**Summary of the U.S. Nuclear Regulatory Commission Staff Review and Evaluation of the Plum Brook Reactor Facility Final Status Survey Attachments**

**Attachment #1, Reactor Office and Laboratory Building (ROLB)** is a three level structure used as offices, radiochemistry laboratory, classroom, conference rooms, library, repair shops, health physics offices, first aid facility, instrument calibration laboratory, new fuel vault and equipment calibration facility. There are 60 survey units in the ROLB. Of the 60 survey units, 42 survey units are Class 1, 10 survey units are Class 2, and 8 survey units are Class 3. All survey units were scanned prior to conducting the beta static measurements. A total of two survey units exceeded the scan investigation level. Upon further investigation, the largest activity found was 13,465 dpm/100 $cm^2$ in investigative measurement IM-1. This was below the DCGL value of 27,166 dpm/100 $cm^2$. The second location that exceeded the investigation level in Survey Unit RO-2-2 was 54,477 dpm/100 $cm^2$. The size of this area was approximately 2 cm (0.79 in) by 2 cm (0.79 in) and the licensee utilized the elevated measurement comparison (EMC) test (e.g., applicable to small areas of elevated concentrations within a survey unit). The EMC test determined a concentration of 82,708 dpm/100 $cm^2$. The EMC test demonstrated that the activity from this small area would not exceed the dose criteria of 25 mrem (0.25 mSv) per year. Although the licensee determined the DCGL for the new fuel vault was 30,831 dpm/100 $cm^2$, the licensee applied the more conservative default DCGL value of 27,166 dpm/100 $cm^2$ for the new fuel vault.

The number of static beta measurements taken in each survey unit ranged from 11-12. The number of samples collected for structural static beta measurements and soil sampling locations were derived from the methods discussed in MARSSIM (NUREG-1575). There were no major changes to the previously approved FSSP. The staff has determined that the ROLB FSSR demonstrates that it meets the requirement of 10 CFR Part 20 Subpart E and that residual contamination has been reduced to levels as low as reasonably achievable (ALARA). Therefore, NRC staff finds the ROLB FSSR acceptable. Residual activity concentrations measured in the soil survey unit (RO-3-28B) were compared to and found to be less than EPA trigger levels.

**Attachment #2, Reactor Service Equipment Building (SEB)** is a three story structure. The SEB housed the water processing equipment, air compressors, electrical control equipment, emergency diesel generators, and health physics radiochemistry/analytical laboratory, and the Cold Pipe Tunnel which also extends into adjacent buildings. A total of 52 survey units were identified for this survey package. A total of 39 survey units were classified as Class 1, 6 survey units were classified as Class 2, and 7 survey units were classified as Class 3. All Class 1 survey units were scanned at 100%. In three survey units, localized areas exceeded the scan investigation level. Upon further investigation, these areas were small (4 $cm^2$ [0.62 $in^2$] and 125 $cm^2$ [19.37 $in^2$]) and did not exceed the DCGL, or were found not to contribute significantly to the dose. The DCGL for the SEB was 27,166 dpm/100 $cm^2$. The DCGL for the Cold Pipe Tunnel was 11,000 dpm/100 $cm^2$. All results were below the DCGL.

The number of static beta measurements taken in each survey unit ranged from 11 to 13. The number of samples collected for structural static beta measurements and soil sampling locations were derived from the methods discussed in MARSSIM (NUREG-1575). All static beta measurements were below the applicable DCGL.

There were no major changes to the previously approved FSSP. The staff has determined that the SEB FSSR demonstrates that it meets the requirement of 10 CFR Part 20 Subpart E and that residual contamination has been reduced to levels as low as reasonably achievable (ALARA). Therefore, NRC staff finds the SEB FSSR acceptable. A comparison with EPA trigger levels is not applicable since there are no soil or groundwater measurements associated with the SEB FSSR.

**Attachment #3, Fan House Building (FHB)** is a two level structure that was designed to collect and process the exhaust air and contaminated water from the Reactor Building and other PBRF buildings. The FHB included fans, pumps, compressors, scrubbers, filters, activated charcoal absorbers, radiation monitors and ventilation for the exhaust system. A total of 38 survey units were classified as Class 1. All Class 1 survey units were scanned at 100%. A total of three survey units exceeded the scan investigation level. Upon further investigation by the licensee, two discrete areas were identified and further measurements showed that the contamination was less than 10,500 dpm/100 $cm^2$. This was below the FHB $DCGL_W$ (36,857 dpm/100 $cm^2$) and no further action was necessary. The third survey unit indicated that a small pipe stub measured 105,000 dpm/100 $cm^2$. The pipe stub was approximately 8.25 cm (3.25 in) in diameter by 5.71 cm (2.25 in) in length. The licensee applied the area factor and conducted an EMC test (e.g., applicable to small areas of elevated concentrations within a survey unit). The $DCGL_{EMC}$ was determined to be 1,400,000 dpm/100 $cm^2$ for this area and demonstrated that the activity from this small area would not exceed the dose release criteria of 25 mrem (0.25 mSv) per year.

The number of static beta measurements for the survey units in the FHB ranged from 11 to 15 for each survey unit. The number of samples collected for structural static beta measurements locations were derived from the methods discussed in MARSSIM (NUREG-1575). All static beta measurements were below the applicable DCGL.

