TECHNICAL EVALUATION REPORT

Introduction

Decommissioning is the process of safely removing a site from service, reducing residual radioactivity through remediation to a level that permits release of the property, and termination of the license. On September 18, 2012, the National Aeronautics and Space Administration (NASA) submitted a request for the termination of the Plum Brook Reactor License TR-3 and the Plum Brook Mock-up Reactor License R-93. NASA's request asserts it has completed all decommissioning activities and the terminal radiation survey and associated documentation demonstrate compliance with the radiological criteria for license termination. The purpose of this Technical Evaluation Report (TER) is to evaluate NASA's compliance with the regulatory requirements for license termination.

1.0 Regulatory Requirements

The regulatory requirements for license termination are specified in section 50.82(b)(6) of Title 10 of the *Code of Federal Regulations* (10 CFR):

> *The Commission will terminate the license if it determines that –*
>
> *(i) The decommissioning has been performed in accordance with the approved decommissioning plan, and*
> *(ii) The terminal radiation survey and associated documentation demonstrate that the facility and site are suitable for release in accordance with the criteria for decommissioning in 10 CFR part 20, subpart E.*

The radiological criteria for license termination are identified in 10 CFR part 20, subpart E. The radiological criteria for unrestricted use in § 20.1402 state that –

> *A site will be considered acceptable for unrestricted use if the residual radioactivity that is distinguishable from background radiation results in a TEDE to the average member of the critical group that does not exceed 25 mrem (0.25 mSv) per year, including that from groundwater sources of drinking water, and that the residual radioactivity has been reduced to levels that are as low as reasonably achievable (ALARA).*

2.0 Background

The Plum Brook Reactor Facility (PBRF) was an 11-hectare (27-acre) site located on NASA's 2,590-hectare (6400-acre) Plum Brook Station near Sandusky, Ohio. The site comprised major buildings and support facilities for two research reactors. The Plum Brook Reactor (License No. TR-3) was a 60 megawatt test reactor that performed experiments on materials used in space flight. The Plum Brook Mock-up Reactor (License No. R-93) was a 100 kilowatt swimming-pool type reactor designed for test "mock-up" of irradiated components for the Plum Brook Reactor. These reactors operated from 1963 to 1973. In 1973, the PBRF was shutdown and placed in a "standby condition" to ensure the physical safety of the facility. In 1999, NASA submitted a proposed Decommissioning Plan (DP) (Agencywide Documents Access and

Management System (ADAMS) Accession Numbers ML993630054 and ML993630075) for the PBRF to decontaminate the facility to a level that would permit license termination and release of the facility for unrestricted use. In its final state, all contaminated materials and equipment would be removed, radioactively contaminated soils would be removed, and buildings and structures would be demolished to below grade and backfilled.

In 2000, NRC published a notice and solicitation of comments concerning the proposed decommissioning action (65 FR 12040; March 7, 2000), and issued an Environmental Assessment and Finding of No Significant Impact concerning this action (65 FR 16421; March 28, 2000).

In 2002, NRC approved the DP and amended the licenses authorizing decommissioning of the PBRF in accordance with the DP (ADAMS Accession No. ML020390069). The DP included a section on the proposed final status survey plan (FSSP) that described the methodology and approach for performing final radiation surveys. The final radiation surveys are designed to demonstrate that the facility has been decontaminated to levels that permit the release of the facility for unrestricted use. In 2007, following the collection of additional characterization data, NASA submitted a revised FSSP (NASA, 2007) for NRC review prior to performing final radiation surveys. In 2008, NRC approved and authorized the revised FSSP in conjunction with a license amendment (ADAMS Accession No. ML073020311). NASA then revised the DP (NASA, 2008a) to reflect the approval of the revised FSSP.

NASA stated that the FSSP was developed in accordance with NUREG-1575, “Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)” (ADAMS Accession No. ML003761476), NUREG-1757, “Consolidated Decommissioning Guidance” (ADAMS Accession Nos. ML063000243 and ML063000252), and DG-4006, “Demonstrating Compliance with the Radiological Criteria for License Termination” (ADAMS Accession No. ML993250287).[1]

3.0 Technical Evaluation

The NASA PBRF Final Status Survey Report (FSSR) is a compilation of 19 documents consisting of the 18 FSSR Attachments and one summary report (See Appendix A). The FSSR Main Body Report (FSSR-MBR) provides a summary of the detailed information presented in the FSSR Attachments, each documenting final status surveys of individual structures, soils, and piping. NRC staff conducted a technical review of each FSSR Attachment to ensure that the methodology and approach was consistent with the FSSP and that the final results met the radiological criteria for license termination in 10 CFR Part 20, subpart E. A summary of each NRC technical review is provided in ADAMS Accession No. ML12236A322.

