source ID no.	FR 706			
α Source isotope	Th-230		β-γ Source isotope	Cl-36			
α Source activity	19400	dpm	β-γ Source activity	5060	dpm		
α Source diameter	47	mm	β-γ Source diameter	47	mm		
α Source assay date	9/1/1997		β-γ Source assay date	8/29/1997			
Date performed	7/1/2024		Location performed at	GJO-B810, RM 163			

Background Data

α Background counts	5	cts (20 min)	β-γ Background counts	822	cts (20 min)
α Background	0.25	cpm	β-γ Background	41.1	cpm

Scaler Efficiency

Alpha			Beta		
20 minute source count	130773	cts	20 minute source count	44526	cts
Gross count rate	6538.7	cpm	Gross count rate	2226.3	cpm
Net count rate	6538.4	cpm	Net count rate	2185.2	cpm
Source activity	19400	dpm	Source activity	5060	dpm
Efficiency	0.34	cpm/dpm	Efficiency	0.43	cpm/dpm

Acceptable Source Range

Alpha			Beta		
20 minute count	130773	cts	20 minute count	44526	cts
Gross count rate	6538.7	cpm	Gross count rate	2226.3	cpm
Net count rate	6538.4	cpm	Net count rate	2185.2	cpm

$$\sigma = \sqrt{\frac{Rg}{1} + \frac{Rb}{20}}$$

where: σ = standard deviation of the net count rate
Rg = Gross count rate (cpm)
Rb = background count rate (cpm)

Alpha σ	80.86	cpm	Beta-Gamma σ	47.21	cpm

Alpha Acceptable Source Ranges (cpm)				Beta Acceptable Source Ranges (cpm)			
1σ	6458	to	6619	1σ	2138	to	2232
2σ	6377	to	6700	2σ	2091	to	2280

Performed: Chad Goodrich — Date: 7/1/2024
Printed name and signature

Reviewed: _____ — Date: _____
Printed name and signature

Alpha Scaler Daily Check Data Sheet

Scaler model: 3030 | Serial no.: 330877 | Calibration due date: 8/17/2024

Detector model: N/A | Serial no.: N/A

Month/year performed: 7/2024 | Location performed at: GJO-B810, RM 163

Alpha source value (cpm): 6538.4

α Source ID no.: FR 693

α Source isotope: Th-230

α Source activity: 19400 dpm

Alpha Acceptable Source Ranges (cpm)

1σ	6458	to	6619
2σ	6377	to	6700

Date	Alpha Background Counts	Alpha Background cpm	Alpha Source Counts	Alpha Source cpm	Critical Value (dpm/100cm^2)	Daily Check Sat/Unsat	Initials
7/1/2024	5	0.25	6447	6447	2.5	Sat	CG
7/2/2024	6	0.30	6513	6513	2.7	Sat	NH
7/3/2024							
7/4/2024							
7/5/2024							
7/6/2024							
7/7/2024							
7/8/2024							
7/9/2024							
7/10/2024	4	0.20	6452	6452	2.2	Sat	CG
7/11/2024							
7/12/2024							
7/13/2024							
7/14/2024							
7/15/2024							
7/16/2024	5	0.25	6647	6647	2.5	Sat	NH
7/17/2024	3	0.15	6607	6607	1.9	Sat	KC
7/18/2024							
7/19/2024							
7/20/2024							
7/21/2024							
7/22/2024							
7/23/2024	2	0.10	6534	6534	1.6	Sat	NH
7/24/2024							
7/25/2024							
7/26/2024							
7/27/2024							
7/28/2024							
7/29/2024							
7/30/2024	2	0.10	6495	6495	1.6	Sat	KC
7/31/2024							

Reviewed: _____ Date: _____

Printed name and signature

Beta Scaler Daily Check Data Sheet

Scaler model: 3030 | Serial no.: 330877 | Calibration due date: 8/17/2024
Detector model: N/A | Serial no.: N/A
Month/year performed: 7/2024 | Location performed at: GJO-B810, RM 163
Beta source value (cpm): 2185.2

β-γ Source ID no.: FR 706
β-γ Source isotope: Cl-36
β-γ Source activity: 5060 dpm