There were no major changes to the previously approved FSSP. The staff has determined that the FHB FSSR demonstrates that it meets the requirement of 10 CFR Part 20 Subpart E and that residual contamination has been reduced to levels ALARA. Therefore, NRC staff finds the FHB FSSR acceptable. A comparison with EPA trigger levels is not applicable since there are no soil or groundwater measurements associated with the FHB FSSR.

**Attachment #4, Pentolite Ditch** is a drainage canal that is approximately one half mile long extending eastward from the PBRF Waste Effluent Monitoring Station (WEMS) outfall to its confluence with the Plum Brook. Liquid effluents (such as storm drainage, waste waters containing radioactive contamination, and processed lake dilution water) from the nuclear test facility were released into the Pentolite Ditch via the WEMS. A total of 42 survey units were identified for this survey package. A total of 36 survey units were identified as Class 1 and 6 survey units were classified as Class 2. All Class 1 survey units were scanned at 100%. One survey unit (OL-3-30) exceeded the scan survey investigation level. The scan investigation

level was 125 net counts per minute (cpm). This corresponds to 2.92 pCi/g. Two static measurements were taken at two locations within the survey unit and resulted in values of 162 net cpm and 119 net cpm, respectively. Soil sample results at both locations were less than the DCGL. The DCGL for soil sample results for Cs-137 and Co-60 were 14.02 pCi/g and 3.8 pCi/g, respectively.

The number of soil samples collected in each survey unit was 11 with the exception of OL-3-8 which collected 14 samples. The number of samples collected for soil sampling locations were derived from the methods discussed in MARSSIM (NUREG-1575). All results were less than the DCGL values established for Cs-137 and Co-60.

There were no major changes to the previously approved FSSP. The staff has determined that the Pentolite Ditch FSSR demonstrates that it meets the requirement of 10 CFR Part 20 Subpart E and that residual contamination has been reduced to levels ALARA. Therefore, NRC staff finds the Pentolite Ditch FSSR acceptable. Residual soil concentrations measured in Pentolite Ditch survey units were compared to and found to be less than EPA trigger levels.

**Attachment #5, Hot Retention Area (HRA)** is a reinforced concrete vault structure designed to hold large volumes of radioactively contaminated water generated in PBRF reactor operations. It functioned as a tank farm for storage, holdup, and decay of water from the hot drain system. There are 34 survey units in the HRA. All survey units are identified as Class 1. All survey units were scanned prior to conducting the beta static measurements. A total of three survey units exceeded the scan investigation level. Upon further investigation, the licensee determined that the elevated scan measurements in the three survey units were less than the DCGL (29,423 dpm/100 $cm^2$).

A total of 11 static beta measurements were taken in each survey unit. The number of samples collected for structural static beta measurements locations were derived from the methods discussed in MARSSIM (NUREG-1575). All static beta measurements were below the applicable DCGL.

There were no major changes to the previously approved FSSP. The staff has determined that the HRA FSSR demonstrates that it meets the requirement of 10 CFR Part 20 Subpart E and that residual contamination has been reduced to levels ALARA. Therefore, NRC staff finds the HRA FSSR acceptable. A comparison with EPA trigger levels is not applicable since there are no soil or groundwater measurements associated with the HRA FSSR.

**Attachment #6, Waste Handling Building (WHB)** is a steel frame and poured concrete construction. It was designed for handling and processing radioactive material. The building was comprised of a main floor (first floor), a partial mezzanine level, and a basement. The building contained equipment for processing contaminated water, protective clothing, miscellaneous contaminated trash or dry active waste (DAW) and experimental equipment. A total of 29 survey units were identified in this final status survey report. Of these, 28 survey units were classified as Class 1, and one survey unit (WH-4-1) was identified as a Class 2. This survey unit included the external surface (i.e., roofs and outside walls) of the building.

All Class 1 survey units were scanned at 100%. Three survey units exceeded the scan investigation level. Survey unit WH-1-3 was further evaluated as a new survey and designated

Design 29C. Three cracks were noted in two areas and additional measurements were taken during the more detailed survey. These were very small areas and they were remediated. One area was determined to be below the $DCGL_W$. In the second area, the activity was measured as 53,000 dpm/100 $cm^2$ and an elevated measurement concentration test was conducted. An area factor of 10.6 was applied to this 300 $cm^2$ (46.5 $in^2$) area and the survey passed the elevated measurement test. Two small areas of elevated activity were detected in WH-1-8. One area measured 30,900 dpm/100 $cm^2$ and this was below the $DCGL_W$. The second area was measured at 74,400 dpm/100 $cm^2$. The area was identified as 126 $cm^2$ (19.53 $in^2$). An elevated measurement concentration test was applied to the area and an area factor of 16.4 was used. This met the elevated measurement test. In survey unit WH-1-9, an elevated measurement was detected and reported as 7,290 dpm/100 $cm^2$. The results were below the $DCGL_W$.

The number of total surface beta activity measurements for each survey unit ranged from 11 to 14. The licensee used various $DCGL_W$ values for various survey units. These survey units are shown in Table 5 of the WHB FSSR. All surface measurements were below the $DCGL_W$. Survey unit WH-3-1 included soils. The results indicated that all Cs-137 and Co-60 sample values were less than the $DCGL_W$ for soils.