The FSSR-MBR also includes a summary of NASA’s offsite remediation activities for the stream bed and banks of the Plum Brook. NRC staff previously evaluated these activities in a Safety Evaluation Report (SER) (ADAMS Accession No. ML100120679). The NRC SER determined that the dose from residual radioactivity in the Plum Brook was substantially below the regulatory criteria for unrestricted use specified in 10 CFR 20.1402.

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[1] The NRC withdrew DG-4006, “Demonstrating Compliance with the Radiological Criteria for License Termination,” from consideration as a regulatory guide in 2002. Appendix D of NUREG-1727 incorporated the guidance that was proposed in DG-4006, and NUREG-1757 replaced NUREG-1727 in 2006.

This technical evaluation is divided into the following sections: (1) source terms; (2) derived concentration guidance levels; (3) area classifications, survey units, and number of measurements; (4) radiation survey instrumentation; (5) investigation levels and scan surveys; (6) systematic measurements and final results; (7) ALARA; (8) NRC inspections and confirmatory surveys; and (9) comparison with the U.S. Environmental Protection Agency (EPA) trigger levels for soils and maximum contaminant levels (MCLs) for groundwater.

3.1 Source Terms

Source term is the radiological characterization of the radionuclide that is present or may be present in the field. The source term is used in developing the decommissioning plan and the FSSP. NUREG-1757, Volume 2, Section 3.3, provides guidance on conditions under which radionuclides or exposure pathways may be considered insignificant and may be eliminated from further consideration. NRC staff considers radionuclides and exposure pathways that contribute less than 10% of the dose criteria to be insignificant contributors. The sum of the dose contributions from all radionuclides and pathways considered insignificant will be no greater than 10% (2.5 mrem [0.025 mSv] per year) of the dose criteria of 25 mrem (0.25 mSv) per year as defined in 10 CFR Part 20, subpart E. The dose contribution from insignificant radionuclides and pathways are accounted for in demonstrating compliance with 10 CFR Part 20, subpart E.

NASA evaluated the radionuclide distribution used to determine the site structure and soil derived concentration guideline level (DCGL) values and identified radionuclides determined to be insignificant contributors for elimination, per the guidance described in NUREG-1757, including embedded and buried piping radionuclide distribution. In the development of the DCGLs in the FSSP, NASA accounted for the dose from the insignificant radionuclides in demonstrating compliance. The lowest total aggregate dose from the remaining structures and soils were 22.5 mrem (0.225 mSv) per year and 24.5 mrem (0.245 mSv) per year, respectively. This also included the dose from embedded pipe, if applicable. NRC staff has determined that this is consistent with NUREG-1757. NRC staff has reasonable assurance that the reported final survey results account for the insignificant radionuclides and NRC staff has determined that this approach is acceptable.

NASA identified radionuclides in site structures and soils and evaluated the results of isotopic analysis of concrete core samples collected as part of the characterization survey to estimate radionuclide distribution. NASA evaluated the radionuclide distribution for smear samples of structural surfaces, concrete core sampling, and soil sampling. NASA identified the radionuclide distribution for each sample collection in the FSSP Tables A-1, A-2, and A-3, respectively. NASA performed radiation dose assessments using each radionuclide in Tables A-1, A-2, and A-3 in RESRAD and RESRAD-Build. RESRAD and RESRAD-Build are computer codes developed by Argonne National Laboratory and are accepted by NRC staff to demonstrate radiation dose compliance for soils and building structures, respectively. The final smear, concrete core, and soil radionuclide distribution are identified in Tables A-4, A-5, and A-6 of the FSSP, respectively. NASA summarized the final radionuclides of concern in Table A-7 that were applied in the final status survey. Below are the radionuclides of concern as identified by NASA's FSSP.

