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# Analysis of H-Canyon Process Tanks in Preparation of Consolidation and Blending for HALEU Fuels

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# EXECUTIVE SUMMARY

High-Assay Low- Enriched Uranium (HALEU) fuels are being developed to support the replacement of Highly Enriched Uranium (HEU) fuels used in U.S. High-Performance Research Reactors (USHPRR) as well as advanced nuclear power reactor designs. The projected demand for HALEU far exceeds the supply and studies are underway to assess various options to partially mitigate the potential short supply. The H-Canyon facility at the Savannah River Site (SRS) Low Enriched Uranium (LEU) containing 4.95% U-235 from the reprocessing of highly enriched foreign and domestic research reactor fuel for the Tennessee Valley Authority's (TVA) commercial power reactor market for several decades. The production of LEU at the H-Canyon facility can be readily transitioned to produce 19.75% HALEU solutions from the current separated inventory of purified HEU solutions in H-Canyon storage.

The Savannah River National Laboratory (SRNL) has been tasked to perform an updated characterization of multiple uranium bearing tanks containing the current separated inventory of purified uranium solutions. Current tanks containing material includes E4-2 (current HEU storage), F1-5 and E1-1 (both containing LEU heels), and E3-2 (current NU inventory). Specifications for HALEU fuel solutions are not defined but can be compared to the ASTM standard specification for uranium metal at <20% U-235. One vendor specification has been included in the table with the ASTM specifications for comparison. Results of analyses have been tabulated and presented for each uranium-bearing tank as well as the process water that is used for tank flushes and to makeup evaporation losses from the tanks.

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| ASTM | American Society for Testing and Materials |
| HALEU | High Assay Low Enriched Uranium |
| HEU | High Enriched Uranium |
| IC-Anions | Ion Chromatography for Anions |
| ICP-ES | Inductively Coupled Plasma – Emission Spectroscopy |
| ICP-MS | Inductively Coupled Plasma – Mass Spectroscopy |
| LOD | Limit of Detection |
| MC&A | Material Control and Accountability |
| MCAT | Material Control and Accountability Transaction Report |
| MDA | Minimum Detection Achieved |
| NU | Normal/Natural Uranium |
| PHA | Pulse Height Analysis |
| SRNL | Savannah River National Laboratory |
| TIC/TOC | Total Inorganic Carbon / Total Organic Carbon |
| TRU | Trans Uranium |
| USHPRR | U.S. High-Performance Research Reactors |

## 1.0 Introduction

In 2021 the Savannah River National Laboratory (SRNL) validated that HALEU can be produced using the H-Canyon facilities through a demonstration of HALEU blending using the product solution from the H-Canyon 2nd U Cycle of solvent extraction.[1] As a follow on, SRNL has been tasked to perform an updated characterization of multiple uranium-bearing tanks containing the current separated inventory of purified uranium solutions. Current tanks containing material includes E4-2 (current HEU storage), F1-5 and E1-1 (both containing LEU heels), and E3-2 (current NU inventory). Specifications for HALEU fuel solutions are not defined but can be compared to the ASTM standard specification for uranium metal at <20% U-235 as shown in Table 1-1. The table also includes desired specifications provided by the vendor.

**Table 1-1. ASTM C1462-21 specification for uranium metal at <20% U-235 and proposed specification by vendor.**

| Element/Isotope | Units | ASTM C1462-21 Specification[2] | Desired Vendor Specification[3] |
|---|---|---|---|
| U-232 | µg $^{232}$U/g $^{235}$U | ≤ 0.014 | |
| U-232 | µg/g U | | ≤ 0.002 |
| U-234 | µg $^{234}$U/g $^{235}$U | ≤ 22100 | |
| U-234 | µg/g U | | ≤ 0.01 |
| U-235 | wt % | < 20 | |
| U-236 | g $^{236}$U/g U | ≤ 0.0046 | ≤ 0.04 |
| TRU alpha activity | Bq/g U | ≤ 250 | |
| Fission Products | Bq/g U | ≤ 6000 | |
| Al | µg/g U | ≤ 150 | ≤ 100 |
| Be | µg/g U | ≤ 10 | ≤ 1 |
| B | µg/g U | ≤ 1 | ≤ 1 |
| Ca | µg/g U | ≤ 300 | ≤ 100 |
| C | µg/g U | ≤ 800 | ≤ 100 |
| Cr | µg/g U | ≤ 1 | ≤ 200 |
| Co | µg/g U | ≤ 10 | ≤ 100 |
| Cu | µg/g U | ≤ 50 | ≤ 250 |
| Fe | µg/g U | ≤ 250 | ≤ 100 |
| Pb | µg/g U | ≤ 10 | ≤ 250 |
| Li | µg/g U | ≤ 10 | ≤ 100 |
| Mg | µg/g U | ≤ 150 | ≤ 100 |
| Mn | µg/g U | ≤ 50 | ≤ 250 |
| Mo | µg/g U | ≤ 100 | ≤ 250 |
| Ni | µg/g U | ≤ 300 | ≤ 200 |
| P | µg/g U | ≤ 100 | ≤ 250 |
| Si | µg/g U | ≤ 250 | ≤ 300 |
| Na | µg/g U | ≤ 25 | ≤ 100 |
| Sn | µg/g U | ≤ 30 | ≤ 250 |
| W | µg/g U | ≤ 100 | ≤ 250 |
| V | µg/g U | ≤ 30 | ≤ 250 |
| Zr | µg/g U | ≤ 250 | ≤ 50 |
| Total Impurities | µg/g U | ≤ 1500 | ≤ 3552.5 |
| Equivalent B Content | µg/g U | ≤ 4 | ≤ 18.8 |
| Other impurities of interest: Sb, Ar, Ba, Bi, Cd, Ce, Cs, Cl, Dy, Eu, F, Gd, Hf, In, La, Nb, N (except nitrate), Pd, K, Ru, Sm, Ag, Sr, S, Ta, Th, Ti, and Zn.<br>Some Generation IV reactors are able to use fuel with a U-236 mass fraction level up to 0.04 g $^{236}$U/g U.[2] | | | |

Samples were analyzed through a variety of analytical methods Table 2-1. Results will be compared to the ASTM specification where applicable and the vendors specifications. Data will be tabulated based on methods with results presented as a solution concentration for each tank analyzed. General radioisotopes of interest in the feedstock are shown in Table 1-2.

**Table 1-2. Alpha, Beta, and Gamma emitters of interest.**

| Alpha Emitters | Beta Emitters | Gamma Emitters |
|---|---|---|
| Americium-241 | Technetium-99 | Cobalt-60 |
| Americium-242/242M | Strontium-90 | Niobium-95 |
| Americium-243 | Yttrium-90 | Zirconium-95 |
| Curium-242 | Promethium-147 | Ruthenium-103 |
| Curium-243 | Plutonium-241 | Ruthenium-106 |
| Curium-244 | | Cesium-134 |
| Curium-245 | | Cesium-137 |
| Curium-246 | | Cerium-144 |
| Curium-247 | | Praseodymium-144 |
| Neptunium-237 | | Thallium-208 |
| Plutonium-238 | | Bismuth-212 |
| Plutonium-239 | | Lead-212 |
| Plutonium-240 | | Americium-241 |
| Plutonium-242 | | |

## 2.0 Experimental Procedure

2.1 Tank Sampling

SRNL requested a 500 mL sample for each of tanks E4-2 (current HEU storage), F1-5 and E1-1 (both containing LEU heels), and E3-2 (current NU inventory). Samples were obtained by H-Canyon personnel per sampling procedures.[4] All samples that were collected were above the reportability limits for enriched uranium which require transfer to the lab using the Material Control and Accountability (MC&A) Transaction Report (MCAT). The lab also requested a 1000 mL sample of the process water that is used for flushes and dilutions for criticality control. This process water is made slightly acidic through the addition a small quantity of nitric acid.[5]

2.2 Subsampling

Each tank sample was subsampled to provide the appropriate quantity of solution for the selected analytical methods. Samples were analyzed for various isotopes and activity through methods including alpha pulse height analysis, a rad screen for total alpha and beta activity, liquid scintillation counting and gamma counting. Other elements or analytes of interest were obtained through inductively coupled plasma mass spectrometry (ICP-MS), inductively coupled plasma atomic emission spectroscopy (ICP-ES), ion chromatography for anions (IC-Anions), and total inorganic/organic carbon (TIC/TOC) by carbon analyzer. A list of methods of analysis are provided in Table 2-1for each solution received from H-Canyon.

**Table 2-1. List of Samples and Methods of Analysis**

| Method | Process Water | Tank E3-2 | Tank E4-2 | Tank E1-1 | Tank F1-5 | Sample volume (mL) |
|---|---|---|---|---|---|---|
| Rad ICP-MS | Y | Y | Y | Y | Y | 5 |
| Rad ICP-ES | Y | Y | Y | Y | Y | 8 |
| Rad IC-Anions | Y | Y | Y | Y | Y | 5 |
| TIC/TOC | | Y | Y | Y | Y | 5 |
| LSC | | Y | Y | Y | Y | 5 |
| Am/Cm | | Y | Y | Y | Y | 5 |
| Pu-238/241 | | Y | Y | Y | Y | 5 |
| Pu-242/244 | | Y | Y | Y | Y | 5 |
| Np-237 | | Y | Y | Y | Y | 5 |
| Sr-90 | | Y | Y | Y | Y | 5 |
| Tc-99 | | Y | Y | Y | Y | 5 |
| Pm-147/ Sm-151 | | Y | Y | Y | Y | 5 |
| U-232 | | Y | Y | Y | Y | 5 |

2.3 Quality Assurance

Requirements for performing reviews of technical reports and the extent of review are established in manual E7 2.60. SRNL documents the extent and type of review using the SRNL Technical Report Design Checklist contained in WSRC-IM-2002-00011, Rev. 2.

## 3.0 Results and Discussion

The uranium tank solutions were characterized based on the requirements for U isotopic and impurity concentrations in the specifications for HALEU metal given in Table 1-1. The U isotopic concentrations for the four tank solutions were calculated using the concentrations measured for the U-232, U-234, U-235, U-236, and U-238 isotopes by ICP-MS provided in Table A-2 to Table A-5(Appendix A). The U isotopic sum of the solution is given in Table 3-1. The one sigma uncertainties in the concentrations are based on the known instrument uncertainties.