There were no major changes to the previously approved FSSP. The staff has determined that the WHB FSSR demonstrates that it meets the requirement of 10 CFR Part 20 Subpart E and that residual contamination has been reduced to levels ALARA. Therefore, NRC staff finds the WHB FSSR acceptable. The soil sample results (WH-3-1) were below the EPA trigger levels and no further action is necessary.

**Attachment #7, Storm Drains, Pipe Trenches & Other Sub-Surface Excavations (SDPTSSE)** consist of a series of drains, trenches and sub-surface excavations on the site. More specifically, the remediation action levels (RALs) identified the following areas for remediation:

- Emergency Retention Basin
- Cold Retention Basins
- Water Effluent Monitoring System
- Storm Drains and Catch Basins
- Waste Handling Building and Fan House Building sub-foundation
- Pentolite Ditch and Environs
- Discrete Contaminated Areas

Figure 1, as shown in the FSSR Attachment 7, is a location map that identifies the above areas and survey units. In addition, several discrete contaminated areas in these areas are identified in Table 1, Spill Area Summary. NRC staff could not determine the discrete contaminated areas from this map. NASA submitted a revised Attachment 7 which shows the location of discrete contamination areas. A total of 39 survey units were identified as Class 1 in this report. There were no survey units identified as a Class 2 or Class 3.

All survey units were scanned at 100%. Three survey units were identified as exceeding the investigation level. In Survey Unit OL-1-2, a 0.09 $m^2$ (1 $ft^2$) area was sampled and the surface soil 0-15.24 cm (0-6 in) detected Cs-137 activity of 4.22 pCi/g and no detectable Co-60 activity.

The sub-surface soil 15.24 cm-30.48 cm (6-12 in) contain Cs-137 activity of 0.747 pCi/g and no detectable Co-60 activity. No further action was necessary. In Survey Unit OL-1-3, surveys confirmed a broken pipe and all piping was removed for disposal. The affected area was re-defined as a new survey unit (OL-1-5). This area was approximately 0.76 m (2.5 ft) by 1.22 m (4 ft). Additional samples were collected within Survey Unit OL-1-3 and no detectable Cs-137 or Co-60 was detected. Soil samples were collected in the new Survey Unit OL-1-5 and the results showed that all samples were below the $DCGL_{EMC}$. Therefore, no further action was necessary.

A total of 11-12 samples were collected from each survey unit and the results showed that activity levels in the soil samples for Cs-137 and Co-60 were below the $DCGL_w$ for each radionuclide.

There were no major changes to the previously approved FSSP. The staff has determined that the SDPTSSE FSSR demonstrates that it meets the requirement of 10 CFR Part 20 Subpart E and that residual contamination has been reduced to levels ALARA. Therefore, NRC staff finds the SDPTSSE FSSR acceptable. The soil results were below the EPA trigger levels and no further action is necessary.

**Attachment #8, Hot Laboratory Building (HLB)** is primarily a concrete structure that was designed to handle and analyze very high levels of radioactive material produced in the PBRF test reactor facility. The types of analysis included chemical, radiochemical, metallurgical analyses of irradiated experiment specimens such as moon rocks, various nuclear fuel materials, and nuclear rocket components. Other activities in the HLB included inspection, disassembly, and modification of reactor core components such as fuel elements, beryllium reflectors, upper grid assemblies, and irradiated test materials. These activities involved potential high level radiological exposures and contamination levels.

The facility contained seven heavily shielded hot cells, support and work areas, and also included hot work areas, a cold work area, equipment areas, a manipulator repair room, and an equipment repair room. The HLB includes underwater transfer canals from the reactor building, dry storage areas, and transfer areas into and out of hot cells. Other areas in the HLB included a decontamination room, change room and showers, hot and cold lavatories and offices.
A total of 140 survey units were identified for the HLB. Of the 140 survey units, 137 survey units were classified as Class 1, two survey units as Class 2, and one survey unit as Class 3. Two survey units within the Class 1 group were identified for soil sampling. All survey units were scanned prior to conducting the beta static measurements. Survey units identified as Class 1 were scanned at 100%.

A total of 37 survey units exceeded the scan investigation level, and the licensee conducted static measurements at these locations. Static measurements provide a more definitive result when compared to a scan measurement. Two survey units (HL-1-58 and HL-4-18) failed and these survey units were remediated, re-surveyed and determined to be below the $DCGL_w$. A summary of the investigative static measurements and results are shown in the NASA FSSR, Attachment 8, Hot Laboratory (Building 1112), Table 12, Summary of Investigative Static Measurements and Results. NRC staff noted that many measurements were either incomplete or blank. NASA revised Table 12 to include the final resolution or outcome of all investigative measurements as identified in the column titled “Comments/Results”.

The number of static beta measurements taken in each survey unit ranged from 11 to 15. The number of samples collected for structural static beta measurements or soil sampling was derived from the methods discussed in MARSSIM (NUREG-1575). All static beta measurements were below the applicable DCGL.