Radionuclides of Concern
Co-60
Cs-137
Eu-154
H-3
I-129
Sr-90
U-233/U-234
U-235/U-236

In conjunction with the DCGL development for structures and soils, NASA also developed DCGL values for both embedded piping (EP) and buried piping (BP). NASA used the software program Microshield v5.04 to compute gamma radiation doses under conservative assumptions identified in the FSSP. The code allows the user to compute gamma radiation doses using different geometry configurations (i.e., cylinder to represent a pipe run) at given receptor points. NASA identified the individual radionuclide DCGL values for EP in Table C-4 of the FSSP.

3.1.1 Evaluation and Finding

NRC staff has determined that the methodology and approach for identifying source terms were incorporated into the18 FSSR Attachments representing various structures, soils, and EP/BP. NRC staff reviewed and approved the methodology and approach for source terms as described in the FSSP. In addition, NRC staff reviewed each individual FSSR Attachment for source terms and found them to be consistent with the FSSP. NRC staff did not find any radionuclides in addition to the radionuclides of concern identified by NASA in Table A-7 of the FSSP. Therefore, NRC staff has determined that NASA has applied the methodology and approach for source terms consistent with the NASA FSSP, NUREG-1575 (MARSSIM), and NUREG-1757 in each FSSR Attachment and the source terms were found to be acceptable.

3.2 Derived Concentration Guideline Levels (DCGLs)

NUREG-1575 (MARSSIM) provides guidance for the development of the DCGLs. MARSSIM provides flexibility for the licensee to demonstrate compliance with 10 CFR Part 20, subpart E in a cost-effective manner. The DCGLs are the residual surface or mass activity concentrations that exist above background. The DCGLs represent the residual amount of radioactivity that would equal the radiation dose standard of 25 mrem (0.25 mSv) per year as established in 10 CFR Part 20, subpart E. The DCGLs are derived for each radionuclide that represents a contaminant of concern. As indicated above, DCGLs are not derived for radionuclides that are deemed insignificant. The measurements are expressed as the surface or mass activity concentration and can be compared directly to the DCGL. The collection of measurements are used to demonstrate that residual contamination levels are below the DCGL and satisfies the 25 mrem (0.25 mSv) per year criterion. The radionuclide distribution, as identified in Table A-7, was used in the development of the DCGLs for average concentrations over large areas ($DCGL_w$), elevated concentrations over small areas ($DCGL_{EMC}$), surrogate values ($DCGL_{SUR}$), and gross beta values ($DCGL_{GB}$). NASA described the development and methodology of the DCGLs in the FSSP.

Generally, the $DCGL_W$ is a single concentration for a single radionuclide and it is used for both structure surface and soil areas. Individual radionuclide activity or concentrations were not directly measured during the final status survey. Rather, NASA developed a methodology consistent with NUREG-1575 (MARSSIM) to convert the nuclide specific $DCGL_w$ to a single general or gross activity DCGL for multiple radionuclides of concern. To facilitate the decommissioning process, NASA further developed $DCGL_{SUR}$ and $DCGL_{GB}$ for those surveys where either difficult-to-detect radionuclides or a suite of radionuclides that emit easy-to-detect beta activity were found. NASA accomplished this by using activity fractions of each radionuclide in each survey unit or area. This approach facilitated the decommissioning process by consolidating all possible $DCGL_W$ values for the survey unit into a single value (i.e., $DCGL_{SUR}$ or $DCGL_{GB}$). The equations used to derive the $DCGL_{SUR}$ and $DCGL_{GB}$, incorporating the $DCGL_W$ for each radionuclide of concern for large areas, were consistent with NUREG-1575 (MARSSIM) and demonstrated that the overall final measurement met the unrestricted release limit of 25 mrem (0.25 mSv) per year.

NASA also developed $DCGL_{EMC}$ for evaluating small localized contaminated areas. The $DCGL_{EMC}$ value was employed to ensure that a small localized contaminated area met the unrestricted dose limit of 25 mrem (0.25 mSv) per year. Thus, $DCGL_{EMC}$ values for small areas could be significantly higher than the $DCGL_W$ value for large areas and still comply with 10 CFR Part 20, subpart E.

In conjunction with the development of DCGLs for structures and soils, NASA also developed DCGLs from measurements inside the surface of embedded and buried piping. NASA established an annual dose goal of 1 mrem (0.01 mSv) per year at a three foot level above concrete from the DCGLs for the interior of embedded and buried piping. In those structural and soil survey units where embedded and buried piping resided, NASA summed the dose from both the structural/soil and embedded and buried piping to ensure that the total dose was less than 25 mrem per year.