The Pu and Np isotopic concentrations measured in the tank solutions were calculated using the data provided in Table A-2 to Table A-5. The concentrations of the Pu-239/240 isotopes were below the minimum detection of the analysis (MDA) for tanks E3-2 and E1-1. The concentration of Np-237 was also below the MDA for tanks E3-2 and E1-1. The ASTM C1462-21[2] criterion given in the Table 1-1 is for the transuranic alpha activity which would include the sum of the Np, Pu, Am, and Cm activities in a product solution. The summation of these activities per gram uranium (in units of Bq/g U) is provided in Table 3-1.

The beta emitter concentration for Tc-99, Sr-90, Y-90, Pm-147, Pu-241 were measured and are compared to the total U in Table 3-1. These were part of the additional isotopes of interest shown in Table 1-2 for potential HALEU solutions. The ASTM C1462-21[2] standard does not have a criterion for total beta activity which would include Sr-90.

The concentrations of gamma-emitting isotopes measured in the tank solutions were calculated using the data provided in Table A-2 to Table A-5 shown under the method name of “Gamma Spec” which was performed by LSC. The concentrations of most isotopes were below the MDA. The concentration of the isotopes which were quantified and the average detection limit for the isotopes with concentrations below the MDA (in units of Bq/g U) were calculated using the concentration of the H-Canyon U product solution

as described above. The results of the calculations are summarized in Table 3-1. The ASTM C1462-21[2] criterion given in Table 1-1 is for the total gamma activity of the fission products. Although the limit is given as 600 Bq/g U, the standard notes that the limit may be as high as 6000 Bq/g U depending upon the requirements of the fuel fabricator. Gamma-emitting isotopes are not individually identified by the C1462 standard.

The concentrations of trace metals in the process water and each tank solution were measured by both ICP-ES and ICP-MS with the data provided in Table A-1 to Table A-5. The concentrations of several elements were below the MDA. For the uranium tank solutions, the concentration of the elements which were quantified and the average detection limit for the elements with concentrations below the MDA (in units of μg/g U) were calculated using the concentration of the H-Canyon U product by summing the concentrations measured for the U-232, U-234, U-235, U-236, and U-238 isotopes by ICP-MS. The results of the calculations are summarized in Table 3-1. The ASTM C1462-21[2] standard for U metal supplied to research reactors also has a criterion for total impurities which is ≤1500 μg/g U per the ASTM standard.

The concentrations of TIC/TOC measured in the tank solutions were calculated using the data provided in Table A-2 to Table A-5. The concentration of both forms of carbon were below the MDA. The concentrations (in units of μg/g U) were calculated using the concentration of the H-Canyon U product measured for the U-232, U-234, U-235, U-236, and U-238 isotopes by ICP-MS. The results of the calculation are summarized in Table 3-1. Although the MDA is much higher than the limit for total carbon in the ASTM C1462-21[2] standard, these values are for trace TIC/TOC in the U solution which should mostly be destroyed in the thermal process used to produce a U oxide. The limit given in the ASTM C1462-21[2] standard is also for trace carbon in U metal.

The concentrations of anions measured in the tank solutions were calculated using the data provided in Table A-2 to Table A-5. The concentrations of all anions except for the nitrate associated with the U and trace metals and $HNO_3$ were below the MDA. The concentrations of the anions with reported values below the MDA (in units of μg/g U) were calculated using the concentration of the H-Canyon U product measured for the U-232, U-234, U-235, U-236, and U-238 isotopes by ICP-MS. The results of the calculation are summarized in Table 3-1. The ASTM C1462-21[2] standard for U metal supplied to research reactors does not have criteria for anions; although, anionic impurities would fall under the criterion for total impurities which is ≤1500 μg/g U for the ASTM standard specification. The trace quantities of some of the anionic impurities (e.g., formate, nitrite, and oxalate) will be mostly destroyed or volatilized in the thermal process used to produce U oxide.

**Table 3-1. Sample results in terms of µg analyte / g U for comparison to ASTM Standard**

| | Process Water | E3-2 | | E4-2 | | E1-1 | | F1-5 | |
|---|---|---|---|---|---|---|---|---|---|
| Sum of Values | | | | | | | | | |
| | Conc. (g/L) | | | | | | | | |
| U (Isotopic Sum)[1] | 4.6E-07 | 567 | | 13 | | 29 | | 156 | |
| | Calculated Activity (Bq/g U) | | | | | | | | |
| Alpha[2] | | 30.1 | | 93.3 | | 154 | | 207 | |
| Gamma[3] | | - | | 8203 | | 65 | | 792 | |
| TIC-TOC | | | | | | | | | |
| Analyte | Conc. (µg C/mL) | Conc. (µg C/mL) | µg/g U | Conc. (µg C/mL) | µg/g U | Conc. (µg C/mL) | µg/g U | Conc. (µg C/mL) | µg/g U |
| Total C | | < 150 | < 265 | < 150 | < 11736 | < 150 | < 5222 | < 150 | < 963 |
| Inorg C | | < 55.7 | < 98 | < 55.7 | < 4358 | < 55.7 | < 1939 | < 55.7 | < 358 |
| Org C | | < 94.4 | < 166 | < 94.7 | < 7409 | < 94.4 | < 3287 | < 94.4 | < 606 |
| ICP-Anions | | | | | | | | | |
| Analyte | Conc. (µg/mL) | Conc. (µg/mL) | µg/ g U | Conc. (µg/mL) | µg/ g U | Conc. (µg/mL) | µg/ g U | Conc. (µg/mL) | µg/ g U |
| Fluoride | < 10 | < 100 | < 176 | < 100 | < 7824 | < 100 | < 3481 | < 100 | < 642 |
| Formate | < 10 | < 100 | < 176 | < 100 | < 7824 | < 100 | < 3481 | < 100 | < 642 |
| Chloride | < 10 | < 100 | < 176 | < 100 | < 7824 | < 100 | < 3481 | < 100 | < 642 |
| Nitrate | < 10 | 305000 | 537914 | 35800 | 2800878 | 20200 | 703257 | 108000 | 693636 |
| Nitrite | 613 | < 100 | < 176 | < 100 | < 7824 | < 100 | < 3481 | < 100 | < 642 |
| Phosphate | < 10 | < 100 | < 176 | < 100 | < 7824 | < 100 | < 3481 | < 100 | < 642 |
| Sulfate | < 10 | < 100 | < 176 | < 100 | < 7824 | < 100 | < 3481 | < 100 | < 642 |
| Oxalate | < 10 | < 100 | < 176 | < 100 | < 7824 | < 100 | < 3481 | < 100 | < 642 |
| Bromide | < 10 | < 500 | < 882 | < 500 | < 39118 | < 500 | < 17407 | < 500 | < 3211 |

| | Process Water | E3-2 | | E4-2 | | E1-1 | | F1-5 | |
|---|---|---|---|---|---|---|---|---|---|
| Pu-Alpha-PHA | | | | | | | | | |
| Analyte | Count (dpm/mL) | Count (dpm/mL) | µg/g U | Count (dpm/mL) | µg/g U | Count (dpm/mL) | µg/g U | Count (dpm/mL) | µg/g U |
| Pu-238 | | 23.5 | 1.1E-06 | 30.7 | 6.3E-05 | 120 | 1.1E-04 | 137 | 2.3E-05 |
| Pu-239/240 | | < 17.2 | < 6.0E-05 | 23.6 | 3.7E-03 | < 16.1 | < 1.1E-03 | 24.2 | 3.1E-04 |
| Pu-241 Liq Scint | | | | | | | | | |
| Analyte | Count (dpm/mL) | Count (dpm/mL) | µg/g U | Count (dpm/mL) | µg/g U | Count (dpm/mL) | µg/g U | Count (dpm/mL) | µg/g U |
| Pu-241 | | < 446000 | < 3.4E-03 | < 3470 | < 1.2E-03 | < 17900 | < 2.7E-03 | < 78300 | < 2.2E-03 |
| Mass Spec Act Pu 242/243 | | | | | | | | | |
| Analyte | Count (dpm/mL) | Count (dpm/mL) | µg/g U | Count (dpm/mL) | µg/g U | Count (dpm/mL) | µg/g U | Count (dpm/mL) | µg/g U |
| Pu-242 | | < 875 | < 1.8E-01 | < 875 | < 7.8E+00 | < 875 | < 3.5E+00 | < 875 | < 6.4E-01 |
| Np-237 Gamma Pha | | | | | | | | | |
| Analyte | Count (dpm/mL) | Count (dpm/mL) | µg/g U | Count (dpm/mL) | µg/g U | Count (dpm/mL) | µg/g U | Count (dpm/mL) | µg/g U |
| Np-237 | | < 0.18 | < 2.0E-04 | 18.5 | 9.2E-01 | < 0.235 | < 5.2E-03 | 0.186 | 7.6E-04 |
| Sr-90 and Tc-99_Beta_Liq Scint | | | | | | | | | |
| Analyte | Count (dpm/mL) | Count (dpm/mL) | µg/g U | Count (dpm/mL) | µg/g U | Count (dpm/mL) | µg/g U | Count (dpm/mL) | µg/g U |
| Sr-90 | | < 60.9 | < 3.5E-07 | < 57.7 | < 1.5E-05 | < 53.6 | < 6.1E-06 | < 57.7 | < 1.2E-06 |
| Tc-99 | | < 27.9 | < 1.3E-03 | < 21.4 | < 4.4E-02 | < 24.9 | < 2.3E-02 | < 22.4 | < 3.8E-03 |
| Pm-147/ Sm-152 | | | | | | | | | |
| Analyte | Count (dpm/mL) | Count (dpm/mL) | µg/g U | Count (dpm/mL) | µg/g U | Count (dpm/mL) | µg/g U | Count (dpm/mL) | µg/g U |
| Pm-147 | | < 1190 | < 9.5E-07 | < 218 | < 7.7E-06 | < 492 | < 7.8E-06 | < 676 | < 2.0E-06 |
| Sm-152 | | < 1320 | < 4.0E-05 | < 294 | < 4.0E-04 | < 734 | < 4.4E-04 | < 1000 | < 1.1E-04 |

