October 20th, 2015

U.S. Nuclear Regulatory Commission
Nuclear Material Safety and Safeguards
Division of Decommissioning, Uranium Recovery, and Waste Programs
Uranium Recovery Licensing Branch
Attention: Mr. John Saxton, Project Manager
Two White Flint North, Mail Stop T8 F5
11545 Rockville Pike
Rockville, MD 20852

Re: Strata Energy Ross In Situ Recovery Project
Source Materials License SUA-1601, Docket No. 040-09091
Response to RAIs for License Condition 12.8 of Source Material License SUA-1601

Dear Mr. Saxton:

By letter dated October 15, 2015, the Nuclear Regulatory Commission (NRC) submitted to Strata Energy, Inc. (Strata) a Request for Additional Information (RAI) in regards to Strata's License Amendment Request to Source Material License SUA-1601 License Condition (LC) 12.8, dated July 27, 2015.

The responses to the RAI are contained in Attachment 1 of this submittal. Strata requests that the NRC staff review and approve the responses. Should the NRC staff find the responses adequate, Strata requests a License Amendment to Source Material License SUA-1601, namely the removal of the preoperational License Condition 12.8 from SUA-1601. To support Strata's request, attached please find the following information:

- Responses to RAI (Attachment 1)
- Revised "Beta-Gamma Contamination Control Program" (Attachment 2)
- Revised "Instrumentation Specifications and Additional Considerations" (Attachment 3)

Please contact me if you have any questions. You can reach me at (307) 686-4066 or mgriffin@stratawyo.com.

Sincerely,

Strata Energy, Inc.

Michael Griffin
Vice President of Permitting, Regulatory and Environmental Compliance

Cc: Mr. John Saxton, NRC Project Manager – **via email**

Attachment 1

RESPONSES TO THE REQUESTS FOR ADDITIONAL INFORMATION

Request for Additional Information (RAI) No. 1:
Identify a beta-gamma detector with sufficient sensitivity below the release criterion in Policy and Guidance Directive FC 83-23, Table 1, footnote f (NRC 1993).

Response to RAI No. 1:
As part of its' beta-gamma contamination control program, Strata has committed to meeting the regulatory limits specified in Table 1 of Enclosure 2 to the Nuclear Regulatory Commission's (NRC) FC 83-23. Footnote "f" to that table lists additional radiation level limits that must be met. The NRC staff requested additional information regarding the instrumentation that would be used to meet the radiation level limits specified in footnote "f". In order to verify that Strata will be able to meet the regulatory limits, Strata has conducted an analysis of the radiation level limits specified in footnote "f" of Table 1.

The textbook "Introduction to Health Physics", 4th Edition, by Herman Cember and Thomas E. Johnson (Cember and Johnson, 2009), contains a formula to obtain a dose rate from surface contamination. The formula is specified on page 229 as formula 6.33b. The formula can be rearranged such that the surface contamination in Becquerel per square centimeter (Bq/cm^2) can be obtained given a dose rate in milliGray per hour (mGy/hr) at a given distance in cm. The formula is as follows:

> Surface Contamination (Bq/cm^2) = dose rate (mGy/hr) / (3.6E-4 x average energy of the beta emitting radionuclide x *e*^-(beta absorption coefficient for air x *d*) x *e*^-(beta absorption coefficient for tissue x 0.007) x beta absorption coefficient for tissue)

As the radionuclide composition of the potential contamination is not currently known, the conservative estimate will be made that the entire beta emitting contamination is due to Protactinium-234m, which emits beta radiation at a maximum energy of 2.29 Mega electronvolts (MeV) and an average energy of 0.8 MeV.

Using equations 6.20 and 6.21 from Cember and Johnson, 2009, the beta absorption coefficients for Pa-234m for air and for tissue were calculated. They are as follows:

> Pa-234m beta absorption coefficient for air = 5.13 cm^2/g
> Pa-234m beta absorption coefficient for tissue = 6.12 cm^2/g

From Example 6.11 of Cember and Johnson, 2009, an assumed air temperature of 27 degrees Celsius yields an air density of 1.2E-3 g/cm^3. The specified regulatory limits are at a distance of 1 cm. Therefore the term *d* is found to be:

> 1 cm X 1.2E-3 g/cm^3 = 1.2E-3 g/cm^2.

Substituting these values into the equation yields:

Surface Contamination (Bq/cm^2) = dose rate (mGy/hr) / (3.6E-4 x 0.8 MeV x *e*^-(5.13 x 1.2E-3) x *e*^-(6.12 x 0.007) x 6.12)

Applying the mathematical operations yields:

Surface Contamination (Bq/cm^2) = dose rate (mGy/hr) / 1.68E-3

The regulatory release limits are an average radiation level associated with surface contamination resulting from beta-gamma emitters of 0.2 millirads per hour (mrad/hr) at a distance of 1 cm, and a maximum radiation level associated with surface contamination resulting from beta-gamma emitters of 1.0 mrad/hr at 1 cm.