NASA provided a survey design that showed the activity fraction and $DCGL_{GB}$ values for various survey units in each FSSR Attachment. The values from the survey design were used and compared to the final static measurements or results to ensure compliance. NASA provided summary tables and test results in each attachment for all survey units. NRC staff reviewed the summary tables for completeness and to ensure that the final result was below the $DCGL_W$.

3.2.1 Evaluation and Finding

NRC staff has determined that the licensee used the correct methods and approaches for developing DCGLs for each FSSR Attachment. NRC staff verified that the licensee applied the radionuclides of concern and the fractional activity into the applicable DCGLs for each FSSR Attachment. NRC staff also verified that the survey results were below the respective DCGLs. NRC staff reviewed the methods and approaches that the licensee used to develop DCGLs, concluded that they were consistent with the NASA FSSP and NUREG-1575 (MARSSIM), and found them to be acceptable.

3.3 Area Classification, Survey Units, and Number of Measurements

NUREG-1757, Volume 2, Revision 1, Consolidated Decommissioning Guidance and NUREG-1575 (MARSSIM) recommends that areas impacted or potentially impacted by radioactive materials be subdivided into three classes. Class 1 areas are areas that have, or had prior to remediation, a potential for radioactive contamination or known contamination. Class 1 areas contain contamination in excess of the $DCGL_w$. Class 2 areas are areas that have, or had prior to remediation, a potential for radioactive contamination or known contamination, but are not expected to exceed the $DCGL_w$. Class 3 areas are any impacted areas that are not expected to contain any residual contamination, or are expected to contain levels of residual contamination at a small fraction of the $DCGL_w$ based on the operating history or the radiological surveys.

Once an impacted area is classified, the guidance provides the suggested survey unit size for structures and land for each classification. These surface areas can be found in Section 4.6 of NUREG-1575. MARSSIM also describes the method for determining the number of samples to be collected in each survey unit for statistical tests. The statistical tests depend on the contaminant being present in background or contaminants not present in background. It is important to note that if all measurements are below the $DCGL_w$ then no statistical test is necessary.

The licensee identified area classification, survey units, and number of measurements for each survey unit in accordance with the FSSP. The licensee submitted 18 FSSR Attachments to NRC for review. The results of NRC staff reviews of the FSSR Attachments are provided in ADAMS Accession No. ML12236A322. Each FSSR Attachment provided the classification for each survey unit and the number of measurements in each survey unit. The licensee selected the Sign Test method and used the appropriate equations consistent with MARSSIM for determining the number of measurements for each survey unit. The Sign Test is used when contaminants are not present in background. The licensee identified the Type I and Type II error parameters as 0.05 and 0.10, respectively, for its calculations. The licensee applied a 20% adjustment factor in the equation. NRC staff has determined that the adjustment factor provided a conservative number of measurements for each survey unit. For example, if the computed value was 10 measurements, the application of the 20% adjustment factor would increase the number of measurements to 12. NRC staff has determined that the Type I and Type II parameters are consistent with MARSSIM. NRC staff observed that the licensee identified a total of 1,295 survey units and pipe runs. The survey units and pipe runs are identified in the proper FSSR Attachments. The table below shows the total number of survey units and pipe runs for each group of surveys (i.e., structures, soils, and embedded piping) including the number of survey units by classification.

Group	Total Survey Units	Class 1	Class 2	Class 3	Total Linear Meter (Feet)
Structures	665	607	44	14	N/A
Soils	399	391	7	1	N/A
Embedded Piping*	231	N/A	N/A	N/A	5,129,174 m (16,828 ft.)
TOTAL	1,295	998	51	15	5,129,174 m (16,828 ft.)

*Each length was evaluated as a pipe run and is not considered a survey unit as defined by MARSSIM.

The majority of the survey units (~93.8%) were Class 1. The number of measurements in each survey unit ranged from 10 to 20.

3.3.1 Evaluation and Finding

NRC staff has determined that the licensee used the area classification, survey units, and number of measurements consistent with the FSSP, NUREG-1757 and NUREG-1575 (MARSSIM) and finds that the classification, survey units, and number of measurements are acceptable.