| | Process Water | E3-2 | | E4-2 | | E1-1 | | F1-5 | |
|---|---|---|---|---|---|---|---|---|---|
| U-232 Alpha PHA | | | | | | | | | |
| Analyte | Count (dpm/mL) | Count (dpm/mL) | µg/g U | Count (dpm/mL) | µg/g U | Count (dpm/mL) | µg/g U | Count (dpm/mL) | µg/g U |
| U-232 | | < 14900 | < 5.4E-04 | 149 | 2.4E-04 | < 145 | < 1.0E-04 | 1980 | 2.6E-04 |
| | | | µg/g $^{235}$U | | µg/g $^{235}$U | | µg/g $^{235}$U | | µg/g $^{235}$U |
| U-232 | | < 14900 | < 7.5E-02 | | 4.4E-04 | | < 2.1E-03 | | 5.1E-03 |
| | | | Bq/g U | | Bq/g U | | Bq/g U | | Bq/g U |
| U-232 | | < 14900 | < 438 | 149 | 191 | < 145 | < 83 | 1980 | 212 |
| Am/Cm Counting | | | | | | | | | |
| Analyte | Count (dpm/mL) | Count (dpm/mL) | µg/g U | Count (dpm/mL) | µg/g U | Count (dpm/mL) | µg/g U | Count (dpm/mL) | µg/g U |
| Am-241 | | < 33.3 | < 1.3E-04 | < 4.07 | < 7.2E-04 | < 12.9 | < 1.0E-03 | < 12.9 | < 1.9E-04 |
| Am-243 | | < 21.8 | < 5.0E-06 | < 2.68 | < 2.8E-05 | < 11.8 | < 5.4E-05 | < 11.8 | < 1.0E-05 |
| Am-242m | | < 43.5 | < 3.5E-06 | < 3.76 | < 1.4E-05 | < 6.87 | < 1.1E-05 | < 6.87 | < 2.0E-06 |
| Cm-243 | | < 28.4 | < 5.4E-06 | < 2.13 | < 1.8E-05 | < 6.34 | < 2.4E-05 | < 6.34 | < 4.4E-06 |
| Cm-242 | | < 36 | < 8.7E-09 | < 3.11 | < 3.3E-08 | < 5.68 | < 2.7E-08 | < 5.68 | < 5.0E-09 |
| Cm-244 | | < 28.4 | < 2.8E-07 | < 2.13 | < 9.3E-07 | < 6.34 | < 1.2E-06 | < 6.34 | < 2.3E-07 |
| Cm-245 | | < 3.37 | < 1.6E-05 | < 0.696 | < 1.4E-04 | < 1.07 | < 9.9E-05 | < 1.07 | < 1.8E-05 |
| Cm-246 | | < 1.45 | < 3.2E-06 | < 0.299 | < 2.9E-05 | < 0.46 | < 2.0E-05 | < 0.46 | < 3.7E-06 |
| Cm-247 | | < 4.41E-4 | < 3.7E-06 | < 9.1E-5 | < 3.4E-05 | < 0.00014 | < 2.3E-05 | < 0.00014 | < 4.3E-06 |
| ICP-MS | | | | | | | | | |
| Analyte | Conc. (µg/L) | Conc. (µg/L) | µg/g U | Conc. (µg/L) | µg/g U | Conc. (µg/L) | µg/g U | Conc. (µg/L) | µg/g U |
| Co | < 0.12 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Ga | < 0.4 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Rb | 1.017 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Sr | 1.510 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Y | 0.151 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Zr | < 0.04 | < 200 | < 0.35 | < 200 | < 15.65 | < 200 | < 6.96 | < 200 | < 1.28 |

| | Process Water | E3-2 | | E4-2 | | E1-1 | | F1-5 | |
|---|---|---|---|---|---|---|---|---|---|
| Nb | < 0.04 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Mo | 0.398 | 672 | 1.18 | < 300 | < 23.47 | < 300 | < 10.44 | < 300 | < 1.93 |
| Ru | < 0.04 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Rh | 0.043 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Pd | < 0.04 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Ag | < 0.04 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Cd | 0.136 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Sn | < 0.04 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Sb | < 0.04 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Te | < 0.04 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Cs | 0.0460 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Ba | 2.90 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| La | 0.081 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Ce | 0.179 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Nd | 0.091 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Sm | < 0.04 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Eu | < 0.04 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Gd | < 0.04 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Tb | < 0.04 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Dy | < 0.04 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Ho | < 0.04 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Er | < 0.04 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Tm | < 0.04 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Yb | < 0.04 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Lu | < 0.04 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Hf | < 0.04 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Ta | < 0.04 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |

| | Process Water | E3-2 | | E4-2 | | E1-1 | | F1-5 | |
|---|---|---|---|---|---|---|---|---|---|
| W | 0.092 | < 300 | < 0.53 | < 300 | < 23.47 | < 300 | < 10.44 | < 300 | < 1.93 |
| Re | < 0.04 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Ir | < 0.04 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Pt | 0.4725 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Au | < 0.16 | < 1000 | < 1.76 | < 1000 | < 78.24 | < 1000 | < 34.81 | < 1000 | < 6.42 |
| Tl | < 0.04 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Pb | 75 | < 300 | < 0.53 | 1036 | 81.05 | < 300 | < 10.44 | 1533 | 9.85 |
| 230 | < 0.04 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| U-232 | < 0.04 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| U-233 | < 0.04 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| U-234 | < 0.04 | 30838 | 54.39 | 84459 | 6608 | 14869 | 517.68 | 80081 | 514 |
| U-235 | < 0.04 | 4090285 | 7214 | 6859785 | 536688 | 1422652 | 49529 | 7981542 | 51262 |
| U-236 | < 0.04 | 825 | 1.46 | 486888 | 38093 | 21889 | 762.05 | 121271 | 778.87 |
| Np-237 | < 0.04 | 1560 | 2.75 | 112 | 8.80 | < 100 | < 3.48 | 402 | 2.58 |
| U-238 | 0.26 | 562883363 | 992730 | 5350373 | 418596 | 27263875 | 949184 | 147518252 | 947444 |
| 240 | < 0.04 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| 241 | < 0.04 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| 242 | < 0.04 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| 243 | < 0.04 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| 244 | < 0.04 | < 100 | < 0.18 | < 100 | < 7.82 | < 100 | < 3.48 | < 100 | < 0.64 |
| Cu | 4.37 | | | | | | | | |
| Ge | < 0.12 | | | | | | | | |
| Pr | < 0.04 | | | | | | | | |
| Os | < 0.04 | | | | | | | | |
| 239 | < 0.04 | | | | | | | | |

| | Process Water | E3-2 | | E4-2 | | E1-1 | | F1-5 | |
|---|---|---|---|---|---|---|---|---|---|
| Gamma-Spec | | | | | | | | | |
| Analyte | Conc. (µg/L) | Count (dpm/mL) | µg/g U | Count (dpm/mL) | µg/g U | Count (dpm/mL) | µg/g U | Count (dpm/mL) | µg/g U |
| Co-60 | | < 11.4 | < 8.0E-09 | < 9.25 | < 2.9E-07 | < 5.23 | < 7.3E-08 | < 7.81 | < 2.0E-08 |
| Nb-95 | | < 25.9 | < 5.3E-10 | < 5.02 | < 4.5E-09 | < 6.95 | < 2.8E-09 | < 12.8 | < 9.5E-10 |
| Zr-95 | | < 47.9 | < 1.8E-09 | < 14.3 | < 2.3E-08 | < 12.8 | < 9.3E-09 | < 25.3 | < 3.4E-09 |
| Ru-103 | | < 26.3 | < 6.5E-10 | < 10.6 | < 1.2E-08 | < 7.04 | < 3.5E-09 | < 13.2 | < 1.2E-09 |
| Ru-106 | | < 120 | < 2.8E-08 | < 49.6 | < 5.1E-07 | < 38.8 | < 1.8E-07 | < 51.4 | < 4.4E-08 |
| Cs-134 | | < 26 | < 1.7E-08 | < 9.46 | < 2.8E-07 | < 7.57 | < 9.9E-08 | < 13.6 | < 3.3E-08 |
| Cs-137 | | < 27.8 | < 2.6E-07 | 8.48 | 3.5E-06 | < 7.66 | < 1.4E-06 | < 15 | < 5.0E-07 |
| Ce-144 | | < 272 | < 6.8E-08 | < 296 | < 3.3E-06 | < 137 | < 6.7E-07 | < 296 | < 2.7E-07 |
| Pr-144 | | < 272 | < 1.2E-12 | < 296 | < 5.7E-11 | < 137 | < 1.2E-11 | < 296 | < 4.7E-12 |
| Hg-203 | | < 28.2 | < 1.6E-09 | < 15.7 | < 4.0E-08 | < 7.35 | < 8.2E-09 | 26.6 | 5.5E-09 |
| Tl-208 | | < 11.3 | < 3.0E-14 | 1000 | 1.2E-10 | < 10.2 | < 5.4E-13 | 98.5 | 9.6E-13 |
| Bi-212 | | < 373 | < 2.0E-11 | 2720 | 6.4E-09 | < 108 | < 1.1E-10 | 237 | 4.6E-11 |
| Pb-212 | | < 52.2 | < 3.0E-11 | 2670 | 6.7E-08 | 50.8 | 5.7E-10 | 256 | 5.3E-10 |

1) Value was calculated by summing the mg/L of U isotopes (232, 233, 234, 235, 236, 238), as measured by ICP-MS, and converting to g/L.
2) Value was calculated by summing the dpm/mL of alpha emitters of interest (Am-241, Am-242/242m, Am-243, Cm-242, Cm-243, Cm-244, Cm-245, Cm-246, Cm-247, Np-237, Pu-238, Pu-239, Pu-240, Pu-242), if detected above the LOD, and converting to Bq/g U.
3) Value was calculated by summing the dpm/mL of gamma emitters of interest if above limit of detection (Co-60, Nb-95, Zr-95, Ru-103, Ru-106, Cs-134, Cs-137, Ce-144, Pr-144, Th-208, Bi-212, Pb-212, Pm-147, Sm-152, Hg-203) and converting to Bq/mL

## 4.0 Conclusions

The Savannah River National Laboratory (SRNL) was tasked to perform an updated characterization of multiple uranium bearing tanks containing the current separated inventory of purified uranium solutions at various enrichment levels. Current tanks containing material includes E4-2 (current HEU storage), E1-1 and F1-5 (both containing LEU heels), and E3-2 (current NU inventory). Specifications for HALEU fuel solutions do not exist but can be compared to the ASTM standard specification for uranium metal at <20% U-235. Comparison of the uranium solutions to the specification at this stage can aid in estimating concentrations following future blending but should be viewed as a benchmark since the uranium solutions in Tanks E1-5 and F1-5 will be consolidated into Tank E4-2 early in calendar year 2024 for storage prior to future down-blending.