For the limit of an average radiation level of 0.2 mrad/hr (0.002 mGy/hr), the corresponding average surface contamination in Bq/cm^2 and dpm/cm^2 is:

0.002 mGy/hr / 1.68E-3 = 1.19 Bq/cm^2 = 71.4 dpm/cm^2

For the limit of a maximum radiation level of 1.0 mrad/hr (0.01 mGy/hr), the corresponding average surface contamination in Bq/cm^2 and dpm/cm^2 is:

0.01 mGy/hr / 1.68E-3 = 5.95 Bq/cm^2 = 357 dpm/cm^2

Table 1 of Enclosure 2 to NRC's FC 83-23 contains average and maximum surface contamination limits for beta-gamma emitting radionuclides of 5,000 dpm/100 cm^2 and 15,000 dpm/100 cm^2 respectively. Converting the limits calculated above to dpm/100 cm^2 yields:

Average radiation level = 71.4 dpm/cm^2 = 7,140 dpm/100 cm^2
Maximum radiation level = 357 dpm/cm^2 = 35,700 dpm/100 cm^2

Since the surface contamination level limits specified in Table 1 are more constrictive than the radiation level limits for both the average and maximum beta-gamma contamination present, Strata has reasonable assurance that if the instrumentation is capable of detecting surface contamination below the limits specified in Table 1, it will also be able to detect surface contamination below the limits specified in footnote "f". Therefore, Strata does not need to identify a beta-gamma detector with sufficient sensitivity to detect radiation levels below those specified in footnote "f" as Strata has determined that instrumentation which will meet the limits specified in Table 1 will also be sufficient to detect surface contamination below the limits specified in footnote "f".

RAI No. 2:
For the radiation detection instruments and contamination control program, as proposed by Strata, describe the methodology Strata will use to determine the detection capability for any expected alpha and beta contamination in terms of disintegrations per minute (dpm) per 100 square centimeters (cm2), in accordance with license condition (LC) 12.8.

Response to RAI No. 2:
Strata commits to utilizing the methodology outlined in the draft Safety Evaluation Report (SER) (NRC, 2015a) for calculating the scan MDC and the static MDC for surveys for both alpha and beta surface contamination. Specifically, the static MDCs for alpha and beta contamination for the Model 3030 were found by using the formula presented in Table 3.1 of NUREG-1507 (NRC 1998). The static MDCs for alpha and beta contamination for the Model 43-93 were found by using the formula presented in Table 3.1 of NUREG-1507 (NRC 1998), with consideration for the probe area. Since the active area of the probe of the Model 43-93 is 100 cm^2, the equations for calculating the MDC for the Model 3030 and the Model 43-93 are identical. The MDCs for both instruments were calculated using counting efficiencies for mixtures of aged yellowcake and pregnant lixiviant which were determined in the response to RAI No. 3. The analysis was conducted for MDCs resulting from gross counting times of 1 and 1.5 minutes. Additionally, a background count time of 1 minute was used along with the following parameters:

Mixture	Radiation Type	Instrument	Background Count Rate (cpm)	Counting Efficiency (%)
Aged Yellowcake	Alpha	3030	3	15.7
		43-93	1	9.0
	Beta	3030	50	15.3
		43-93	300	8.9
Pregnant Lixiviant	Alpha	3030	3	12.6
		43-93	1	7.2
	Beta	3030	50	13.9
		43-93	300	8.0

The results of the calculations are presented in Table 7, included at the end of this attachment.

The methodology for determining the scan MDC for alpha contamination is Equation 6-12 of NUREG-1575 (NRC, 2000), and the methodology for determining the scan MDC for beta-gamma contamination is Equation 6-10 of NUREG-1575 (NRC, 2000).

For the alpha scan MDC, Strata assumed a 90% probability of detecting 1 count. Using a residence time of 7 seconds and a counting efficiency of 9.0% for alpha contamination for the mixture "aged yellowcake", the alpha scan MDC was calculated as 219 dpm/100 cm^2. For a residence time of 7 seconds and a counting efficiency of 7.2% for alpha contamination for the mixture "pregnant lixiviant", the alpha scan MDC was calculated as 274 dpm/100 cm^2.

For the beta-gamma scan MDC, Strata assumed a surveyor efficiency of 50%, a false positive rate of 60%, a true positive proportion of 95%, a 7 second residence time, and a 300 cpm background count rate. Using a counting efficiency of 8.9% for beta contamination for the mixture “aged yellowcake”, the beta-gamma scan MDC was calculated as 1112 dpm/100 cm^2. For a counting efficiency of 8.0% for beta contamination for the mixture “pregnant lixiviant”, the beta-gamma scan MDC was calculated as 1237 dpm/100 cm^2.