3.4 Radiation Survey Instrumentation

NUREG-1575 (MARSSIM) states that measurement methods used to generate field data should be classified into scanning surveys and direct static measurements. Scanning is the process by which the operator uses portable radiation detection instruments to detect the presence of radionuclides on a specific surface (ground, wall, floor, equipment). Scanning surveys are performed to locate radiation anomalies indicating residual gross activity that may require further investigation or action. Elevated scan levels triggered further measurements, including direct static beta measurements. Direct static beta measurements are taken by placing the instrument at the appropriate distance above the surface, taking a discrete measurement over a pre-set time interval and recording the results. For the case of soils, soil samples were collected and returned to a laboratory where analytical equipment can determine the number of counts within the sample and the counts are converted to an activity (expressed in a unit of disintegrations per minute) or a concentration (expressed in a unit of picocurie per unit volume).

The detection sensitivity of a measurement system refers to a radiation level or quantity of radioactive material that can be measured or detected with some known or estimated level of confidence. The primary parameters that affect the detection capability of a radiation detector are the background count rate, the detection efficiency of the detector and the counting time interval.

For each survey design, the licensee selected the instruments for the final status survey unit to ensure that sensitivities were sufficient to detect well below the DCGL value for each survey unit. The licensee identified the equations for the minimum detection sensitivities, for static and scan alpha and beta measurements. NRC staff observed that the equations used by the licensee to determine the minimum detectable concentration (or activity) for scan and static beta measurements were consistent with MARSSIM. The licensee also provided the detector model, detector efficiency, and minimum detectable counts for scan and static alpha and beta measurements. NRC staff observed that this information is provided in the FSSR Attachments and is consistent with NASA's FSSP and MARSSIM.

The licensee calculated the static beta measurements by subtracting the counts obtained from a closed detector position (shielding) from the counts obtained from an open detector position (no shielding). The open detector position accounts for all beta and gamma emissions that interact with the detector chamber and produce or register a count. The close detector position accounts for the gamma emissions that interact with the detector chamber and produce or register a count. The difference in counts between these two counting geometries represents the static beta measurements. NRC staff identified a concern with this counting method. NRC staff expressed a concern that if adequate shielding (used in the close detector position) is not applied, then the counts in this position may detect not only the gamma emissions, but possibly energetic beta emissions that may penetrate the inadequate shielding. An inadequate shield to stop all beta particles would result in an under estimation of the true or correct activity that may be present. The licensee provided a technical basis document (ADAMS Accession No. ML080320376) that described the amount of shielding. The licensee indicated that it would use a shield thick enough to stop the most energetic beta emissions. NRC staff determined that the thickness of the shielding was adequate to address the concern and that all static beta measurements are acceptable.

3.4.1 Evaluation and Finding

NRC staff has determined that the licensee used proper instrumentation to detect the radionuclides of concern for both scan surveys and direct static beta measurements. The licensee used proper instrumentation parameters, equations, and methods, to detect and determine the true or correct activity. NRC staff has determined that the approach is consistent with NASA's FSSP and NUREG-1575 (MARSSIM). NRC staff has determined that the radiation instrumentation, instrumentation parameters, equations, and methods used by NASA are acceptable.

3.5 Investigation Levels and Scan Surveys

NUREG-1575 (MARSSIM) recommends conducting a scanning survey to identify locations within the survey unit that exceed the investigation level. NASA established an investigation level that ranged from 50-75% of the $DCGL_W$. For Class 1 areas, scanning surveys are designed to detect small areas of elevated activity that are not detected by the measurements using the systematic pattern. Structure surfaces and soil areas in Class 1 survey units are scanned at 100%. Scanning surveys in Class 2 areas are conducted at a level that is proportional to the potential for finding areas of elevated activity. Class 2 survey units should have a lower probability for areas of elevated activity than a Class 1 survey unit. Structure surfaces and soil areas in Class 2 survey units are scanned between 10% and 100%. The Class 3 area should have the lowest potential for areas of elevated activity. In Class 3 areas, scan surveys should be based on those locations that may have some probability of harboring residual contamination. NASA has a minimum scan coverage of 10% for Class 3 areas. The class-based survey scan coverage and action level requirements used by NASA are shown in the table below.