There were no major changes to the previously approved FSSP. NRC staff has determined that the HLB FSSR demonstrated that it meets the requirement of 10 CFR Part 20 Subpart E and that residual contamination has been reduced to levels ALARA. Therefore, NRC staff finds the HLB FSSR acceptable. The soil results were below the EPA trigger levels and no further action is necessary.

**Attachment #9, Embedded Piping (EP)** systems include the Primary Cooling Water (PCW), Quadrant and Canal Piping, Hot Drains, and Cold Drains. The diameter of the EP ranged from 5.08 cm (2 in) to 60.96 cm (24 in). EP is any pipe situated below the minus three foot elevation 191.4 m (628 ft mean sea level) that is totally encased in concrete or piping directly beneath building floors that may not be totally encased in concrete, but contained within the structural foundation of the building. In addition, EP is grouted at the time of license termination to demonstrate compliance with the release criterion.

EP was an interconnected system of piping that contained and transported water with residual radioactive material. The residual radioactive material was the byproduct of activation and corrosive material from reactor and research operations. Approximately 243.84 m (800 ft) of embedded PCW piping will remain in place. This includes portions of the by-pass cleanup, instrument cooling and shutdown loops, and drain lines. Approximately 85.34 m (280 ft) of 60.96 cm (24 in) stainless steel PCW pipe remains. Other EP remaining includes a total of 609.6 m (2000 ft) of carbon steel piping in the quadrants and canals, 1524 m (5000 ft) in length for the hot drains, and 1524 m (5000 ft) in length for the cold drains. The licensee decontaminated 100% of the interior surfaces of radiologically contaminated EP.

The EP interior surfaces were surveyed using several different radiation detectors. All measurements were converted to dpm/100 $cm^2$. Unlike other final status survey packages where DCGLs were derived for surface contamination and correlated to the release criteria of 25 mrem (0.25 mSv) per year, the EP derived DCGLs from the interior pipe surface and established a dose goal of 1 mrem (0.01 mSv) per year at a three foot level above the surface of the concrete where an individual may occupy. Thus, the total dose includes the dose from any potential surface contamination and any potential dose contribution from EP. NASA established DCGL values for EP for Co-60, Eu-152, Eu-154, Nb-94, Ag-108m, and Cs-137. These values are shown in Table 1a and Table 5 of the FSSR, Attachment 9.

NASA stated that as a result of this remediation and survey campaign, 167 runs of EP were remediated, surveyed and grouted in compliance with the NASA FSSP and its implementing procedures. Table 7 and Table 8 in FSSR Attachment 9 provide a summary of the EP survey results. The tables are divided into piping where Co-60 is the nuclide of concern (Table 7) and piping where Cs-137 is the nuclide of concern (Table 8). NRC staff reviewed Table 7 and Table 8 and observed that all average annual embedded piping doses were less than 1 mrem (0.01 mSv) per year with the exception of EP1.11 and EP 1.12. The annual average dose from these two EPs was 1.009 mrem (0.01 mSv) per year and 1.37 mrem (0.0137 mSv) per year, respectively. These two EPs are not shown in Table 7 and Table 8. NRC staff observed in Table

7 and Table 8 that the DCGLs in these tables were not consistent with the DCGLs identified in Table 1a and Table 5, and in some cases, the DCGLs had higher values in both Table 7 and Table 8 than what was reported in Table 1a and Table 5. NASA stated that since the methodology for surveying the 60.96 cm (24 in) diameter reactor coolant piping was distinctly different than surveys performed in other piping systems, NASA elected to describe the survey methodology and provide results in Appendix D in an attempt to minimize confusion. Piping EP-1.11 and EP-1.12 were surveyed with beta detectors. NRC staff also observed that Table 7 and Table 8 included maximum and average activity values for each EP. NRC staff could not determine from this report if the EP doses were computed from the average activity or the maximum activity. NASA stated that the dose from each pipe run is the average activity and confirmed that the average dose and the survey measurements support the position that the final dose is less than the DCGL.

NRC staff determined that the establishment of a dose goal of 1 mrem (0.01 mSv) per year is ALARA. NASA demonstrated that the average annual EP dose was less than 1 mrem (0.01 mSv) per year per pipe run. The FSSR for EP does not include soils or groundwater. Thus, EPA trigger levels are not within the scope of this report.

**Attachment #10, Emergency Retention Basin (ERB)** was a 1.21 hectare (3 acre) above ground earthen water storage basin. The ERB was used as emergency storage for radioactively contaminated water that exceeded liquid effluent discharge criteria. The ERB was later modified and pumps were added to handle potential storm drain overflow from unusually heavy rainfall.

A total of 7 survey units were identified for the ERB. All 7 survey units were classified as Class 1. All survey units were scanned prior to conducting the final status soil sampling and measurements. Survey units identified as Class 1 were scanned at 100%. The scan investigation level was set at 7.7 pCi/g or 75% of the 10.3 pCi/g DCGL for Cs-137. One survey unit failed the investigation scan. This was survey unit OL-1-27. Four soil samples were collected and analyzed in survey unit OL-1-27. The Cs-137 concentrations ranged from1.06 pCi/g to 4.29 pCi/g, and Co-60 concentrations were less than the minimum detectable activity (MDA). Therefore, all results were below the $DCGL_{sur}$ and $DCGL_{w}$ for soils and no further action was necessary for survey unit OL-1-27.