As both scan MDCs were higher than the applicable regulatory limit of 1,000 dpm/100 cm^2, the proposed residence time was increased to 14 seconds. Equation 6-8 of NUREG-1575 (NRC, 2000) then yields a s_i = 1.38 * SQRT([300 cpm/(60 s/min)]/14 s) = 11.6. Equation 6-9 of NUREG-1575 (NRC, 2000) yields MDCR = 11.6 * (60/14) = 49.7. Using these new parameters in Equation 6-10 of NUREG-1575 (NRC, 2000), the beta-gamma scan MDCs were calculated as 790 dpm/100 cm^2 for the mixture “aged yellowcake” and 879 dpm/100 cm^2 for the mixture “pregnant lixiviant”.

The alpha scan MDCs were recalculated for the increased residence time. The new alpha scan MDCs were found to be 110 dpm/100 cm^2 for the mixture “aged yellowcake” and 137 dpm/100 cm^2 for the mixture “pregnant lixiviant”.

RAI No. 3:

As part of calculating minimum detectable concentrations (MDCs) of methods and radiation detection equipment proposed for use at the Ross ISR Project, provide radionuclide-weighted counting efficiencies for the major mixtures likely to be encountered at the Ross ISR Project. This should include, at a minimum, radionuclide mixtures for lixiviant and yellowcake.

Response to RAI No.3:

Strata has followed the methodology outlined in the draft SER attached with NRC's October 15, 2015 letter (NRC, 2015a) to calculate the radionuclide-weighted counting efficiency for two major mixtures likely to be encountered at the Ross In Situ Recovery (ISR) Project. The two mixtures which were considered were aged yellowcake and production fluid, or "pregnant lixiviant". The pregnant lixiviant is the process fluid which is returning from the wellfield to the plant, and will contain higher concentrations of radionuclides than the "barren lixiviant", or the process fluids which return to the wellfield after passing over the resin beds. In considering the mixtures, Strata has not taken into account radon gas (Rn-222) nor the short lived decay products of radon (radon daughters). Although the radon daughters are alpha and beta emitters, they were excluded from the calculations as the calculations are considering surface contamination levels, not airborne contamination levels.

Although there was suitable data regarding the radionuclide composition of aged yellowcake (DOE, 2009), Strata found minimal data regarding the composition in pregnant lixiviant. Strata identified two sources of data regarding the radionuclide composition in lixiviant (Brown, 1982 and LCI, 2015). The LCI, 2015 document contained a radionuclide composition analysis on pregnant lixiviant from a Uranium Recovery facility in Wyoming, using alkaline based mining techniques similar to that proposed by Strata. The LCI, 2015 document showed that the concentrations of the long-lived decay products of natural uranium in the pregnant lixiviant are negligible. Two radionuclides had elevated concentrations, namely Ra-226 and Th-234, with concentrations of 2,700 and 2,290 pCi/L respectively. Converting to Bq/L yields Ra-226 and Th-234 concentrations of 99.9 and 84.7 Bq/L respectively. Interestingly, the LCI, 2015 document lists the concentration of Th-230 as 0.7 pCi/L, or 0.026 Bq/L.

The paper prepared by Brown (Brown, 1982) performed an analysis on the radionuclide composition of pregnant lixiviant for three ISR mines using alkaline leach based mining techniques. Although the mining technique is similar to that proposed at the Ross Project, two of the mines in the analysis were in South Texas, Bruni (Hebbronville) mine and the Lamprecht plant near Ray Point. Additionally, the data was obtained during the 1970s, so although the basic mining technique is the same, there will be differences due to advances in technology and the chemical constituents of the lixiviant. However, the third mine where data was obtained was Irigaray mine, an ISR mine located in Wyoming roughly 110 miles from the Ross Project. The paper (Brown, 1982) only lists concentrations for Th-230 and Ra-226. The concentration ranges for Th-230 are 56 - 93 Bq/L, and for Ra-226 are 10 - 150 Bq/L. While the concentrations of Ra-226 are very similar in both analyses, the concentrations of Th-230 are substantially different.

For data which was not available, Strata made reasonable estimations which are conservative in nature. These estimations will be verified once Strata begins operations and can analyze site specific conditions. One estimation that Strata made was that the concentrations of Th-230 are the higher concentrations found in the Brown analysis (Brown, 1982). Also, the highest values of the concentration ranges in the

Brown paper were used, namely 93 Bq/L for Th-230 and 150 Bq/L for Ra-226. As there was no data regarding the concentrations of Th-231 and Pa-234m for the pregnant lixiviant, Strata made the following estimations. For Th-231 and Pa-234m, Strata assumed that Th-231 was in secular equilibrium with U-235 and Pa-234m was in secular equilibrium with Th-234. This estimation is valid as the half lives of the parent radionuclides are much longer than the half lives of the daughter radionuclides.