Survey Unit Classification	Scan Survey Coverage	Flag Scanning Measurement Results When	Static Measurement or Sample Result Investigation Levels
Class 1	100%	>$DCGL_{EMC}$	>$DCGL_{EMC}$
Class 2	10 to 100%	>$DCGL_W$ or >MDC_{Scan} If MDC_{Scan} is > $DCGL_W$	>$DCGL_W$
Class 3	Minimum of 10%	>$DCGL_W$ or >MDC_{Scan} If MDC_{Scan} is > $DCGL_W$	If equal to or greater than 50% of the $DCGL_W$

NRC staff has determined that the above action levels are consistent with NUREG-1575 (MARSSIM). The licensee conducted scan surveys in each survey unit. The results are reported in the FSSR Attachments. The licensee submitted 18 FSSR Attachments to NRC for review. The results of NRC staff reviews are provided in ADAMS Accession No. ML12236A322. NASA conducted scan coverage at 100% for Class 1 survey units, between 10% and 100% for Class 2 survey units, and a minimum of 10% for Class 3 survey units. Technicians identified potential areas for investigation based on an observed elevated count rate or a count rate that exceeded the $DCGL_W$. The licensee identified these elevated measurements and conducted further investigations. NASA determined the size of the elevated measured area, applied the area factor and established a $DCGL_{EMC}$. A static beta measurement was conducted on the affected area and if the static beta measurement did not exceed the $DCGL_{EMC,}$ then the measurement passed. If the static beta measurement did not pass, NASA would re-evaluate the survey unit and establish additional survey units, perform remediation, and conduct another static beta measurement using the $DCGL_W$. NRC staff observed that the licensee investigated each survey unit that may have potentially exceeded the $DCGL_W$ and presented the results of the investigation in a summary of scan investigations and static measurements table in each FSSR Attachment. NRC staff reviewed the results of the summary of scan investigation and static measurements for each FSSR Attachment, and determined that the approach and methodology was consistent with NUREG-1575 (MARSSIM) and the NASA FSSP.

3.5.1 Evaluation and Finding

NRC staff has determined that the licensee applied the proper scan coverage for each survey unit and classification, and used the investigation levels consistent with MARSSIM and NASA's FSSP. NRC staff has determined that the investigation levels and scan survey results are acceptable.

3.6 Systematic Measurements and Final Results

NASA reported systematic measurements and final results for structures, soils, and EP for large areas to demonstrate compliance with 10 CFR Part 20, subpart E. Systematic measurements were compared to DCGLs ($DCGL_W$, $DCGL_{SUR}$, or $DCGL_{GB}$). With the exception of the scan investigation results (which are reported separately), all systematic measurement results were reported for each survey unit in each FSSR Attachment as either dpm/100 cm^2 for structures, pCi/g for soils, and mrem/yr for EP. NASA reported both the maximum and average survey results, and these results were compared to the $DCGL_W$ value.

3.6.1 Evaluation and Finding

NRC staff reviewed all results reported by NASA in each survey unit and each FSSR Attachment and observed that all reported systematic measurement results, including the maximum value, were below the $DCGL_W$ and no further statistical tests were necessary. NRC staff reviewed this information for each FSSR Attachment and provided a summary of its review in ADAMS Accession No. ML12236A322.

Radiation doses from EP for affected survey units were summed with the dose from the DCGL values to ensure that the total effective dose equivalent was less than the regulatory limit of 25 mrem (0.25 mSv) per year for unrestricted release.

NRC staff determined that all systematic measurements and final survey results were below the $DCGL_W$ and NRC staff found the results to be acceptable.

3.7 ALARA

NASA demonstrated that the residual contamination has been reduced to levels that are ALARA. NASA used a screening level equivalent DCGL for the revised default mixture of 14,124 dpm/100 cm^2. NASA performed 7,459 total static beta measurements on structures. The average static beta result was 547 ± 479 dpm/100 cm^2. NASA reported an upper confidence interval at the 95% level of 558 dpm/100 cm^2. NRC staff determined that 95% of the 7,459 static beta results, or approximately 7,086 static beta results were equal to or less than 558 dpm/100 cm^2. This value is below the reference screening level gross activity DCGL of 14,124 dpm/100 cm^2.

NASA used surface soil screening values of 11.0 pCi/g for Cs-137, 3.8 pCi/g for Co-60, and 1.7 pCi/g for Sr-90. The maximum Cs-137, Co-60, and Sr-90 concentrations in soils detected by NASA were 7.62 pCi/g,1.0 pCi/g, and 0.089 pCi/g, respectively. The maximum concentration value for each radionuclide detected by NASA was below the surface soil screening values.