The uranium isotopic composition of the solutions when down-blended to HALEU should meet the isotopic requirements of the ASTM C1462 standard for all isotopes (i.e., U-232, U-234, U-235, U-236, and U-238) except for the U-236. The measured U-232 concentration in the HALEU solutions exceeds the criterion in the ASTM C1462-21 standard (≤0.0014 μg/g U-235) when the ICP-MS data are evaluated. However, the method provided only the limit of detection for mass 232. The analysis for U-232 by alpha PHA shows the U-232 concentration in the bulk of the uranium in Tank E4-2 is less than 0.0014 μg/g U-235; however, the concentration in Tanks E1-1 and F1-5 (which only contain tank heels of solution) was below the MDA and slightly exceeded the C1462 criterion, respectively. The U-234 concentration in all tanks was below the 22,100 μg/g U-234 limit in the ASTM C1462-21 standard. However, the U-236 concentration in each of the tanks exceed the 0.0046 g/g U criterion in the standard due to the recovery of the uranium from irradiated fuel. The C1462 standard does allow for increased concentrations of U-236 up to 0.04 g/g U based upon agreement between the buyer and seller. The U-236 concentration in all solutions will meet this higher concentration provided in the exception and desired by the vendor.

The impurity concentrations measured in the HALEU solution were all less than the maximum values permitted by the ASTM C1462-21 standard except for lead where tanks E4-2 and F1-5 contained 81.05 μg/g U and 9.85 μg/g U respectively. When compared to the provided vendor specification, the permitted lead level becomes 250 μg/g U which puts the solutions within specification. The lead possibly originates from the process water (75 μg/L Pb) that is added periodically to the tanks to make up for evaporation. The TRU activity in the solution which includes Np, Pu, Am, and Cm, isotopes (Table 1-2) are all below the criterion (≤250 Bq/g U) in the C1462 standard. The isotopes contributing to the total were Np-237, Pu-238, and Pu-239/240. All other isotopes were below the MDA. The Sr-90 and Tc-99 activity was less than the MDA. The gamma-emitting fission and activation products in the HALEU solution were also low as most isotopes detected were below the MDA with only a few concentrations above the MDA (Table 3-1).

The HALEU solution was also analyzed for anionic species and TIC/TOC; although, the ASTM C1462 standard does not have criteria for specific anionic impurities and the limit for carbon in the standard applies to carbon in the U metal. Both inorganic and organic carbon concentrations in the solution were below the MDA; however, using the MDA values for both forms of carbon per gram of uranium would provide a number that would exceed the limit in the standard. Most of the carbon present in the HALEU solution should be destroyed in the thermal process used to produce a U oxide. The concentrations of all anions except for nitrate were below the MDA. The presence of anionic species in the HALEU is not expected to be a problem.

## 5.0 Recommendations, Path Forward or Future Work

Some impurities in the uranium solution could not be evaluated. The impurities missing from the solution characterizations include Al, Be, B, Ca, Cr, Cu, Fe, Li, Mg, Mn, Ni, Si, Na, and V. All these impurities should be available through an ICP-ES analysis. However, obtaining an accurate quantification for these impurities will require a uranium removal step prior to the analyses. The dilutions required for the ICP-ES and other methods due to the high uranium concentration are problematic for more accurate elemental analysis and result in large MDAs for many impurities.

The characterization data for the solutions did not identify any issues which preclude the consolidation of the uranium from Tanks E1-1 and F1-5 into Tank E4-2. A post-consolidation sample should be obtained and analyzed by the methods used for the current characterization but with modifications to the sample preparation for uranium removal where applicable. This pretreatment may be beneficial for all samples in which uranium is not analyzed directly.

## 6.0 References

1. Rudisill, T. S.; Daniel, W. E. *Demonstration of the Blending of the H-Canyon 2nd U Cycle Product with Natural U to Produce a HALEU Solution*; Savannah River National Laboratory: Aiken, SC, 2021; p 53.
2. ASTM, In *Standard Specification for Uranium Metal Enriched to Less Than 20 % U-235*, ASTM International: West Conshohocken, PA, 2021; Vol. C1462-21.
3. Figuero, W., RE: U3O8 Specification. Email providing TRiso -X desired specifications for HALEU ed.; Shehee, T., Ed. 2023.
4. *Sampling 211-H A-Line Tanks*; Savannah River Site: Aiken, SC, 2022.
5. Verenes, M. *Procurement Specification for Nitric Acid 51%*; Savannah River Site: Aiken, SC, 2009.

## Appendix A. Compilation of Analysis for Process water and the Uranium Tanks

**Table A-1. Analytical results for H-Canyon process water**

| Analyte | Method | Concentration | Units | 1 Sigma %UNC |
|---|---|---|---|---|
| Fluoride | IC-Anions | < 10 | µg/mL | – |
| Formate | IC-Anions | < 10 | µg/mL | – |
| Chloride | IC-Anions | < 10 | µg/mL | – |
| Nitrite | IC-Anions | < 10 | µg/mL | – |
| Nitrate | IC-Anions | 613 | µg/mL | 10 |
| Phosphate | IC-Anions | < 10 | µg/mL | – |
| Sulfate | IC-Anions | < 10 | µg/mL | – |
| Oxalate | IC-Anions | < 10 | µg/mL | – |
| Bromide | IC-Anions | < 10 | µg/mL | – |
| Co | ICP-MS | < 0.12 | µg/L | – |
| Ga | ICP-MS | < 0.4 | µg/L | – |
| Rb | ICP-MS | 1.017 | µg/L | 4.8 |
| Sr | ICP-MS | 1.510 | µg/L | 1.4 |
| Y | ICP-MS | 0.151 | µg/L | 7.5 |
| Zr | ICP-MS | < 0.04 | µg/L | – |
| Nb | ICP-MS | < 0.04 | µg/L | – |
| Mo | ICP-MS | 0.398 | µg/L | 13.3 |
| Ru | ICP-MS | < 0.04 | µg/L | – |
| Rh | ICP-MS | 0.0433 | µg/L | 4.0 |
| Pd | ICP-MS | < 0.04 | µg/L | – |
| Ag | ICP-MS | < 0.04 | µg/L | – |
| Cd | ICP-MS | 0.136 | µg/L | 5.5 |
| Sn | ICP-MS | < 0.04 | µg/L | – |
| Sb | ICP-MS | < 0.04 | µg/L | – |
| Te | ICP-MS | < 0.04 | µg/L | – |
| Cs | ICP-MS | 0.0460 | µg/L | 8.9 |
| Ba | ICP-MS | 2.90 | µg/L | 2.4 |
| La | ICP-MS | 0.0814 | µg/L | 11.9 |
| Ce | ICP-MS | 0.179 | µg/L | 3.2 |
| Nd | ICP-MS | 0.0914 | µg/L | 2.9 |
| Sm | ICP-MS | < 0.04 | µg/L | – |

| Analyte | Method | Concentration | Units | 1 Sigma %UNC |
|---|---|---|---|---|
| Eu | ICP-MS | < 0.04 | µg/L | – |
| Gd | ICP-MS | < 0.04 | µg/L | – |
| Tb | ICP-MS | < 0.04 | µg/L | – |
| Dy | ICP-MS | < 0.04 | µg/L | – |
| Ho | ICP-MS | < 0.04 | µg/L | – |
| Er | ICP-MS | < 0.04 | µg/L | – |
| Tm | ICP-MS | < 0.04 | µg/L | – |
| Yb | ICP-MS | < 0.04 | µg/L | – |
| Lu | ICP-MS | < 0.04 | µg/L | – |
| Hf | ICP-MS | < 0.04 | µg/L | – |
| Ta | ICP-MS | < 0.04 | µg/L | – |
| W | ICP-MS | 0.0925 | µg/L | 4.5 |
| Re | ICP-MS | < 0.04 | µg/L | – |
| Ir | ICP-MS | < 0.04 | µg/L | – |
| Pt | ICP-MS | 0.472 | µg/L | 3.4 |
| Au | ICP-MS | < 0.16 | µg/L | – |
| Tl | ICP-MS | < 0.04 | µg/L | – |
| Pb | ICP-MS | 75.1 | µg/L | 6.2 |
| 230 | ICP-MS | < 0.04 | µg/L | – |
| 232 | ICP-MS | < 0.04 | µg/L | – |
| 233 | ICP-MS | < 0.04 | µg/L | – |
| 234 | ICP-MS | < 0.04 | µg/L | – |
| 235 | ICP-MS | < 0.04 | µg/L | – |
| 236 | ICP-MS | < 0.04 | µg/L | – |
| 237 | ICP-MS | < 0.04 | µg/L | – |
| 238 | ICP-MS | 0.263 | µg/L | 2.7 |
| 240 | ICP-MS | < 0.04 | µg/L | – |
| 241 | ICP-MS | < 0.04 | µg/L | – |
| 242 | ICP-MS | < 0.04 | µg/L | – |
| 243 | ICP-MS | < 0.04 | µg/L | – |
| 244 | ICP-MS | < 0.04 | µg/L | – |
| Cu | ICP-MS | 4.37 | µg/L | 2.0 |
| Ge | ICP-MS | < 0.12 | µg/L | – |
| Pr | ICP-MS | < 0.04 | µg/L | – |
| Os | ICP-MS | < 0.04 | µg/L | – |