Beta Acceptable Source Ranges (cpm)

1σ	2138	to	2232
2σ	2091	to	2280

Date	Beta Background Counts	Beta Background cpm	Beta Source Counts	Beta Source cpm	Critical Value (dpm/100cm^2)	Daily Check Sat/Unsat	Initials
7/1/2024	822	41	2271	2230	25	Sat	CG
7/2/2024	795	40	2290	2250	25	Sat	NH
7/3/2024							
7/4/2024							
7/5/2024							
7/6/2024							
7/7/2024							
7/8/2024							
7/9/2024							
7/10/2024	818	41	2228	2187	25	Sat	CG
7/11/2024							
7/12/2024							
7/13/2024							
7/14/2024							
7/15/2024							
7/16/2024	799	40	2221	2181	25	Sat	NH
7/17/2024	808	40	2240	2200	25	Sat	KC
7/18/2024							
7/19/2024							
7/20/2024							
7/21/2024							
7/22/2024							
7/23/2024	768	38	2246	2208	24	Sat	NH
7/24/2024							
7/25/2024							
7/26/2024							
7/27/2024							
7/28/2024							
7/29/2024							
7/30/2024	787	39	2212	2173	24	Sat	CG
7/31/2024							

Reviewed: _____ Date: _____
Printed name and signature

CERTIFICATE OF CALIBRATION
(COUNT-RATE INSTRUMENT)

RSA Laboratories, Inc.
19 Pendleton Drive, P.O. Box 61
Hebron, Connecticut 06248
(860) 228-0721 Fax (860) 228-4402

Customer and Contact:	**RSI EnTech, Attn: Anthony Martinez (970) 248-6756**				
Customer Address:	**2597 Legacy Way, Grand Junction, CO 81503**				
Inst. Mfr. & Model	**Ludlum Model 26**	Inst. Type	**Survey meter**	Inst. s/n	**9836**
Det. Mfr. & Model	**not indicated**	Det. Type	**G-M Pancake**	Det. s/n	**not indicated**
Calibration Date	**06 February 2024**	Due Date	**06 February 2025**	Cal Interval	**1 year**

Environmental conditions: Temperature **71°F** Relative Humidity **26%** Atmospheric Pressure **29.85** inches Hg

Pre-calibration Checks:

[X] Contamination survey	[X] Battery check	[ ] Slow response check		
[X] Mechanical check	[X] Audio check	[ ] Window Operation	[X] Det. Volts	**900** Vdc
[ ] Meter zero	[ ] Reset check	[ ] Plateau check		
[ ] Geotropism check	[ ] Fast response check	[ ] Alarm set	[X] Input sens.	**1800** mV

[X] Pulse generator s/n 94926 [ ] Oscilloscope s/n 171-04928 [ ] Voltmeter s/n 574100002

Comments: **All efficiencies measured at near contact, cap off.**

Precision check souce s/n **D700** Isotope **Cl-36** Dedicated Source? [ ] Yes [X] No

Reading #1 **6,620 cpm** Reading #2 **6,530 cpm** Reading #3 **6,590 cpm** Mean **6,580 cpm**

Precision: [X] ±<10% [ ] ±10-20% [ ] Out of tolerance

Range Multiplier	Reference Calibration Point	Instrument Indication "As Found"	Instrument Indication "As Left"
n/a	80,000 cpm	80.0 kcpm	80.0 kcpm
n/a	20,000 cpm	20.0 kcpm	20.0 kcpm
n/a	8,000 cpm	8.0 kcpm	8.0 kcpm
n/a	2,000 cpm	2.0 kcpm	2.0 kcpm
n/a	800 cpm	800 cpm	800 cpm
n/a	200 cpm	200 cpm	200 cpm
n/a	80 cpm	80 cpm	80 cpm
n/a	20 cpm	20 cpm	20 cpm

All ranges calibrated electronically.