3.7.1 Evaluation and Finding

NRC staff reviewed the results of all structure and soil measurements performed by NASA and observed that the structure and soil results were below the screening values for both structures and soils. NRC staff determined that NASA satisfied the ALARA criterion for structures and soils and NRC staff found this acceptable.

3.8 NRC Inspections and Confirmatory Surveys

NRC Region III inspectors conducted inspections between 2007 and 2012 that independently supports the technical evaluation of the 18 individual FSSR Attachments and the Plum Brook SER. The inspections included a review of selected radiation instrumentation calibration and detection sensitivities, final status survey records to verify that residual contamination was less than the DCGLs as stated in the licensee's FSSP, and a review of the licensee's survey and sampling process to ensure it was effective in identifying areas of elevated activity necessary to meet the appropriate DCGLs. The inspections also included performance of independent confirmatory surveys and sampling of selected areas at the site. The inspection reports include ADAMS Accession Nos. ML071940476, ML073550392, ML081480522, ML091480119, ML093650247, ML102580370, ML110680091, ML113470416, ML12135A229 and ML12271A180.

In 2011-2012, a regulatory compliance issue of minor safety significance was identified for a failure to adequately calculate gross beta DCGLs as described in the FSSP. The inspectors determined that the licensee's corrective actions adequately addressed and corrected the issue. NRC inspectors verified the adequacy of the licensee's assessment that no license amendment or 10 CFR 50.59 evaluation was required as a result of the corrective action taken.

3.8.1 Evaluation and Findings

NRC inspectors concluded that all confirmatory survey results were consistent with the licensee's and well below the required DCGLs. NRC inspectors also found the calculated DCGLs for the areas surveyed by the inspectors were appropriate and were determined in accordance with the requirements in the FSSP and followed NUREG-1575 (MARSSIM). Finally, NRC inspectors concluded that the survey units, where release records were reviewed, were appropriate for release in accordance with the FSSP and followed MARSSIM guidance. NRC staff has determined that the NRC Region III inspections independently confirmed this technical evaluation and NRC staff has determined that the inspections were acceptable.

3.9 Comparison with EPA Trigger Levels for Soils and MCLs for Groundwater

Consistent with the October 2002 Memorandum of Understanding (MOU) between NRC and EPA, the PBRF license termination process includes a review of residual contamination levels in soil and groundwater. The MOU established a mechanism for agency consultation during the decommissioning process if there is radioactive contamination in excess of EPA's trigger levels for soils or MCLs for groundwater. The EPA trigger levels for soils and MCLs for groundwater are identified in the FSSR-MBR.

3.9.1 Evaluation and Findings

NASA calculated the average of the maximum values of the principal soil contaminant radionuclides (i.e., Co-60, Sr-90, and Cs-137) measured in all samples selected by the FSSP, and also collected over 600 water samples from 2007 to 2011. NRC staff reviewed all soil and groundwater results collected by NASA and found that no result exceeded the EPA trigger levels or MCL values. NRC staff has determined that the residual contamination in soil and groundwater are below the applicable EPA trigger levels and MCL values and NRC staff found this acceptable.

4.0 Environmental Considerations

The environmental impacts associated with decommissioning the PBRF were previously evaluated in conjunction with the license amendment authorizing the decommissioning of the PBRF. The Environmental Assessment and Finding of No Significant Impact concerning this action was published in the *Federal Register* (65 FR 16421; March 28, 2000).

5.0 Conclusion

NRC staff concludes that the licensee conducted final status surveys in accordance with the NASA FSSP. NRC staff has determined that the survey results, documented in the FSSR, demonstrate compliance with the radiological criteria for license termination specified in 10 CFR Part 20, subpart E and that residual contamination has been reduced to levels ALARA.

6.0 References

NASA, 2007. NASA Safety and Mission Assurance Directorate, *Final Status Survey Plan for the Plum Brook Reactor Facility*, Rev.1, February 2007 (ADAMS Accession Nos. ML070450166, ML070450170 and ML070450171).

NASA, 2008. NASA Plum Brook Reactor Facility Technical Basis Document, *Shield Analyses for the Ludlum 44-116 Probe,* PBRF-TBD-07-006, January 30, 2008 (ADAMS Accession No. ML080320376).