| Analyte | Method | Concentration | Units | 1 Sigma %UNC |
|---|---|---|---|---|
| 239 | ICP-MS | < 0.04 | µg/L | – |
| Ag | ICP-ES | < 0.00193 | mg/L | – |
| Al | ICP-ES | < 0.031 | mg/L | – |
| B | ICP-ES | < 0.0156 | mg/L | – |
| Ba | ICP-ES | < 0.00133 | mg/L | – |
| Be | ICP-ES | < 0.00126 | mg/L | – |
| Ca | ICP-ES | < 0.161 | mg/L | – |
| Cd | ICP-ES | < 0.00316 | mg/L | – |
| Ce | ICP-ES | < 0.0379 | mg/L | – |
| Co | ICP-ES | < 0.00679 | mg/L | – |
| Cr | ICP-ES | < 0.0127 | mg/L | – |
| Cu | ICP-ES | < 0.00785 | mg/L | – |
| Fe | ICP-ES | < 0.031 | mg/L | – |
| Gd | ICP-ES | < 0.00416 | mg/L | – |
| K | ICP-ES | < 0.473 | mg/L | – |
| La | ICP-ES | < 0.00341 | mg/L | – |
| Li | ICP-ES | < 0.0707 | mg/L | – |
| Mg | ICP-ES | < 0.014 | mg/L | – |
| Mn | ICP-ES | < 0.00212 | mg/L | – |
| Mo | ICP-ES | < 0.0209 | mg/L | – |
| Na | ICP-ES | < 1.75 | mg/L | – |
| Ni | ICP-ES | < 0.0184 | mg/L | – |
| P | ICP-ES | < 0.171 | mg/L | – |
| Pb | ICP-ES | < 0.163 | mg/L | – |
| S | ICP-ES | < 0.0958 | mg/L | – |
| Sb | ICP-ES | < 0.0931 | mg/L | – |
| Si | ICP-ES | < 0.497 | mg/L | – |
| Sn | ICP-ES | < 0.123 | mg/L | – |
| Sr | ICP-ES | < 0.002 | mg/L | – |
| Th | ICP-ES | < 0.111 | mg/L | – |
| Ti | ICP-ES | < 0.0137 | mg/L | – |
| U | ICP-ES | < 0.107 | mg/L | – |
| V | ICP-ES | < 0.0163 | mg/L | – |
| Zn | ICP-ES | < 0.0105 | mg/L | – |
| Zr | ICP-ES | < 0.00133 | mg/L | – |

**Table A-2. Analytical results for H-Canyon tank E3-2 containing natural uranium.**

| Analyte | Method | Concentration | Units | 1 Sigma %UNC | Relative to U (µg/g U) |
|---|---|---|---|---|---|
| Total C | TIC-TOC | < 150 | ug C/mL | 14 | < 265 |
| Inorg C | TIC-TOC | < 55.7 | ug C/mL | 14 | < 98 |
| Org C | TIC-TOC | < 94.4 | ug C/mL | 14 | < 166 |
| Fluoride | IC-Anions | < 100 | µg/mL | - | < 176 |
| Formate | IC-Anions | < 100 | µg/mL | - | < 176 |
| Chloride | IC-Anions | < 100 | µg/mL | - | < 176 |
| Nitrate | IC-Anions | 3.1E+05 | µg/mL | 10 | 5.4E+05 |
| Nitrite | IC-Anions | < 100 | µg/mL | - | < 176 |
| Phosphate | IC-Anions | < 100 | µg/mL | - | < 176 |
| Sulfate | IC-Anions | < 100 | µg/mL | - | < 176 |
| Oxalate | IC-Anions | < 100 | µg/mL | - | < 176 |
| Bromide | IC-Anions | < 500 | µg/mL | - | < 882 |
| Co | ICP-MS | < 100 | ug/L | - | < 0.18 |
| Ga | ICP-MS | < 100 | ug/L | - | < 0.18 |
| Rb | ICP-MS | < 100 | ug/L | - | < 0.18 |
| Sr | ICP-MS | < 100 | ug/L | - | < 0.18 |
| Y | ICP-MS | < 100 | ug/L | - | < 0.18 |
| Zr | ICP-MS | < 200 | ug/L | - | < 0.35 |
| Nb | ICP-MS | < 100 | ug/L | - | < 0.18 |
| Mo | ICP-MS | 6.7E+02 | ug/L | 8.6 | 1.18 |
| Ru | ICP-MS | < 100 | ug/L | - | < 0.18 |
| Rh | ICP-MS | < 100 | ug/L | - | < 0.18 |
| Pd | ICP-MS | < 100 | ug/L | - | < 0.18 |
| Ag | ICP-MS | < 100 | ug/L | - | < 0.18 |
| Cd | ICP-MS | < 100 | ug/L | - | < 0.18 |
| Sn | ICP-MS | < 100 | ug/L | - | < 0.18 |
| Sb | ICP-MS | < 100 | ug/L | - | < 0.18 |
| Te | ICP-MS | < 100 | ug/L | - | < 0.18 |
| Cs | ICP-MS | < 100 | ug/L | - | < 0.18 |
| Ba | ICP-MS | < 100 | ug/L | - | < 0.18 |
| La | ICP-MS | < 100 | ug/L | - | < 0.18 |
| Ce | ICP-MS | < 100 | ug/L | - | < 0.18 |
| Nd | ICP-MS | < 100 | ug/L | - | < 0.18 |

| Analyte | Method | Concentration | Units | 1 Sigma %UNC | Relative to U (µg/g U) |
|---|---|---|---|---|---|
| Sm | ICP-MS | < 100 | ug/L | - | < 0.18 |
| Eu | ICP-MS | < 100 | ug/L | - | < 0.18 |
| Gd | ICP-MS | < 100 | ug/L | - | < 0.18 |
| Tb | ICP-MS | < 100 | ug/L | - | < 0.18 |
| Dy | ICP-MS | < 100 | ug/L | - | < 0.18 |
| Ho | ICP-MS | < 100 | ug/L | - | < 0.18 |
| Er | ICP-MS | < 100 | ug/L | - | < 0.18 |
| Tm | ICP-MS | < 100 | ug/L | - | < 0.18 |
| Yb | ICP-MS | < 100 | ug/L | - | < 0.18 |
| Lu | ICP-MS | < 100 | ug/L | - | < 0.18 |
| Hf | ICP-MS | < 100 | ug/L | - | < 0.18 |
| Ta | ICP-MS | < 100 | ug/L | - | < 0.18 |
| W | ICP-MS | < 300 | ug/L | - | < 0.53 |
| Re | ICP-MS | < 100 | ug/L | - | < 0.18 |
| Ir | ICP-MS | < 100 | ug/L | - | < 0.18 |
| Pt | ICP-MS | < 100 | ug/L | - | < 0.18 |
| Au | ICP-MS | < 1000 | ug/L | - | < 1.76 |
| Tl | ICP-MS | < 100 | ug/L | - | < 0.18 |
| Pb | ICP-MS | < 300 | ug/L | - | < 0.53 |
| 230 | ICP-MS | < 100 | ug/L | - | < 0.18 |
| 232 | ICP-MS | < 100 | ug/L | - | < 0.18 |
| 233 | ICP-MS | < 100 | ug/L | - | < 0.18 |
| 234 | ICP-MS | 3.1E+04 | ug/L | 2.8 | 54.4 |
| 235 | ICP-MS | 4.1E+06 | ug/L | 0.3 | 7.21E+03 |
| 236 | ICP-MS | 825 | ug/L | 3.9 | 1.46 |
| 237 | ICP-MS | 1560 | ug/L | 2.6 | 2.75 |
| 238 | ICP-MS | 5.6E+08 | ug/L | 0.2 | 9.93E+05 |
| 240 | ICP-MS | < 100 | ug/L | - | < 0.18 |
| 241 | ICP-MS | < 100 | ug/L | - | < 0.18 |
| 242 | ICP-MS | < 100 | ug/L | - | < 0.18 |
| 243 | ICP-MS | < 100 | ug/L | - | < 0.18 |
| 244 | ICP-MS | < 100 | ug/L | - | < 0.18 |
| Pu-238 | Pu-Alpha-PHA | 23.5 | dpm/mL | 30.1 | 1.1E-06 |
| Pu-239/240 | Pu-Alpha-PHA | < 17.2 | dpm/mL | - | < 6.0E-05 |
| Pu-241 | Pu-241 Liq Scint | < 4.5E+05 | dpm/mL | - | < 3.4E-03 |