The number of soil samples taken in each survey unit ranged from 12 to 13. The number of soil samples was derived from the NASA FSSP. The plan is consistent with NUREG-1575 (MARSSIM). A total of 74 soil samples were collected and analyzed from the ERB. All soil sample results, except for two survey units, were less than the MDA for Cs-137. For survey units OL-27 and OL-32, the maximum soil sample concentrations for Cs-137 were 0.273 pCi/g and 0.15 pCi/g, respectively. These values were below the DCGL. Therefore, no further action is necessary. The licensee also collected 20 surface and subsurface soil samples and performed gamma spectroscopy on these samples. The results for all surface and subsurface soil samples were less than the MDA for Cs-137 and Co-60, respectively. Therefore, no further action was necessary.

There were no major changes to the previously approved FSSP. NRC staff has determined that the ERB FSSR demonstrated that it meets the requirement of 10 CFR Part 20 Subpart E and that residual contamination has been reduced to levels ALARA. The results of all soil samples

for the ERB were below the EPA trigger levels and no further action is necessary. Groundwater is not within the scope of the ERB final status survey.

**Attachment #11, Reactor Containment Vessel (CV)** is a large cylindrical steel shell that enclosed the 60 MW (thermal) Plum Brook Reactor and associated experiment test area. The Reactor CV is 30.48 m (100 ft) in diameter and 33.83 m (111 ft) in height. It was designed to prevent the release of radioactive materials directly to the environment.

The Reactor CV was divided into 87 survey units with 85 survey units as Class 1 and 2 survey units are Class 2. All surface areas in a Class 1 survey unit are scanned at 100%. An investigation was conducted on 4 survey units. A survey unit can be further investigated if the technician detects additional audible count rates or determines that the scan count rate equivalent exceeded 75% of the $DCGL_w$. One survey unit, CV-1-17, exceeded the $DCGL_w$. The other three survey units, after static measurements, were below the $DCGL_w$ and NASA determined that no further action was necessary. The size of each area, where the elevated measurements were found, was equal to or less than 100 $cm^2$ (15.5 $in^2$) The licensee conducted static measurements in CV-1-17, applied the elevated measurement comparison, in accordance with the FSSP, and determined that the static measurements in CV-1-17 were below the $DCGL_{emc}$ (418,361 dpm/100 $cm^2$). An area factor of 40.2 was applied to the static measurements to determine the $DCGL_{emc}$. NASA determined that no further action was necessary.

NASA performed final static beta measurements in each survey unit. The number of measurements ranged from 11 to 16 in each survey unit. All measurements were below the $DCGL_w$. There were no major changes to the FSSP. Therefore, NRC staff concluded that the final status survey results were acceptable and in compliance with 10 CFR Part 20, Subpart E. No soils or groundwater were within the scope of the Reactor CV final status survey. Thus, EPA trigger levels were not applicable.

**Attachment #12, Reactor Building (RB)** is a large four story steel and concrete structure which housed the Plum Brook 60 MW Test Reactor, the 100 kW Mockup Reactor (MUR) and associated experimental and test facilities. The RB is 49.38 m (162 ft) by 45.41 m (149 ft) with four levels. Two levels are below grade level -4.57 m (-15 ft) and -7.26m (-25 ft), another at 0 ft grade level, and 3.66 m (12 ft) above grade level. The RB provided support to operations occurring within the CV area. Within the RB were the concrete canals that provided a transport route into and out of the CV. The canals were utilized to transport radioactive material into and out of the CV

A total of 130 survey units were identified in the RB. Of the 130 survey units, 116 survey units were identified as Class 1, 13 survey units were Class 2, and 1 survey unit was Class 3. All survey units were designed for structure surveys except one survey unit for soils. All survey units were scanned prior to conducting the beta static measurements. Survey units identified as Class 1 were scanned at 100%.

A total of 11 survey units exceeded the scan investigation level and further radiological surveys were conducted on these areas. In Table 13 of the FSSR, the licensee identified the survey units for investigation, the size of the elevated area, the static measurement result and comments. In several survey units, the licensee conducted further measurements. Of the 33

survey units, the results of 20 static measurements required no further action. The remaining survey units were re-evaluated using the $DCGL_{emc}$ as described in the FSSP. NRC staff observed that many of these survey units were equal to or less than 100 $cm^2$ (15.5 $in^2$). These survey units did not exceed the $DCGL_{emc}$ value and therefore no further action was required.

The number of static beta measurements taken in each survey unit ranged from 10 to 16. The number of samples collected for structural static beta measurements or soil sampling (one survey unit) are derived from the methods discussed in MARSSIM (NUREG-1575) and are consistent with the licensee's FSSP.

The licensee indicated in the conclusion (Section 5.8) that there was one change from initial assumptions (in the FSS Plan) regarding the extent of residual activity in the RB. One area of potentially contaminated soil identified underneath the sanitary sump at the -4.57m (-15 ft) elevation. No re-classification of survey units was required as a result of final status survey measurements and investigations. The soil results were below the EPA trigger levels and no further action is necessary.