The activity fractions for aged yellowcake were provided in the draft SER (NRC, 2015a). The activity fractions for pregnant lixiviant were calculated using the data and estimations listed above. The specific activity of 6.77E-7 Ci/g for natural Uranium was found in footnote (3) to Appendix B of 10 CFR 20. An average concentration of uranium in pregnant lixiviant is 25-30 ppm, and a conservative estimate of the concentration of uranium in the pregnant lixiviant which will be used is 40 ppm. Converting to Bq/L yields:

Concentration of U in pregnant lixiviant = 40 ppm = 40 mg/L = 0.04 g/L = 1E3 Bq/L

Therefore, the primary radionuclides of concern for contamination from pregnant lixiviant in regards to alpha radiation are:

	Bq/L	Fraction
U (total)	1,000	0.805
U-238	486	0.391
U-235	22	0.018
U-234	492	0.396
Th-230	93	0.075
Ra-226	150	0.121

Table A: Alpha Emitting Primary Radionuclides of Concern

The primary radionuclides of concern for contamination from pregnant lixiviant in regards to beta radiation are:

	Bq/L	Fraction
Th-234	84.7	0.443
Th-231	22	0.115
Pa-234m	84.7	0.443

Table B: Beta Emitting Primary Radionuclides of Concern

The two instruments which will be used in Strata's contamination control program are a Ludlum Model 3030 and a Ludlum Model 43-93. The serial number of the Model 3030 is 312331, and the calibration date was 8/27/2015. The Model 3030 was calibrated using a Th-230 source for alpha and a Sr/Y-90 source for beta. The calibration record is on site and available for inspection.

The serial number of the Model 43-93 is PR351860, and it is coupled to a Ludlum Model 2360 ratemeter/scalemeter/data logger, serial number 319919. The two components were calibrated as a unit using a Th-230 source for alpha and a Sr/Y-90 source for beta, with a calibration date of 8/26/2015. The calibration record is on site and available for inspection.

The two calibration sources which Strata will use in the Radiation Protection Program are a Th-230 source for alpha and a Sr/Y-90 source for beta. The two sources are NIST traceable, and the records are on site and available for inspection. Table 1 shows the serial numbers and activity for each calibration source. All numbered tables referenced in this section are attached at the end of the attachment.

Table 2 shows the calculation of the instrument efficiency for the Ludlum Model 3030 and Model 43-93. The instrument efficiency, ε_i, was calculated according to the method outlined in ISO 7503-1 (ISO, 1988), namely that ε_i = (measured counts (cpm) – background counts (cpm)) / source surface emission rate (dpm). The instrument efficiency for the Model 3030 is 64% for beta and 63% for alpha. The instrument efficiency for the Model 43-93 is 36% for alpha and 37% for beta.

The radionuclide mixture weighted counting efficiencies were calculated using the methodology outlined in the draft SER (NRC, 2015a). As Strata does not have a beta calibration source which emits beta particles at energies similar to the lower energy betas emitters (i.e. Th-231 and Th-234), the instrument efficiency for those radionuclides is listed as zero. Table 3 is the calculation for the Ludlum Model 3030 for a mixture of aged yellowcake. The source for the uranium and activity fraction are NRC, 2015b. The source for the energy and branching ratio are from Table 2-2 of DOE, 2009 (low yield radiations are not included). The weighted instrument efficiency for the Model 3030 for aged yellowcake is 15.7% for alpha and 15.3% for beta.

Table 4 is the calculation for the Ludlum Model 43-93 for a mixture of aged yellowcake. The source for the uranium and activity fraction are NRC, 2015b. The source for the energy and branching ratio are from Table 2-2 of DOE, 2009 (low yield radiations are not included). The weighted counting efficiency of the Model 43-93 is 9.0% for alpha and 8.9% for beta.

Table 5 is the calculation for the Ludlum Model 3030 for a mixture of pregnant lixiviant. The source for the activity fractions are NRC, 2015b, LCI, 2015, and Brown, 1982. The sources for the energy and branching ratio are from Table 2-2 of DOE, 2009 and the Health Physics and Radiological Health Handbook (1992) (low yield radiations are not included). The weighted instrument efficiency for the Model 3030 for pregnant lixiviant is 12.6% for alpha and 13.9% for beta.

Table 6 is the calculation for the Ludlum Model 43-93 for a mixture of pregnant lixiviant. The source for the uranium and activity fraction are NRC, 2015b, LCI, 2015, and Brown, 1982. The sources for the energy and branching ratio are from Table 2-2 of DOE, 2009 and the Health Physics and Radiological Health Handbook (1992) (low yield radiations are not included). The weighted counting efficiency of the Model 43-93 for a mixture of pregnant lixiviant is 7.2% for alpha and 8.0% for beta.