| Analyte | Method | Concentration | Units | 1 Sigma %UNC | Relative to U (µg/g U) |
|---|---|---|---|---|---|
| Pu-242 | MS Pu-242/244 | < 875 | dpm/mL | - | < 1.8E-01 |
| Np-237 | Np-237 Gamma_PHA | < 0.18 | dpm/mL | - | < 2.0E-04 |
| Sr-90 | Sr-90 Beta Liq scint | < 60.9 | dpm/mL | - | < 3.5E-07 |
| Tc-99 | Tc-99 Beta Liq Scint | < 27.9 | dpm/mL | - | < 1.3E-03 |
| Pm-147 | Pm-147/Sm-151 | < 1190 | dpm/mL | - | < 9.5E-07 |
| Sm-151 | Pm-147/Sm-151 | < 1320 | dpm/mL | - | < 4.0E-05 |
| U-232 | U-232 Alpha PHA | < 1.5E+04 | dpm/mL | - | < 5.4E-04 |
| Alpha | Rad Screen | 8.1E+05 | dpm/mL | 10 | |
| Beta | Rad Screen | 8.6E+05 | dpm/mL | 11 | |
| Co-60 | Gamma Spec | < 11.4 | dpm/mL | - | < 8.0E-09 |
| Nb-95 | Gamma Spec | < 25.9 | dpm/mL | - | < 5.3E-10 |
| Zr-95 | Gamma Spec | < 47.9 | dpm/mL | - | < 1.8E-09 |
| Ru-103 | Gamma Spec | < 26.3 | dpm/mL | - | < 6.5E-10 |
| Ru-106 | Gamma Spec | < 120 | dpm/mL | - | < 2.8E-08 |
| Cs-134 | Gamma Spec | < 26.0 | dpm/mL | - | < 1.7E-08 |
| Cs-137 | Gamma Spec | < 27.8 | dpm/mL | - | < 2.6E-07 |
| Ce-144 | Gamma Spec | < 272 | dpm/mL | - | < 6.8E-08 |
| Pr-144 | Gamma Spec | < 272 | dpm/mL | - | < 1.2E-12 |
| Hg-203 | Gamma Spec | < 28.2 | dpm/mL | - | < 1.6E-09 |
| Tl-208 | Gamma Spec | < 11.3 | dpm/mL | - | < 3.0E-14 |
| Bi-212 | Gamma Spec | < 373 | dpm/mL | - | < 2.0E-11 |
| Pb-212 | Gamma Spec | < 52.2 | dpm/mL | - | < 3.0E-11 |
| Am-241 | Am/Cm Counting | < 33.3 | dpm/mL | - | < 1.3E-04 |
| Am-243 | Am/Cm Counting | < 21.8 | dpm/mL | - | < 5.0E-06 |
| Am-242M | Am/Cm Counting | < 43.5 | dpm/mL | - | < 3.5E-06 |
| Cm-243 | Am/Cm Counting | < 28.4 | dpm/mL | - | < 5.4E-06 |
| Cm-242 | Am/Cm Counting | < 36.0 | dpm/mL | - | < 8.7E-09 |
| Cm-244 | Am/Cm Counting | < 28.4 | dpm/mL | - | < 2.8E-07 |
| Cm-245 | Am/Cm Counting | < 3.4 | dpm/mL | - | < 1.6E-05 |
| Cm-246 | Am/Cm Counting | < 1.5 | dpm/mL | - | < 3.2E-06 |
| Cm-247 | Am/Cm Counting | < 4.4E-04 | dpm/mL | - | < 3.7E-06 |

**Table A-3. Analytical results for H-Canyon tank E4-2 containing HEU.**

| Analyte | Method | Concentration | Units | 1 Sigma %UNC | Relative to U (µg/g U) |
|---|---|---|---|---|---|
| Total C | TIC-TOC | < 150 | ug C/mL | 14 | < 1.2E+04 |
| Inorg C | TIC-TOC | < 55.7 | ug C/mL | 14 | < 4358 |
| Org C | TIC-TOC | < 94.7 | ug C/mL | 14 | < 7409 |
| Fluoride | IC-Anions | < 100 | µg/mL | - | < 7824 |
| Formate | IC-Anions | < 100 | µg/mL | - | < 7824 |
| Chloride | IC-Anions | < 100 | µg/mL | - | < 7824 |
| Nitrate | IC-Anions | 3.6E+04 | µg/mL | 10 | 2.8E+06 |
| Nitrite | IC-Anions | < 100 | µg/mL | - | < 7824 |
| Phosphate | IC-Anions | < 100 | µg/mL | - | < 7824 |
| Sulfate | IC-Anions | < 100 | µg/mL | - | < 7824 |
| Oxalate | IC-Anions | < 100 | µg/mL | - | < 7824 |
| Bromide | IC-Anions | < 500 | µg/mL | - | < 3.9E+04 |
| Co | ICP-MS | < 100 | ug/L | - | < 7.82 |
| Ga | ICP-MS | < 100 | ug/L | - | < 7.82 |
| Rb | ICP-MS | < 100 | ug/L | - | < 7.82 |
| Sr | ICP-MS | < 100 | ug/L | - | < 7.82 |
| Y | ICP-MS | < 100 | ug/L | - | < 7.82 |
| Zr | ICP-MS | < 200 | ug/L | - | < 16 |
| Nb | ICP-MS | < 100 | ug/L | - | < 7.82 |
| Mo | ICP-MS | < 300 | ug/L | - | < 23 |
| Ru | ICP-MS | < 100 | ug/L | - | < 7.82 |
| Rh | ICP-MS | < 100 | ug/L | - | < 7.82 |
| Pd | ICP-MS | < 100 | ug/L | - | < 7.82 |
| Ag | ICP-MS | < 100 | ug/L | - | < 7.82 |
| Cd | ICP-MS | < 100 | ug/L | - | < 7.82 |
| Sn | ICP-MS | < 100 | ug/L | - | < 7.82 |
| Sb | ICP-MS | < 100 | ug/L | - | < 7.82 |
| Te | ICP-MS | < 100 | ug/L | - | < 7.82 |
| Cs | ICP-MS | < 100 | ug/L | - | < 7.82 |
| Ba | ICP-MS | < 100 | ug/L | - | < 7.82 |
| La | ICP-MS | < 100 | ug/L | - | < 7.82 |
| Ce | ICP-MS | < 100 | ug/L | - | < 7.82 |
| Nd | ICP-MS | < 100 | ug/L | - | < 7.82 |

| Analyte | Method | Concentration | Units | 1 Sigma %UNC | Relative to U (µg/g U) |
|---|---|---|---|---|---|
| Sm | ICP-MS | < 100 | ug/L | - | < 7.82 |
| Eu | ICP-MS | < 100 | ug/L | - | < 7.82 |
| Gd | ICP-MS | < 100 | ug/L | - | < 7.82 |
| Tb | ICP-MS | < 100 | ug/L | - | < 7.82 |
| Dy | ICP-MS | < 100 | ug/L | - | < 7.82 |
| Ho | ICP-MS | < 100 | ug/L | - | < 7.82 |
| Er | ICP-MS | < 100 | ug/L | - | < 7.82 |
| Tm | ICP-MS | < 100 | ug/L | - | < 7.82 |
| Yb | ICP-MS | < 100 | ug/L | - | < 7.82 |
| Lu | ICP-MS | < 100 | ug/L | - | < 7.82 |
| Hf | ICP-MS | < 100 | ug/L | - | < 7.82 |
| Ta | ICP-MS | < 100 | ug/L | - | < 7.82 |
| W | ICP-MS | < 300 | ug/L | - | < 23 |
| Re | ICP-MS | < 100 | ug/L | - | < 7.82 |
| Ir | ICP-MS | < 100 | ug/L | - | < 7.82 |
| Pt | ICP-MS | < 100 | ug/L | - | < 7.82 |
| Au | ICP-MS | < 1000 | ug/L | - | < 78.2 |
| Tl | ICP-MS | < 100 | ug/L | - | < 7.82 |
| Pb | ICP-MS | 1036 | ug/L | 3.6 | 81 |
| 230 | ICP-MS | < 100 | ug/L | - | < 7.82 |
| 232 | ICP-MS | < 100 | ug/L | - | < 7.82 |
| 233 | ICP-MS | < 100 | ug/L | - | < 7.82 |
| 234 | ICP-MS | 8.4E+04 | ug/L | 0.2 | 6608 |
| 235 | ICP-MS | 6.9E+06 | ug/L | 0.3 | 5.4E+05 |
| 236 | ICP-MS | 4.9E+05 | ug/L | 0.2 | 3.8E+04 |
| 237 | ICP-MS | 112 | ug/L | 3.1 | 8.80 |
| 238 | ICP-MS | 5.4E+06 | ug/L | 0.2 | 4.2E+05 |
| 240 | ICP-MS | < 100 | ug/L | - | < 7.82 |
| 241 | ICP-MS | < 100 | ug/L | - | < 7.82 |
| 242 | ICP-MS | < 100 | ug/L | - | < 7.82 |
| 243 | ICP-MS | < 100 | ug/L | - | < 7.82 |
| 244 | ICP-MS | < 100 | ug/L | - | < 7.82 |
| Pu-238 | Pu-Alpha-PHA | 30.7 | dpm/mL | 145.6 | 6.3E-05 |
| Pu-239/240 | Pu-Alpha-PHA | 23.6 | dpm/mL | 62.9 | 3.7E-03 |
| Pu-241 | Pu-241 Liq Scint | < 3470 | dpm/mL | - | < 1.2E-03 |

| Analyte | Method | Concentration | Units | 1 Sigma %UNC | Relative to U (µg/g U) |
|---|---|---|---|---|---|
| Pu-242 | MS Pu-242/244 | < 875 | dpm/mL | - | < 7.8E+00 |
| Np-237 | Np-237 Gamma_PHA | 18.5 | dpm/mL | 13.0 | 9.2E-01 |
| Sr-90 | Sr-90 Beta Liq scint | < 57.7 | dpm/mL | - | < 1.5E-05 |
| Tc-99 | Tc-99 Beta Liq Scint | < 21.4 | dpm/mL | - | < 4.4E-02 |
| Pm-147 | Pm-147/Sm-151 | < 218 | dpm/mL | - | < 7.7E-06 |
| Sm-151 | Pm-147/Sm-151 | < 294 | dpm/mL | - | < 4.0E-04 |
| U-232 | U-232 Alpha PHA | 149 | dpm/mL | 20.0 | 2.4E-04 |
| Alpha | Rad Screen | 1.2E+06 | dpm/mL | 10.0 | |
| Beta | Rad Screen | 9.3E+04 | dpm/mL | 47.0 | |
| Co-60 | Gamma Spec | < 9.25 | dpm/mL | - | < 2.9E-07 |
| Nb-95 | Gamma Spec | < 5.02 | dpm/mL | - | < 4.5E-09 |
| Zr-95 | Gamma Spec | < 14.3 | dpm/mL | - | < 2.3E-08 |
| Ru-103 | Gamma Spec | < 10.6 | dpm/mL | - | < 1.2E-08 |
| Ru-106 | Gamma Spec | < 49.6 | dpm/mL | - | < 5.1E-07 |
| Cs-134 | Gamma Spec | < 9.5 | dpm/mL | - | < 2.8E-07 |
| Cs-137 | Gamma Spec | 8.5 | dpm/mL | 29.9 | 3.5E-06 |
| Ce-144 | Gamma Spec | < 296 | dpm/mL | - | < 3.3E-06 |
| Pr-144 | Gamma Spec | < 296 | dpm/mL | - | < 5.7E-11 |
| Hg-203 | Gamma Spec | < 15.7 | dpm/mL | - | < 4.0E-08 |
| Tl-208 | Gamma Spec | 1000 | dpm/mL | 5.0 | 1.2E-10 |
| Bi-212 | Gamma Spec | 2720 | dpm/mL | 5.0 | 6.4E-09 |
| Pb-212 | Gamma Spec | 2670 | dpm/mL | 5.0 | 6.7E-08 |
| Am-241 | Am/Cm Counting | < 4.07 | dpm/mL | - | < 7.2E-04 |
| Am-243 | Am/Cm Counting | < 2.68 | dpm/mL | - | < 2.8E-05 |
| Am-242M | Am/Cm Counting | < 3.76 | dpm/mL | - | < 1.4E-05 |
| Cm-243 | Am/Cm Counting | < 2.13 | dpm/mL | - | < 1.8E-05 |
| Cm-242 | Am/Cm Counting | < 3.11 | dpm/mL | - | < 3.3E-08 |
| Cm-244 | Am/Cm Counting | < 2.13 | dpm/mL | - | < 9.3E-07 |
| Cm-245 | Am/Cm Counting | < 0.70 | dpm/mL | - | < 1.4E-04 |
| Cm-246 | Am/Cm Counting | < 0.30 | dpm/mL | - | < 2.9E-05 |
| Cm-247 | Am/Cm Counting | < 9.1E-05 | dpm/mL | - | < 3.4E-05 |