**Attachment #13, Primary Pump House (PPH)** is primarily a concrete structure that was designed to house major components of the reactor primary cooling water system. This included the heat exchanger, three primary pumps, flow measuring and monitoring equipment, a cleanup system, and a fuel element test rig. The PPH also included a waste sump for contaminated water. The major purpose of this facility was to provide primary coolant to the reactor system and remove excess heat.

A total of 42 survey units were identified for the PPH. A total of 30 survey units were identified for the interior of the building and 12 survey units were identified for the exterior of the building. All 42 survey units were classified as Class 1. All survey units were scanned prior to conducting the beta static measurements. Survey units identified as Class 1 were scanned at 100%.

A total of 7 survey units exceeded the scan investigation level and the licensee conducted static measurements at these locations. The size of the elevated areas was equal to or less than 100 $cm^2$ (15.5 $in^2$). The static measurement in one survey unit was 25,000 dpm/100 $cm^2$. This exceeded the $DCGL_w$ which was 23,713 dpm/100 $cm^2$. The licensee calculated the $DCGL_{emc}$ for this elevated area using an area factor of 40.2 and the average residual activity concentration which was 1943 dpm/100 $cm^2$. The licensee calculated the $DCGL_{emc}$ to be $9.53 \times 10^5$ dpm/100 cm2. NRC staff determined that this was not the correct $DCGL_{emc}$ value. The $DCGL_{emc}$ value should be 78,109 dpm/100 $cm^2$ (40.2 x 1943 = 78,109) and not $9.50 \times 10^5$ dpm/100 $cm^2$. NRC staff determined that the correct $DCGL_{emc}$ value is 78,109 dpm/100 $cm^2$. NASA accepted NRC's observation and the calculation was corrected in Attachment 13, Revision 1.

The licensee provided the radionuclide activity fraction and gross activity DCGL values in Table 3. In this table, the radionuclide activity fraction showed that H-3 represents almost half of the radionuclide fraction for the interior surface. And for Room 4, in addition to the H-3, I-129 represented approximately 22%. The licensee determined a gross activity DCGL using the radionuclide mixture identified in Table 3. The gross activity DCGL is used when there is a mixture of radionuclides. The licensee indicated that the static beta measurements were performed with a beta scintillation detector, LMI 44-9. On page 13 in the FSS report, the licensee stated that the gross activity DCGL can also account for so-called hard-to-detect (HTD)

radionuclides. The licensee further indicated that the latter are not detected, or detected with very low efficiency, by the beta detectors selected for final status surveys of structures. NUREG-1575 (MARSSIM) pg 4-9 states that if the mixture contains radionuclides that cannot be measured using field survey equipment, laboratory analyses of surface materials may be necessary. NUREG-1575, Table 4.1 indicates that H-3 cannot be detected using direct radiation field instrumentation. NRC staff requested ORISE to review the capabilities of NASA to account for the hard-to-detect radionuclides, such as H-3 and I-129. ORISE reviewed the methods used by NASA for H-3 and I-129 to account for these hard-to-detect radionuclides in the development of the DCGLs and field measurements, and determined that the methods were appropriate. ORISE did identify a deficiency in the methods used by NASA for U-234. This issue was addressed in the NRC Region III inspection report and identified as a minor regulatory compliance issue. NASA addressed the minor regulatory compliance issue with appropriate corrective actions. The NRC Region III reviewed these corrective actions and had no further concerns, which is documented in an Inspection Report 2011-002 (ML12135A229).

The number of static beta measurements taken in each survey unit ranged from 11 to 12. The number of static beta measurements was derived from the NASA FSSP. The plan is consistent with NUREG-1575.

There were no major changes to the previously approved FSSP. NRC staff determined that the PPH FSSR demonstrated that it meets the requirement of 10 CFR Part 20 Subpart E and that residual contamination has been reduced to levels ALARA. There were no soil results for this survey package so EPA trigger levels are not applicable.

**Attachment #14, Transport Roadways and Parking Lots (TRPL)** includes the paved roadways and parking lots within and in the vicinity of the site over which licensed radioactive materials were transported or stored during operations and decommissioning. The surface areas are mostly asphalt or hard-packed asphalt-gravel mixture.

A total of 15 survey units were identified in this final status survey package. Of these, 11 survey units were identified as Class 1 and 4 survey units were identified as Class 2. All survey units were scanned prior to conducting the beta static measurements. Survey units identified as Class 1 were scanned 100%. No survey units exceeded a scan investigation level or warranted further investigation. Therefore, no further action was required.

The number of static beta measurements taken in each survey unit ranged from 10 to 14. The number of samples collected for structural static beta measurements are derived from the methods discussed in MARSSIM (NUREG-1575) and are consistent with the licensee's FSSP. NRC staff observed that the licensee reported a maximum total surface beta activity value of 14,108 dpm/100 $cm^2$ in Survey Unit TR-2-1. This value represents approximately 68% of the $DCGL_w$. This value is below the $DCGL_w$ value of 20,831 dpm/100 $cm^2$ for this final status survey package. The licensee noted that the area of this elevated measurement was a 4 cm (1.57 in) by 4 cm (1.57 in) and conducted additional beta scan measurements 9.14 m (30 ft) north and 9.14 m (30 ft) south of this elevated measurement and found no other elevated measurements. The licensee indicated that this particular area will be remediated prior to termination. NRC staff has determined that the reported value was below the prescribed $DCGL_w$ value for this final status survey package.