The counting efficiencies are summarized in Table C below.

Mixture	Radiation Type	Instrument	Counting Efficiency (%)
Aged Yellowcake	Alpha	3030	15.7
		43-93	9.0
	Beta	3030	15.3
		43-93	8.9
Pregnant Lixiviant	Alpha	3030	12.6
		43-93	7.2
	Beta	3030	13.9
		43-93	8.0

Table C: Summary of Counting Efficiencies

RAI No. 4:

Clarify how the proposed strontium-90 calibration source will be used to determine weighted counting efficiencies for beta-emitting progeny of natural uranium.

Response to RAI No. 4:

As discussed in NRC's October 15th letter (NRC, 2015a) in the "Description" section of RAI No. 4, and in more detail in the draft SER Open Item No. 4, Strata currently only has a Sr/Y-90 source for determining the instruments' efficiency for beta radiation. Strata chose this calibration source as Y-90 has a maximum beta energy of 2.245 MeV, similar to one of the primary radionuclides of concern Pa-234m which has a maximum beta energy of 2.29 MeV. As discussed in RAI No. 3, Strata does not have a calibration source which emits beta radiation in the energy range of the lower energy beta emitters, namely Th-234 and Th-231, and thus the efficiency of the detector for the lower energy beta particles is discounted. This is accounted for by assuming the efficiency is zero when performing the radionuclide mixture weighted efficiency for the instrument. As both the static and scan MDCs for beta radiation are near the regulatory limit of 1,000 dpm/100 cm^2 removable surface contamination and require a long residence time and survey time to be below the limits, Strata will purchase a C-14 calibration source. The addition of the C-14 calibration source is appropriate as it emits lower energy beta particles in the energy range of the beta particles emitted by Th-231 and Th-234. Additionally, C-14 is one of the recommended calibration sources in Table 1 of the ANSI standard N323AB-2013 for beta surface contamination. A brief analysis of the additional efficiency gained by using a C-14 calibration source shows an estimated weighted counting efficiency gain of 3% for the Model 43-93 for the mixture "aged yellowcake" and an estimated weighted counting efficiency gain of 4% for the Model 43-93 for the mixture "pregnant lixiviant".

RAI No. 5:

Quantify the "controlled, slow speed" scan described by Strata in its July 27, 2015 letter, in terms of a minimum residence time of the Ludlum Model 43-93 over a contaminated area.

Response to RAI No. 5:

In order to quantify the "controlled, slow speed" required for surveys for alpha contamination while scanning, Strata calculated the alpha and beta-gamma scan MDC for the counting efficiency of the Model 43-93 for the mixtures of aged yellowcake and pregnant lixiviant. Strata utilized the methodology outlined in the draft SER (NRC, 2015a), namely the use of Equation 6-12 of NUREG-1575 (NRC, 2000). Strata assumed a 90% probability of detecting 1 count. The initially proposed residence time of 7 seconds was not found to be acceptable for beta-gamma surface contamination as the beta-gamma scan MDCs for both major mixtures were above the regulatory limits. The proposed residence time of 14 seconds is acceptable as it is below the regulatory limits for both alpha and beta-gamma surface contamination and because the alpha scan MDC values bound the 500 dpm alpha/ 100 cm2 value for the lower limit of detection specified in Table 3, "Summary of Survey Frequencies," of NRC Regulatory Guide 8.30, "Health Physics Surveys in Uranium Recovery Facilities." (NRC 2002).

Therefore, the minimum residence time will be 14 seconds. The 14 second residence time corresponds to a scan rate of 0.5 cm/s over the smallest dimension of the detector (the approximate width of 7 cm).

Therefore, the scan rate of 0.5 cm/s will be incorporated into the appropriate procedures, and personnel at the facility will be trained to conduct the surveys at the specified scan rate.

RAI No. 6:
Demonstrate that static surveys for beta contamination will reach an MDC lower than Strata's proposed action level of 75% of the regulatory limit (or 750 dpm per 100 cm2).

Response to RAI No. 6:
Strata calculated the static MDC for the Ludlum Model 3030 and Model 43-93 in the response to RAI No. 2. The static MDC for the Ludlum Model 3030 is below the proposed internal limit for both alpha and beta contamination, and thus Strata proposes that the internal limit of 750 dpm/100 cm^2 remain for removable contamination surveys.