**Table A-4. Analytical results for H-Canyon tank E1-1 containing LEU heels.**

| Analyte | Method | Concentration | Units | 1 Sigma %UNC | Relative to U (µg/g U) |
|---|---|---|---|---|---|
| Total C | TIC-TOC | < 150 | ug C/mL | 14 | < 5222 |
| Inorg C | TIC-TOC | < 56 | ug C/mL | 14 | < 1939 |
| Org C | TIC-TOC | < 94 | ug C/mL | 14 | < 3287 |
| Fluoride | IC-Anions | < 100 | µg/mL | - | < 3481 |
| Formate | IC-Anions | < 100 | µg/mL | - | < 3481 |
| Chloride | IC-Anions | < 100 | µg/mL | - | < 3481 |
| Nitrate | IC-Anions | 2.0E+04 | µg/mL | 10 | 703257 |
| Nitrite | IC-Anions | < 100 | µg/mL | - | < 3481 |
| Phosphate | IC-Anions | < 100 | µg/mL | - | < 3481 |
| Sulfate | IC-Anions | < 100 | µg/mL | - | < 3481 |
| Oxalate | IC-Anions | < 100 | µg/mL | - | < 3481 |
| Bromide | IC-Anions | < 500 | µg/mL | - | < 1.7E+04 |
| Co | ICP-MS | < 100 | ug/L | - | < 3.48 |
| Ga | ICP-MS | < 100 | ug/L | - | < 3.48 |
| Rb | ICP-MS | < 100 | ug/L | - | < 3.48 |
| Sr | ICP-MS | < 100 | ug/L | - | < 3.48 |
| Y | ICP-MS | < 100 | ug/L | - | < 3.48 |
| Zr | ICP-MS | < 200 | ug/L | - | < 6.96 |
| Nb | ICP-MS | < 100 | ug/L | - | < 3.48 |
| Mo | ICP-MS | < 300 | ug/L | - | < 10.4 |
| Ru | ICP-MS | < 100 | ug/L | - | < 3.48 |
| Rh | ICP-MS | < 100 | ug/L | - | < 3.48 |
| Pd | ICP-MS | < 100 | ug/L | - | < 3.48 |
| Ag | ICP-MS | < 100 | ug/L | - | < 3.48 |
| Cd | ICP-MS | < 100 | ug/L | - | < 3.48 |
| Sn | ICP-MS | < 100 | ug/L | - | < 3.48 |
| Sb | ICP-MS | < 100 | ug/L | - | < 3.48 |
| Te | ICP-MS | < 100 | ug/L | - | < 3.48 |
| Cs | ICP-MS | < 100 | ug/L | - | < 3.48 |
| Ba | ICP-MS | < 100 | ug/L | - | < 3.48 |
| La | ICP-MS | < 100 | ug/L | - | < 3.48 |
| Ce | ICP-MS | < 100 | ug/L | - | < 3.48 |
| Nd | ICP-MS | < 100 | ug/L | - | < 3.48 |

| Analyte | Method | Concentration | Units | 1 Sigma %UNC | Relative to U (µg/g U) |
|---|---|---|---|---|---|
| Sm | ICP-MS | < 100 | ug/L | - | < 3.48 |
| Eu | ICP-MS | < 100 | ug/L | - | < 3.48 |
| Gd | ICP-MS | < 100 | ug/L | - | < 3.48 |
| Tb | ICP-MS | < 100 | ug/L | - | < 3.48 |
| Dy | ICP-MS | < 100 | ug/L | - | < 3.48 |
| Ho | ICP-MS | < 100 | ug/L | - | < 3.48 |
| Er | ICP-MS | < 100 | ug/L | - | < 3.48 |
| Tm | ICP-MS | < 100 | ug/L | - | < 3.48 |
| Yb | ICP-MS | < 100 | ug/L | - | < 3.48 |
| Lu | ICP-MS | < 100 | ug/L | - | < 3.48 |
| Hf | ICP-MS | < 100 | ug/L | - | < 3.48 |
| Ta | ICP-MS | < 100 | ug/L | - | < 3.48 |
| W | ICP-MS | < 300 | ug/L | - | < 10.4 |
| Re | ICP-MS | < 100 | ug/L | - | < 3.48 |
| Ir | ICP-MS | < 100 | ug/L | - | < 3.48 |
| Pt | ICP-MS | < 100 | ug/L | - | < 3.48 |
| Au | ICP-MS | < 1000 | ug/L | - | < 34.8 |
| Tl | ICP-MS | < 100 | ug/L | - | < 3.48 |
| Pb | ICP-MS | < 300 | ug/L | - | < 10.4 |
| 230 | ICP-MS | < 100 | ug/L | - | < 3.48 |
| 232 | ICP-MS | < 100 | ug/L | - | < 3.48 |
| 233 | ICP-MS | < 100 | ug/L | - | < 3.48 |
| 234 | ICP-MS | 1.5E+04 | ug/L | 1.6 | 518 |
| 235 | ICP-MS | 1.4E+06 | ug/L | 0.3 | 5.0E+04 |
| 236 | ICP-MS | 2.2E+04 | ug/L | 1.2 | 762 |
| 237 | ICP-MS | < 100 | ug/L | - | < 3.48 |
| 238 | ICP-MS | 2.7E+07 | ug/L | 0.1 | 9.5E+05 |
| 240 | ICP-MS | < 100 | ug/L | - | < 3.48 |
| 241 | ICP-MS | < 100 | ug/L | - | < 3.48 |
| 242 | ICP-MS | < 100 | ug/L | - | < 3.48 |
| 243 | ICP-MS | < 100 | ug/L | - | < 3.48 |
| 244 | ICP-MS | < 100 | ug/L | - | < 3.48 |
| Pu-238 | Pu-Alpha-PHA | 120 | dpm/mL | 19.3 | 1.1E-04 |
| Pu-239/240 | Pu-Alpha-PHA | < 16 | dpm/mL | - | < 1.1E-03 |
| Pu-241 | Pu-241 Liq Scint | < 1.8E+04 | dpm/mL | - | < 2.7E-03 |

| Analyte | Method | Concentration | Units | 1 Sigma %UNC | Relative to U (µg/g U) |
|---|---|---|---|---|---|
| Pu-242 | MS Pu-242/244 | < 875 | dpm/mL | - | < 3.5E+00 |
| Np-237 | Np-237 Gamma_PHA | < 0.24 | dpm/mL | - | < 5.2E-03 |
| Sr-90 | Sr-90 Beta Liq Scint | < 54 | dpm/mL | - | < 6.1E-06 |
| Tc-99 | Tc-99 Beta Liq Scint | < 25 | dpm/mL | - | < 2.3E-02 |
| Pm-147 | Pm-147/Sm-151 | < 492 | dpm/mL | - | < 7.8E-06 |
| Sm-151 | Pm-147/Sm-151 | < 734 | dpm/mL | - | < 4.4E-04 |
| U-232 | U-232 Alpha PHA | < 145 | dpm/mL | - | < 1.0E-04 |
| Alpha | Rad Screen | 2.2E+05 | dpm/mL | 10.0 | |
| Beta | Rad Screen | 5.3E+04 | dpm/mL | 21.0 | |
| Co-60 | Gamma Spec | < 5.2 | dpm/mL | - | < 7.3E-08 |
| Nb-95 | Gamma Spec | < 7.0 | dpm/mL | - | < 2.8E-09 |
| Zr-95 | Gamma Spec | < 12.8 | dpm/mL | - | < 9.3E-09 |
| Ru-103 | Gamma Spec | < 7.0 | dpm/mL | - | < 3.5E-09 |
| Ru-106 | Gamma Spec | < 38.8 | dpm/mL | - | < 1.8E-07 |
| Cs-134 | Gamma Spec | < 7.6 | dpm/mL | - | < 9.9E-08 |
| Cs-137 | Gamma Spec | < 7.7 | dpm/mL | - | < 1.4E-06 |
| Ce-144 | Gamma Spec | < 137 | dpm/mL | - | < 6.7E-07 |
| Pr-144 | Gamma Spec | < 137 | dpm/mL | - | < 1.2E-11 |
| Hg-203 | Gamma Spec | < 7.4 | dpm/mL | - | < 8.2E-09 |
| Tl-208 | Gamma Spec | < 10.2 | dpm/mL | - | < 5.4E-13 |
| Bi-212 | Gamma Spec | < 108 | dpm/mL | - | < 1.1E-10 |
| Pb-212 | Gamma Spec | 50.8 | dpm/mL | 9.5 | 5.7E-10 |
| Am-241 | Am/Cm Counting | < 12.9 | dpm/mL | - | < 1.0E-03 |
| Am-243 | Am/Cm Counting | < 11.8 | dpm/mL | - | < 5.4E-05 |
| Am-242m | Am/Cm Counting | < 6.9 | dpm/mL | - | < 1.1E-05 |
| Cm-243 | Am/Cm Counting | < 6.3 | dpm/mL | - | < 2.4E-05 |
| Cm-242 | Am/Cm Counting | < 5.7 | dpm/mL | - | < 2.7E-08 |
| Cm-244 | Am/Cm Counting | < 6.3 | dpm/mL | - | < 1.2E-06 |
| Cm-245 | Am/Cm Counting | < 1.1 | dpm/mL | - | < 9.9E-05 |
| Cm-246 | Am/Cm Counting | < 0.46 | dpm/mL | - | < 2.0E-05 |
| Cm-247 | Am/Cm Counting | < 1.4E-04 | dpm/mL | - | < 2.3E-05 |