Local background (cpm) ≈ 62

Range Multiplier	Cal. Source Used (isotope and s/n)	Source Activity (dpm)	Instrument Reading (cpm)	4π Instrument Efficiency (%)
1 min. count	C-14 #4456	202,100	8,310	4.08
1 min. count	Pm-147 #1613-32	1,089	165	9.46
1 min. count	Tc-99 #D702	23,064	3,580	15.25
1 min. count	Cs-137 #2886	11,399	3,100	26.65
1 min. count	Cl-36 #D700	23,598	6,580	27.62
1 min. count	Sr/Y-90 #D711	27,845	9,140	32.60
1 min. count	Th-230 #91TH2200210	38,900	4,370	11.07

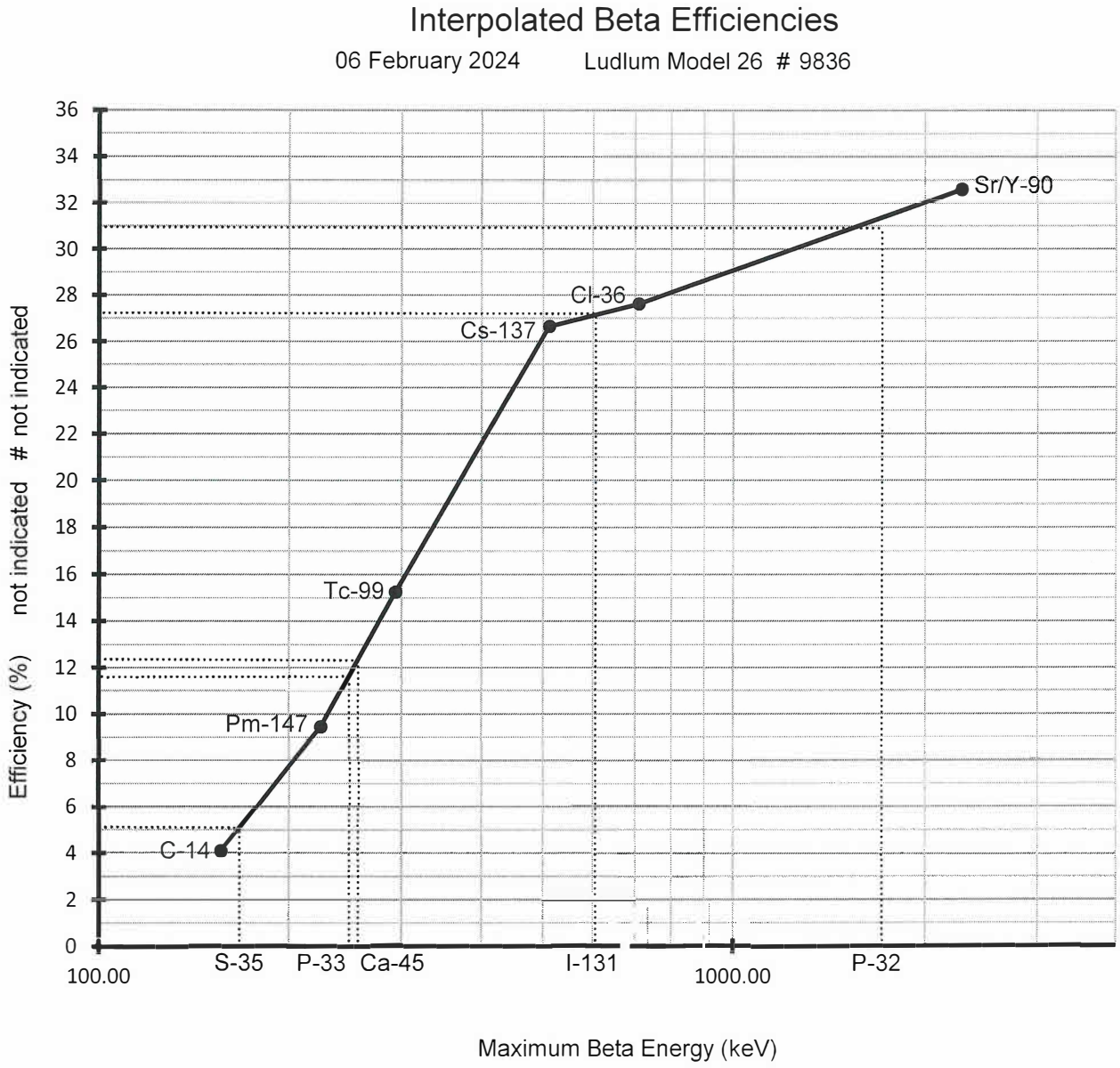
Instrument indicates within ±10% of calibration points unless otherwise indicated. Source-to-detector entry window distance for efficiency determination is 1 cm unless otherwise specified. RSA Laboratories certifies that the above instrument has been calibrated with standards traceable to the National Institute of Standards and Technology, or have been derived from accepted values of natural physical constants, or have been derived by the ratio-type of calibration techniques.