NASA 2008a. NASA Safety and Mission Assurance Directorate, *Decommissioning Plan for the Plum Brook Reactor Facility*, Rev. 6, July 2008 (ADAMS Accession No. ML082070086).

NASA, 2012. Plum Brook Reactor Facility, Request for Termination of Licenses Nos. TR-3, Docket No. 50-30 and R-93, Docket No. 50-185, September 2012 (ADAMS Accession No.ML12268A326).

NRC, 1998. U.S. Nuclear Regulatory Commission, DG-4006, "Demonstrating Compliance with the Radiological Criteria for License Termination," August 1998 (ADAMS Accession No. ML993250287).[2]

NRC, 2000. U.S. Nuclear Regulatory Commission, "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)," NUREG 1575, Rev.1, August 2000 (ADAMS Accession No. ML003761476).

NRC, 2006. U.S. Nuclear Regulatory Commission, "Consolidated Decommissioning Guidance," NUREG-1757, Volume 1, Rev. 2, and Volume 2, Rev. 1, September 2006 (ADAMS Accession Nos. ML063000243 and ML063000252).

EPA-NRC, 2002. "Memorandum of Understanding, U.S. Environmental Protection Agency and U.S. Nuclear Regulatory Commission, Consultation and Finality on Decommissioning and Decontamination of Contaminated Sites," October 9, 2002 (ADAMS Accession No. ML022830208)..

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[2] The NRC withdrew DG-4006, "Demonstrating Compliance with the Radiological Criteria for License Termination," from consideration as a regulatory guide in 2002. Appendix D of NUREG-1727 incorporated the guidance that was proposed in DG-4006, and NUREG-1757 replaced NUREG-1727 in 2006.

Appendix A

Plum Brook Reactor Facility Final Status Survey Report

FSSR - Main Body Report (ADAMS Accession No. ML12264A559)

FSSR Attachment 1 – Reactor Office Laboratory Building (ADAMS Accession Nos. ML103060324 and ML103060323)

FSSR Attachment 2 – Service Equipment Building (ADAMS Accession Nos. ML103060324, ML103060331 and ML103080859)

FSSR Attachment 3 – Fan House (ADAMS Accession Nos. ML103060324 and ML103060333)

FSSR Attachment 4 - Pentolite Ditch (ADAMS Accession No. ML102390408)

FSSR Attachment 5 - Hot Retention Area (ADAMS Accession Nos. ML103060324 and ML103060329)

FSSR Attachment 6 – Waste Handling Building (ADAMS Accession Nos. ML103060324 and ML103060328)

FSSR Attachment 7 – Storm Drains, Pipe Trenches & Other Sub-Surface Excavations (ADAMS Accession Nos. ML12100A123, ML12100A124 and ML12100A126)

FSSR Attachment 8 – Hot Laboratory (ADAMS Accession Nos. ML12100A123, ML12100A129, ML12100A130, and ML12100A125)

FSSR Attachment 9 – Embedded Piping (ADAMS Accession Nos. ML12100A123 and ML12100A127)

FSSR Attachment 10 – Emergency Retention Basin (ADAMS Accession No. ML11243A183)

FSSR Attachment 11- Reactor Containment Vessel (ADAMS Accession Nos. ML11262A287, ML11262A285 and ML11262A286)

FSSR Attachment 12 – Reactor Building (ADAMS Accession Nos. ML12030A231, ML12030A229, ML12030A230, and ML12030A232)

FSSR Attachment 13 – Primary Pump House (ADAMS Accession Nos. ML12020A100, ML12020A096 and ML12020A097)

FSSR Attachment 14 – Transport Roadways and Parking Lots (ADAMS Accession No. ML12068A261)

FSSR Attachment 15 – Miscellaneous Structures and Pads (ADAMS Accession Nos. ML12025A128, ML12025A126 and ML12025A127)

FSSR Attachment 16 – Open Land Areas within Restricted Area and Outside Buffer Area (ADAMS Accession Nos. ML12065A214 and ML12065A334)

FSSR Attachment 17 – Buried and Miscellaneous Piping (ADAMS Accession No. ML12201A111)

FSSR Attachment 18 – Excavated and Backfill Materials (ADAMS Accession Nos. ML12059A333 and ML12059A365)