The licensee indicated that there was only one change from what was proposed in the FSSP and that was the TRPL being divided into 15 Survey Units. The original FSS Plan did not provide a breakdown of the TRPL. No re-classification of survey units was required as a result of the final status survey measurements and investigations. Therefore, NRC staff finds the TRPL FSSR acceptable. This final status survey report attachment did not include soils so there were no comparisons with the EPA trigger levels.

**Attachment #15, Miscellaneous Structures and Pads (MSP)** is a consortium of concrete support structures within the licensed area that includes the Water Effluent Monitoring System (WEMS), the Cooling Tower pad, several Substation Transformer Vaults and Pads, the Assembly and Test Storage (ATS) Building Tunnel, eight miscellaneous concrete pads, the Precipitator Sludge Setting Basin, and the Reactor Security and Control Building. These structures and pads provided the basic foundation or support for various miscellaneous operations. Some of these structures and pads supported the mechanical and/or electrical operations to the plant, including equipment and components that transported and/or stored radioactive material.

A total of 44 survey units were identified for this attachment. Of the 44 total survey units, 38 survey units were identified as Class 1 and 2 survey units were identified as Class 2. Class 1 survey units areas were scanned at 100% and Class 2 surveys areas were scanned at 50%. There were no scans that exceeded an investigation level and there were no soil sampling for this attachment. The number of static beta measurements taken for each survey unit ranged from 10 to 16 measurements. All static beta measurements were below the applicable DCGL.

There were no major changes to the previously approved FSSP. NRC staff has determined that the MSP FSSR demonstrated that it meets the requirement of 10 CFR Part 20 Subpart E and that residual contamination has been reduced to levels ALARA. Therefore, NRC staff finds the MSP FSSR acceptable. This final status survey report attachment did not include soils so there were no comparisons with the EPA trigger levels.

**Attachment #16, Open Land Areas (OLA)** comprises the 11-hectare (27 acre) land area inside the PBRF restricted area fence and adjacent buffer areas. The OLA includes the present open area land surface that is soil-covered and does not include any paved areas. The PBRF 11-hectare (27 acre) site contained several multi-story buildings and numerous support structures. Below grade structures and utilities extended throughout the site. These included underground pipe and utility tunnels, storm drains, catch basins, sanitary sewers, water and gas supply lines, cathodic protection wells and ground water monitoring wells. Prior to decommissioning, about 25% of the site was occupied by buildings, water processing structures and sludge basins, paved roadways, parking areas, sidewalks and equipment pads. The remainder of the site surface was open land soil areas.

The OLA includes a total of 59 survey units. This includes 52 Class 1 and 7 Class 2 survey units. A total of 3 survey units required a scan investigation. The investigation of these areas showed that the results were less than the DCGL for Cs-137, below the minimum detectable activity (MDA) or the unity fraction was less than 1. NRC staff has determined that the results meet the release criteria as defined in the NASA FSS Plan and they are acceptable.

The number of soil samples for each survey unit ranged from 11-15. A total of 680 soil samples were analyzed for Cs-137 and Co-60. All results for Co-60 were less than the minimum detectable activity (MDA). All results for Cs-137 were less than the $DCGL_w$ for Cs-137. NRC staff has determined that the results are below the $DCGL_w$ for both Co-60 and Cs-137 and this is acceptable.

There were several changes from what was proposed in the FSSP. The original FSS Plan for OLA identified 11 environmental survey areas. This was later changed to 59 survey units and all were classified equal to or higher than the survey class identified in the FSS Plan. Therefore, NRC staff finds the OLA FSSR acceptable. All soil sample results were below the EPA trigger levels.

**Attachment #17, Buried and Miscellaneous Piping** defines Buried Pipe (BP) as any pipe buried in soil and situated outside the structural foundation of a building, such as storm drain, footer drains, or sanitary lines. Miscellaneous Piping (MP) is any piping, conduit or similar systems which does not meet the definition of BP or EP, but will remain in the structure. All piping that was embedded in concrete structure above the -0.91 m (-3 ft) elevation was removed during demolition and surveyed for release and recycled or disposed of as radioactive waste. All MP situated above -0.91 m (-3 ft) elevation was removed and disposed of as radioactive waste or surveyed to no detectable activity standards and released for recycling.

All impacted BP/MP were classified, remediated, and resurveyed for compliance with release criteria and are included in this attachment. Pipes that could not be effectively remediated were removed and discarded as radioactive waste. A total of 24 survey units of BP/MP and all were identified as Class1 survey units, except one Class 3 survey unit. All survey units were remediated and surveyed. Interior surfaces of piping were surveyed using detectors (NaI or CsI) mounted in engineered sleds. Static radiological survey measurements were taken at one foot increments along its entire length, except the sanitary system and other large diameter piping. Direct surface beta measurements were made on accessible portions of Class 3 active sanitary sewer system piping. Field measurements in cpm were converted to equivalent beta measurements in $dpm/100cm^2$ through application of surrogate calculation and piping correction factors. These calculated activity densities were assessed against the applicable DCGL from the FSSP for compliance with 25 mrem (0.25 mSv) per year release criterion. The DCGLs for BP/MP were the same as the structural values.