However, the static MDC for a one minute survey count time for the Ludlum Model 43-93 for beta contamination was found to be 1045 dpm/100 cm^2 for "pregnant lixiviant" and 939 dpm/100 cm^2 for "aged yellowcake". As these static MDCs are not acceptable, Strata conducted an additional calculation of static MDCs, but with a 1.5 minute survey count time. The additional survey count time yielded static beta MDCs of 848 dpm/100 cm^2 ("pregnant lixiviant") and 762 dpm/100 cm^2 ("aged yellowcake"). These MDCs are still not desirable, as they are close to the regulatory limit of 1,000 dpm/100 cm^2 for removable surface contamination, however due to operational logistics Strata has determined that the benefit of a lower static MDC for beta contamination is not worth the cost of requiring personnel to conduct a 2 minute survey count time. Additionally, Strata will purchase a C-14 calibration source which will greatly improve the weighted counting efficiency of the Model 43-93 and will lower the static MDC for beta contamination.

Thus Strata proposes a revised internal limit of 900 dpm/100 cm^2 during an interim period. Although the static MDC for alpha contamination is well below the revised internal limit, Strata proposes that the revised internal limit be for both alpha and beta-gamma surface contamination. Although Strata could potentially hold two separate internal limits, one for contamination due to alpha radiation and one for beta radiation, Strata requests that one internal limit be used for both alpha and beta radiation due to operational logistics. Namely, if Strata were to apply separate limits, it would require personnel at the site to perform two separate surveys, one for alpha radiation and one for beta radiation.

Strata believes the revised internal limit is sufficient as it is below the regulatory limit and will only be utilized during an interim period. Once the C-14 calibration source is received and Strata is able to conduct an analysis of the site specific radionuclide composition of the "pregnant lixiviant", Strata will recalculate the static MDCs for both alpha and beta contamination and will propose a revised, more restrictive internal limit. Strata commits to obtaining receipt of the calibration source, performing the analysis of the "pregnant lixiviant", and subsequently revising the internal limit within 3 months of the beginning of operations at the Ross Project.

References

1. American National Standards Institute (ANSI). 2013. ANSI N323AB–2013, "Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments." ANSI: New York, New York, 2013.

2. Brown, S. 1982. Radiological Aspects of Uranium Solution Mining. Uranium, 1, pp 37-52, Elsevier.

3. Cember, H and Johnson, T. 2009. Introduction to Health Physics, Fourth Edition, McGraw-Hill Companies, Inc., 2009.

4. DOE (U.S. Department of Energy). 2009. DOE-STD-1136-2009, "Guide of Good Practices for Occupational Radiological Protection in Uranium Facilities," July 2009, http://energy.gov/sites/prod/files/2013/06/f1/doe-std-1136-2009.pdf, accessed August 27, 2015.

5. ISO (International Organization for Standardization). 1988. ISO–7503–1, "Evaluation of Surface Contamination – Part 1: Beta Emitters and Alpha Emitters (first edition)." ISO: Geneva, Switzerland. 1988.

6. LCI (Lost Creek ISR, LLC). 2015. Letter from J. Cash, LCI to J. Saxton, NRC RE: Reply to NRC's November 3, 2014 Letter Regarding License Condition 12.10 Lost Creek ISR Project License SUA-1598, Docket 040-09068, TAC J00717. ADAMS Accession No. ML15029A423.

7. NRC (U.S. Nuclear Regulatory Commission). 1998. NUREG-1507, "Minimum Detectable Concentrations With Typical Radiation Survey Instruments for Various Contaminants and Field Conditions," June 1998.

8. NRC (U.S. Nuclear Regulatory Commission). 2000. Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM). NUREG-1575, Washington, DC: NRC, Office of Nuclear Regulatory Research. Accession No. ML003761476.

9. NRC (U.S. Nuclear Regulatory Commission). 2002. Regulatory Guide 8.30, Revision 1, "Health Physics Surveys in Uranium Recovery Facilities." Washington, DC., ADAMS Accession No. ML021260524.

10. NRC (U.S. Nuclear Regulatory Commission). 2015a. REQUEST FOR ADDITIONAL INFORMATION ON SUBMITTAL REGARDING LICENSE CONDITION 12.8, ROSS ISR PROJECT, CROOK COUNTY, WY, SOURCE MATERIAL LICENSE SUA-1601, DOCKET NO. 040-09091, TAC J00735.

11. NRC (U.S. Nuclear Regulatory Commission). 2015b. NRC Glossary, definition of natural uranium, http://www.nrc.gov/reading-rm/basic-ref/glossary/natural-uranium.html, accessed May 21, 2015.