RSA Laboratories ID# **24687**

Calibrated by: **Kurt D. Newton** [redacted] Date: **06 February 2024**

CERTIFICATE OF CALIBRATION
(COUNT-RATE INSTRUMENT)

RSA Laboratories, Inc.
19 Pendleton Drive, P.O. Box 61
Hebron, Connecticut 06248
(860) 228-0721 Fax (860) 228-4402



Calibrated by: **Kurt D. Newton** [redacted] Date: **06 February 2024**

CERTIFICATE OF CALIBRATION
(COUNT-RATE INSTRUMENT)

RSA Laboratories, Inc.
19 Pendleton Drive, P.O. Box 61
Hebron, Connecticut 06248
(860) 228-0721 Fax (860) 228-4402

Customer and Contact:	**RSI EnTech, Attn: Anthony Martinez (970) 248-6756**				
Customer Address:	**2597 Legacy Way, Grand Junction, CO 81503**				
Inst. Mfr. & Model	**Ludlum Model 3030**	Inst. Type	**Dual Scaler**	Inst. s/n	**330877**
Det. Mfr. & Model	**not indicated**	Det. Type	**Alpha/Beta Scintillator**	Det. s/n	**not indicated**
Calibration Date	**17 August 2023**	Due Date	**17 August 2024**	Cal Interval	**1 year**

Environmental conditions: Temperature **72°F** Relative Humidity **57%** Atmospheric Pressure **29.75** inches Hg

Pre-calibration Checks:

- [X] Contamination survey
- [X] Mechanical check
- [X] Meter zero
- [ ] Geotropism check
- [X] Battery check
- [X] Audio check
- [X] Reset check
- [ ] Fast response check
- [ ] Slow response check
- [X] Window Operation
- [ ] Plateau check
- [ ] Alarm set
- [X] Det. Volts **700** Vdc
- [X] Input sens. **see comments**

- [X] Pulse generator s/n 94926
- [ ] Oscilloscope s/n 171-04928
- [ ] Voltmeter s/n 574100002

Comments: **Alpha channel threshold = 120 mV, window = 120 mV to ∞. Beta channel threshold = 4.6 mV, window = 4.6 mV to 60 mV. Calibrated using AC line power.**

Precision check source s/n **D700** Isotope **Cl-36** Dedicated Source? [ ] Yes [X] No
Reading #1 **8,883 cpm** Reading #2 **8,847 cpm** Reading #3 **8,878 cpm** Mean **8,869 cpm**
Precision: [X] ±<10% [ ] ±10-20% [ ] Out of tolerance

Range Multiplier	Reference Calibration Point	Instrument Indication "As Found"	Instrument Indication "As Left"
1 min.	50 cpm	50 counts	50 counts
1 min.	500 cpm	500 counts	500 counts
1 min.	5,000 cpm	5,000 counts	5,000 counts
1 min.	50,000 cpm	50,001 counts	50,001 counts
1 min.	500,000 cpm	500,012 counts	500,012 counts

All ranges calibrated electronically.

Local background (cpm) ≈ 0 (α) 25 (β)

Range Multiplier	Cal. Source Used (isotope and s/n)	Source Activity (dpm)	Instrument Reading (cpm)	4π Instrument Efficiency (%)
1 min. count	Th-230 #91TH4700001	33,000	9,798 (α)	29.69
1 min. count	Cl-36 #D700	23,598	8,869 (β)	37.48

Instrument indicates within ±10% of calibration points unless otherwise indicated. Source-to-detector entry window distance for efficiency determination is 1 cm unless otherwise specified. RSA Laboratories certifies that the above instrument has been calibrated with standards traceable to the National Institute of Standards and Technology, or have been derived from accepted values of natural physical constants, or have been derived by the ratio-type of calibration techniques.