The dose to future site occupants was calculated for selected MP and BP using the piping contamination levels measured in final status surveys. Six survey units with the highest dose potential (four MP survey units and two BP survey units) found to have calculated doses ranging from 3.7 E-11 to 1.72E-01 mrem/year. The calculated dose for the eleven-pipe cluster in the Quad C wall with the highest concentration of MPs was 2.6E-03 mrem/year. The results for the BP calculated for the Resident Farmer Scenario and an Intruder Scenario were 4.66E-05 mrem/year and 1.72E-01 mrem/year respectively. This demonstrates that the use of structural DCGLs for BP and MP is an acceptable approach for all remaining BP/MP piping.

The mean fixed measurements of all survey units were below the DCGLw. Subsequent to observations of elevated activity in eight survey units, elevated measurement comparisons (EMC) and elevated measurement tests (EMT) were performed and all were satisfactory. The results presented in BP/MP FSSR demonstrated that the release criterion in 10 CFR Part 20

Subpart E was met. Residual surface activity concentration measurement results were shown to be less than NRC screening level values – demonstrating that the ALARA criterion is satisfied. Therefore, NRC staff finds that BP/MP FSSR acceptable.

There is no soil survey units included in the survey of the BP/MP. Also, the groundwater is not within the scope of the BP/MP final status survey. Therefore, comparison with EPA trigger levels is not applicable to BP/MP survey measurements results.

**Attachment #18, Excavated and Backfill Material** final status survey differs from previous final status surveys such that this final status survey consist of the survey of material, removed from various areas of the site, and processed (surveyed) at a central location on site. Previous final status survey report attachments included structures, such as buildings and embedded/underground piping and lands. The licensee identified the excavated areas in Figure 2 of the Plum Brook Reactor Facility. The excavated areas included the following areas:

- Emergency Retention Basin
- Pentolite Ditch
- Cold Retention Basins
- Miscellaneous Structures and Pads (including the WEMS)
- Storm Drains and Catch Basin
- HRA Underground Storage Tanks
- WHB and Fan House sub-foundation
- Spill Areas
- Building Demolition
- Plum Brook
- Impacted Utilities
- RCRA Soil Area (contaminated with volatile organic compounds (VOCs)
- Decommissioning Temporary Use Material (consisted mostly of gravel and ballast)

All excavated soils were classified as Class 1 and were scanned at 100%. The processing of the soils was divided into two operations. The first operation consisted of soils being processed thru a ScanSort conveyor system. Soil moving through this process was handled in 226.8 kg (500 lbs) batches and 211 batches were processed thru the conveyors. The batches were identified as survey units. NASA applied a more restrictive limit (10.4 pCi/g) on the excavated and backfill soils to ensure compliance with the site soil $DCGL_w$ of 14.7 pCi/g for Cs-137. The diversion control set point (DCS) was set at 5.2 pCi/g, which was one half of the $DCGL_w$ for soils for Cs-137. Batches of soils that exceeded the DCS were further evaluated, tested, and either free release because further soil sampling and analysis indicated that the activity was below the DCS or disposed of as radioactive waste. The licensee indicated that approximately 87,996,930,970 kg (194,000,000 lbs) of soils were processed by the ScanSort system and less than 1% of the material was assayed to be greater than 5.2 pCi/g.

In each conveyor batch (survey unit), the licensee collected between 16 and 20 final status survey samples for further isotopic analysis at the onsite counting laboratory to determine if the activities met the $DCGL_w$ of 14.7 pCi/g for Cs-137 and 3.8 pCi/g for Co-60. These measurements would be equivalent to the static measurements conducted for structures and soils. All results were below the $DCGL_w$ for Co-60 and Cs-137. NRC staff concluded that the

final status survey results for soils from the ScanSort conveyor operation were below the $DCGL_w$ and this was acceptable.

The second operation was the surveying of soils in 15.24 cm (6 in) lifts. These soils were scanned at 100% with a gamma scan walkover. Approximately 8,618,256 kg (19,000,000 lbs) of soils consisted of 41 survey units. In one survey unit (OL-5-6) an investigation was performed in several localized areas. The licensee terminated the survey and remediated the soils. Upon resurveying by the licensee, no scan investigation levels were exceeded.

In each soil lift batch (survey unit), the licensee collected between 11-12 final status survey samples for further isotopic analysis at the onsite counting laboratory to determine if the activities met the $DCGL_w$ of 14.7 pCi/g for Cs-137 and 3.8 pCi/g for Co-60. These measurements would be equivalent to the static measurements conducted for structures and soils. All results were below the $DCGL_w$ for Co-60 and Cs-137. NRC staff concluded that the final status survey results for soils from soil lift operation were below the $DCGL_w$ and this was acceptable.

There were no major changes to the previously approved FSSP. NRC staff has determined that the Excavation and Backfill Material FSSR demonstrates that it meets the requirement of 10 CFR Part 20 Subpart E and that residual contamination has been reduced to levels ALARA. Therefore, NRC staff finds the Excavation and Backfill Material FSSR acceptable. All excavated soils were below the EPA trigger levels.