Source Isotope	Source ID	Source Activity (dpm)	Source Surface Emission (dpm)
Th-230	0514-01	15420	7710
Sr/Y-90	081590-01	41300	20650

Table 1: Calibration Sources

Ludlum Model 43-93

	Alpha	Beta
Background Count #	Background Counts (cpm)	
1	1	414
2	2	353
3	1	339
4	0	353
5	0	372
Average	0.8	366.2
Count #	Counts (cpm)	
1	2736	8130
2	2667	7962
3	2815	8028
4	2736	8039
5	2760	8158
Average	2742.8	8063.4
Net counts (cpm)	2742	7697.2
Source Surface Emission (dpm)	7710	20650
Instrument Efficiency	0.36	0.37

Ludlum Model 3030

	Alpha	Beta
Background Count #	Background Counts (cpm)	
1	0	45
2	0	42
3	0	34
4	0	45
5	0	46
Average	0	42.4
Count #	Counts (cpm)	
1	4927	13239
2	4860	13239
3	4807	13239
4	4796	13239
5	4907	13239
Average	4859.4	13239
Net counts (cpm)	4859.4	13196.6
Source Surface Emission (dpm)	7710	20650
Instrument Efficiency	0.63	0.64

Table 2: Calculation of the Instrument Efficiency, ε_i

Isotope	Energy (MeV)	Uranium Fraction	Branching Ratio	Instrument Efficiency	Surface Efficiency	Weighted Efficiency
U-238	4.15	0.485	0.21	0.63	0.25	0.0160
U-238	4.20	0.485	0.79	0.63	0.25	0.0603
U-234	4.72	0.493	0.28	0.63	0.25	0.0217
U-234	4.77	0.493	0.72	0.63	0.25	0.0559
U-235	4.21	0.022	0.06	0.63	0.25	0.0002
U-235	4.37	0.022	0.17	0.63	0.25	0.0006
U-235	4.40	0.022	0.55	0.63	0.25	0.0019
U-235	4.60	0.022	0.05	0.63	0.25	0.0002

Alpha Counting Efficiency =	0.157

Isotope	Energy (keV)	Activity Fraction	Branching Ratio	Instrument Efficiency	Surface Efficiency	Weighted Efficiency
Th-234	103	0.489	0.21	0	0	0.0000
Th-234	193	0.489	0.79	0	0.25	0.0000
Pa-234m	2290	0.489	0.98	0.64	0.5	0.1534
Th-231	206	0.022	0.13	0	0.25	0.0000
Th-231	287	0.022	0.12	0	0.25	0.0000
Th-231	288	0.022	0.37	0	0.25	0.0000
Th-231	305	0.022	0.35	0	0.25	0.0000

Beta Counting Efficiency =	0.153

Table 3: Mixture Weighted Counting Efficiency, Model 3030, Aged Yellowcake

Isotope	Energy (MeV)	Uranium Fraction	Branching Ratio	Instrument Efficiency	Surface Efficiency	Weighted Efficiency
U-238	4.15	0.485	0.21	0.36	0.25	0.0092
U-238	4.20	0.485	0.79	0.36	0.25	0.0345
U-234	4.72	0.493	0.28	0.36	0.25	0.0124
U-234	4.77	0.493	0.72	0.36	0.25	0.0319
U-235	4.21	0.022	0.06	0.36	0.25	0.0001
U-235	4.37	0.022	0.17	0.36	0.25	0.0003
U-235	4.40	0.022	0.55	0.36	0.25	0.0011
U-235	4.60	0.022	0.05	0.36	0.25	0.0001

Alpha Counting Efficiency =	0.090

Isotope	Energy (keV)	Activity Fraction	Branching Ratio	Instrument Efficiency	Surface Efficiency	Weighted Efficiency
Th-234	103	0.489	0.21	0	0	0.0000
Th-234	193	0.489	0.79	0	0.25	0.0000
Pa-234m	2290	0.489	0.98	0.37	0.5	0.0887
Th-231	206	0.022	0.13	0	0.25	0.0000
Th-231	287	0.022	0.12	0	0.25	0.0000
Th-231	288	0.022	0.37	0	0.25	0.0000
Th-231	305	0.022	0.35	0	0.25	0.0000

Beta Counting Efficiency =	0.089

Table 4: Mixture Weighted Counting Efficiency, Model 43-93, Aged Yellowcake

Isotope	Energy (MeV)	Activity Fraction	Branching Ratio	Instrument Efficiency	Surface Efficiency	Weighted Efficiency
U-238	4.15	0.391	0.21	0.63	0.25	0.0129
U-238	4.20	0.391	0.79	0.63	0.25	0.0487
U-234	4.72	0.396	0.28	0.63	0.25	0.0175
U-234	4.77	0.396	0.72	0.63	0.25	0.0449
U-235	4.21	0.018	0.06	0.63	0.25	0.0002
U-235	4.37	0.018	0.17	0.63	0.25	0.0005
U-235	4.40	0.018	0.55	0.63	0.25	0.0016
U-235	4.60	0.018	0.05	0.63	0.25	0.0001
Th-230	4.62	0.075	0.24	0.63	0.25	0.0028
Th-230	4.68	0.075	0.76	0.63	0.25	0.0090
Ra-226	4.60	0.121	0.06	0.63	0.25	0.0011
Ra-226	4.78	0.121	0.95	0.63	0.25	0.0181