RSA Laboratories ID# **24456**

Calibrated by: **Kurt D. Newton** [redacted] Date: **17 August 2023**

CERTIFICATE OF CALIBRATION
(EXPOSURE RATE INSTRUMENT)

RSA Laboratories, Inc.
19 Pendleton Drive, P.O. Box 61
Hebron, Connecticut 06248
(860) 228-0721 Fax (860) 228-4402

Customer and Contact:	**RSI EnTech, Attn: Anthony Martinez (970) 248-6756**				
Customer Address:	**2597 Legacy Way, Grand Junction, CO 81503**				
Inst. Mfr. & Model	**Thermo Scientific Micro Rem**	Inst. Type	**Survey Meter**	Inst. s/n	**19288**
Det. Mfr. & Model	**not indicated**	Det. Type	**Organic Scintillator**	Det. s/n	**not indicated**
Calibration Date	**17 August 2023**	Due Date	**17 August 2024**	Cal Interval	**1 year**

Environmental conditions: Temperature **72°F** Relative Humidity **57%** Atmospheric Pressure **29.75** inches Hg

Pre-calibration Checks:

- [X] Contamination survey
- [X] Mechanical check
- [X] Meter zero
- [X] Geotropism check
- [X] Battery check
- [X] Audio check
- [X] Reset check
- [X] Fast response check
- [X] Slow response check
- [ ] Window Operation
- [ ] Plateau check
- [ ] Alarm set
- [ ] Det. Volts Vdc
- [ ] Input sens. mV

- [X] Pulse generator s/n 94926
- [ ] Oscilloscope s/n 171-04928
- [ ] Voltmeter s/n 574100002

Comments:

Precision check source s/n **5** Isotope **Cs-137** Dedicated Source? [ ] Yes [X] No

Reading #1 **1,400 µrem/h** Reading #2 **1,400 µrem/h** Reading #3 **1,400 µrem/h** Mean **1,400 µrem/h**

Precision: [X] ±<10% [ ] ±10-20% [ ] Out of tolerance

Range Multiplier	Reference Calibration Point	Instrument Indication "As Found"	Instrument Indication "As Left"
x 1000	154,402 µR/h	155,000 µrem/h	155,000 µrem/h
x 1000	48,811 µR/h	50,000 µrem/h	50,000 µrem/h
x 100	14,444 µR/h	14,500 µrem/h	14,500 µrem/h
x 100	4,981 µR/h	5,000 µrem/h	5,000 µrem/h
x 10	1,544 µR/h	1,550 µrem/h	1,550 µrem/h
x 10	498 µR/h	500 µrem/h	500 µrem/h
x 1	149 µR/h	150 µrem/h	150 µrem/h
x 1	50 µR/h	50 µrem/h	50 µrem/h
x 1	4,200 cpm @ 800 mV	150 µrem/h	150 µrem/h
x 1	2,700 cpm @ 800 mV	50 µrem/h	50 µrem/h
x 0.1	420 cpm @ 800 mV	15.0 µrem/h	15.0 µrem/h
x 0.1	270 cpm @ 800 mV	5.0 µrem/h	5.0 µrem/h

x 0.1 range calibrated electronically.

Sources used: ^{137}Cesium 750 mCi s/n KR-6244 and KR-6250, and ^{137}Cesium 750 µCi s/n 163.

Calibration points calculated to center of detector volume unless otherwise specified. Instrument indicates within ±10% of calibration points unless otherwise indicated. RSA Laboratories certifies that the above instrument has been calibrated with standards traceable to the National Institute of Standards and Technology, or have been derived from accepted values of natural physical constants, or have been derived by the ratio-type of calibration techniques.

RSA Laboratories ID# **24454**

Calibrated by: **Kurt D. Newton** [redacted] Date: **17 August 2023**