**Table A-5. Analytical results for H-Canyon tank F1-5 containing LEU heels.**

| Analyte | Method | Concentration | Units | 1 Sigma %UNC | Relative to U (µg/g U) |
|---|---|---|---|---|---|
| Total C | TIC-TOC | < 150 | ug C/mL | 14 | < 963 |
| Inorg C | TIC-TOC | < 56 | ug C/mL | 14 | < 358 |
| OrgC | TIC-TOC | < 94 | ug C/mL | 14 | < 606 |
| Fluoride | IC-Anions | < 100 | µg/mL | - | < 642 |
| Formate | IC-Anions | < 100 | µg/mL | - | < 642 |
| Chloride | IC-Anions | < 100 | µg/mL | - | < 642 |
| Nitrate | IC-Anions | 1.1E+05 | µg/mL | 10 | 6.9E+05 |
| Nitrite | IC-Anions | < 100 | µg/mL | - | < 642 |
| Phosphate | IC-Anions | < 100 | µg/mL | - | < 642 |
| Sulfate | IC-Anions | < 100 | µg/mL | - | < 642 |
| Oxalate | IC-Anions | < 100 | µg/mL | - | < 642 |
| Bromide | IC-Anions | < 500 | µg/mL | - | < 3211 |
| Co | ICP-MS | < 100 | ug/L | - | < 0.64 |
| Ga | ICP-MS | < 100 | ug/L | - | < 0.64 |
| Rb | ICP-MS | < 100 | ug/L | - | < 0.64 |
| Sr | ICP-MS | < 100 | ug/L | - | < 0.64 |
| Y | ICP-MS | < 100 | ug/L | - | < 0.64 |
| Zr | ICP-MS | < 200 | ug/L | - | < 1.28 |
| Nb | ICP-MS | < 100 | ug/L | - | < 0.64 |
| Mo | ICP-MS | < 300 | ug/L | - | < 1.93 |
| Ru | ICP-MS | < 100 | ug/L | - | < 0.64 |
| Rh | ICP-MS | < 100 | ug/L | - | < 0.64 |
| Pd | ICP-MS | < 100 | ug/L | - | < 0.64 |
| Ag | ICP-MS | < 100 | ug/L | - | < 0.64 |
| Cd | ICP-MS | < 100 | ug/L | - | < 0.64 |
| Sn | ICP-MS | < 100 | ug/L | - | < 0.64 |
| Sb | ICP-MS | < 100 | ug/L | - | < 0.64 |
| Te | ICP-MS | < 100 | ug/L | - | < 0.64 |
| Cs | ICP-MS | < 100 | ug/L | - | < 0.64 |
| Ba | ICP-MS | < 100 | ug/L | - | < 0.64 |
| La | ICP-MS | < 100 | ug/L | - | < 0.64 |
| Ce | ICP-MS | < 100 | ug/L | - | < 0.64 |
| Nd | ICP-MS | < 100 | ug/L | - | < 0.64 |

| Analyte | Method | Concentration | Units | 1 Sigma %UNC | Relative to U (µg/g U) |
|---|---|---|---|---|---|
| Sm | ICP-MS | < 100 | ug/L | - | < 0.64 |
| Eu | ICP-MS | < 100 | ug/L | - | < 0.64 |
| Gd | ICP-MS | < 100 | ug/L | - | < 0.64 |
| Tb | ICP-MS | < 100 | ug/L | - | < 0.64 |
| Dy | ICP-MS | < 100 | ug/L | - | < 0.64 |
| Ho | ICP-MS | < 100 | ug/L | - | < 0.64 |
| Er | ICP-MS | < 100 | ug/L | - | < 0.64 |
| Tm | ICP-MS | < 100 | ug/L | - | < 0.64 |
| Yb | ICP-MS | < 100 | ug/L | - | < 0.64 |
| Lu | ICP-MS | < 100 | ug/L | - | < 0.64 |
| Hf | ICP-MS | < 100 | ug/L | - | < 0.64 |
| Ta | ICP-MS | < 100 | ug/L | - | < 0.64 |
| W | ICP-MS | < 300 | ug/L | - | < 1.93 |
| Re | ICP-MS | < 100 | ug/L | - | < 0.64 |
| Ir | ICP-MS | < 100 | ug/L | - | < 0.64 |
| Pt | ICP-MS | < 100 | ug/L | - | < 0.64 |
| Au | ICP-MS | < 1000 | ug/L | - | < 6.42 |
| Tl | ICP-MS | < 100 | ug/L | - | < 0.64 |
| Pb | ICP-MS | 1533 | ug/L | 1.9 | 9.85 |
| 230 | ICP-MS | < 100 | ug/L | - | < 0.64 |
| 232 | ICP-MS | < 100 | ug/L | - | < 0.64 |
| 233 | ICP-MS | < 100 | ug/L | - | < 0.64 |
| 234 | ICP-MS | 8.0E+04 | ug/L | 1.7 | 514 |
| 235 | ICP-MS | 8.0E+06 | ug/L | 0.4 | 51262 |
| 236 | ICP-MS | 1.2E+05 | ug/L | 1.0 | 779 |
| 237 | ICP-MS | 402 | ug/L | 5.0 | 2.58 |
| 238 | ICP-MS | 1.5E+08 | ug/L | 0.4 | 9.5E+05 |
| 240 | ICP-MS | < 100 | ug/L | - | < 0.64 |
| 241 | ICP-MS | < 100 | ug/L | - | < 0.64 |
| 242 | ICP-MS | < 100 | ug/L | - | < 0.64 |
| 243 | ICP-MS | < 100 | ug/L | - | < 0.64 |
| 244 | ICP-MS | < 100 | ug/L | - | < 0.64 |
| Pu-238 | Pu-Alpha-PHA | 137 | dpm/mL | 25.4 | 2.3E-05 |
| Pu-239/240 | Pu-Alpha-PHA | 24 | dpm/mL | - | 3.1E-04 |
| Pu-241 | Pu-241 Liq Scint | < 7.8E+04 | dpm/mL | - | < 2.2E-03 |

| Analyte | Method | Concentration | Units | 1 Sigma %UNC | Relative to U (µg/g U) |
|---|---|---|---|---|---|
| Pu-242 | MS Pu-242/244 | < 875 | dpm/mL | - | < 6.4E-01 |
| Np-237 | Np-237 Gamma_PHA | 1.9E-01 | dpm/mL | 13.0 | 7.6E-04 |
| Sr-90 | Sr-90 Beta Liq Scint | < 58 | dpm/mL | - | < 1.2E-06 |
| Tc-99 | Tc-99 Beta Liq Scint | < 22 | dpm/mL | - | < 3.8E-03 |
| Pm-147 | Pm-147/Sm-151 | < 676 | dpm/mL | - | < 2.0E-06 |
| Sm-151 | Pm-147/Sm-151 | < 1000 | dpm/mL | - | < 1.1E-04 |
| U-232 | U-232 Alpha PHA | 1980 | dpm/mL | 20.0 | 2.6E-04 |
| Alpha | Rad Screen | 1.2E+06 | dpm/mL | 10.0 | |
| Beta | Rad Screen | 2.8E+05 | dpm/mL | 22.0 | |
| Co-60 | Gamma Spec | < 7.8 | dpm/mL | - | < 2.0E-08 |
| Nb-95 | Gamma Spec | < 12.8 | dpm/mL | - | < 9.5E-10 |
| Zr-95 | Gamma Spec | < 25.3 | dpm/mL | - | < 3.4E-09 |
| Ru-103 | Gamma Spec | < 13.2 | dpm/mL | - | < 1.2E-09 |
| Ru-106 | Gamma Spec | < 51.4 | dpm/mL | - | < 4.4E-08 |
| Cs-134 | Gamma Spec | < 13.6 | dpm/mL | - | < 3.3E-08 |
| Cs-137 | Gamma Spec | < 15.0 | dpm/mL | - | < 5.0E-07 |
| Ce-144 | Gamma Spec | < 296 | dpm/mL | - | < 2.7E-07 |
| Pr-144 | Gamma Spec | < 296 | dpm/mL | - | < 4.7E-12 |
| Hg-203 | Gamma Spec | 26.6 | dpm/mL | 8.6 | 5.5E-09 |
| Tl-208 | Gamma Spec | 98.5 | dpm/mL | 5.76 | 9.6E-13 |
| Bi-212 | Gamma Spec | 237 | dpm/mL | 11.5 | 4.6E-11 |
| Pb-212 | Gamma Spec | 256 | dpm/mL | 5.0 | 5.3E-10 |
| Am-241 | Am/Cm Counting | < 12.9 | dpm/mL | - | < 1.9E-04 |
| Am-243 | Am/Cm Counting | < 11.8 | dpm/mL | - | < 1.0E-05 |
| Am-242M | Am/Cm Counting | < 6.9 | dpm/mL | - | < 2.0E-06 |
| Cm-243 | Am/Cm Counting | < 6.3 | dpm/mL | - | < 4.4E-06 |
| Cm-242 | Am/Cm Counting | < 5.7 | dpm/mL | - | < 5.0E-09 |
| Cm-244 | Am/Cm Counting | < 6.3 | dpm/mL | - | < 2.3E-07 |
| Cm-245 | Am/Cm Counting | < 1.1 | dpm/mL | - | < 1.8E-05 |
| Cm-246 | Am/Cm Counting | < 0.46 | dpm/mL | - | < 3.7E-06 |
| Cm-247 | Am/Cm Counting | < 1.4E-04 | dpm/mL | - | < 4.3E-06 |

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