Alpha Counting Efficiency =	0.126

Isotope	Energy (keV)	Activity Fraction	Branching Ratio	Instrument Efficiency	Surface Efficiency	Weighted Efficiency
Th-234	103	0.443	0.21	0	0	0.0000
Th-234	193	0.443	0.79	0	0.25	0.0000
Pa-234m	2290	0.443	0.98	0.64	0.5	0.1389
Th-231	206	0.115	0.13	0	0.25	0.0000
Th-231	287	0.115	0.12	0	0.25	0.0000
Th-231	288	0.115	0.37	0	0.25	0.0000
Th-231	305	0.115	0.35	0	0.25	0.0000

Beta Counting Efficiency =	0.139

Table 5: Mixture Weighted Counting Efficiency, Model 3030, Pregnant Lixiviant

Isotope	Energy (MeV)	Uranium Fraction	Branching Ratio	Instrument Efficiency	Surface Efficiency	Weighted Efficiency
U-238	4.15	0.391	0.21	0.36	0.25	0.0074
U-238	4.20	0.391	0.79	0.36	0.25	0.0278
U-234	4.72	0.396	0.28	0.36	0.25	0.0100
U-234	4.77	0.396	0.72	0.36	0.25	0.0257
U-235	4.21	0.018	0.06	0.36	0.25	0.0001
U-235	4.37	0.018	0.17	0.36	0.25	0.0003
U-235	4.40	0.018	0.55	0.36	0.25	0.0009
U-235	4.60	0.018	0.05	0.36	0.25	0.0001
Th-230	4.62	0.075	0.24	0.36	0.25	0.0016
Th-230	4.68	0.075	0.76	0.36	0.25	0.0051
Ra-226	4.60	0.121	0.06	0.36	0.25	0.0007
Ra-226	4.78	0.121	0.95	0.36	0.25	0.0103

Alpha Counting Efficiency =	0.072

Isotope	Energy (keV)	Activity Fraction	Branching Ratio	Instrument Efficiency	Surface Efficiency	Weighted Efficiency
Th-234	103	0.443	0.21	0	0	0.0000
Th-234	193	0.443	0.79	0	0.25	0.0000
Pa-234m	2290	0.443	0.98	0.37	0.5	0.0803
Th-231	206	0.115	0.13	0	0.25	0.0000
Th-231	287	0.115	0.12	0	0.25	0.0000
Th-231	288	0.115	0.37	0	0.25	0.0000
Th-231	305	0.115	0.35	0	0.25	0.0000

Beta Counting Efficiency =	0.080

Table 6: Mixture Weighted Counting Efficiency, Model 43-93, Pregnant Lixiviant

Mixture	Radiation Type	Instrument	static MDC (dpm/100 cm^2) (tg = 1 min)	static MDC (dpm/100 cm^2) (tg = 1.5 min)
Aged Yellowcake	Alpha	3030	103	80
		43-93	85	64
	Beta	3030	466	374
		43-93	939	762
Pregnant Lixiviant	Alpha	3030	129	100
		43-93	106	81
	Beta	3030	520	418
		43-93	1045	848

Table 7: Static MDC for a survey count time of 1 min and 1.5 min

Attachment 2

REVISED BETA-GAMMA CONTAMINATION CONTROL PROGRAM

Note: The revisions to the originally proposed beta-gamma contamination control program have been bolded in the text.

A contamination control program is outlined in Strata's Technical Report (TR) Section 5.7.6. The following information is meant to supplement the commitments set forth in Strata's TR Section 5.7.6. Strata will utilize the technique of slowly scanning personnel, equipment, or material until an elevated reading is observed, and then the user will hold the detector over the area in question for a static sampling. Thus the decision to determine if the frisk is within compliance with contamination limits will be determined by use of the static measurement.

Surveys for Surface Contamination in Restricted Areas

A program for surveying for surface contamination in restricted areas from beta radiation is already described in the TR. No further clarification or additional commitments are needed.

General Plant and Unrestricted Areas

In accordance with the TR Section 5.7.6.1.2, weekly spot-checks by the RSO or RST for removable surface contamination using filter paper smear tests will be conducted. The smear tests will now also include analysis for beta contamination. The smear tests will be analyzed using a Ludlum Model 3030 sample counter, or equivalent instrumentation. Consistent with the TR Section 5.7.6.1.2, contamination levels for alpha or beta exceeding the applicable values will be cause for immediate cleaning by trained radiation workers.

Special Surveys during Maintenance Activities

In accordance with the TR Section 5.7.6.1.3, contamination surveys may be conducted before, during, or after non-routine work. These surveys will be conducted at the discretion of the RSO, and will generally be specified in an operating procedure related to the task or in the Radiation Work Permit issued for the task. Contamination surveys will be performed using the Ludlum Model 2360 and Ludlum Model 43-93 instruments, or equivalent instrumentation. Both alpha and beta-gamma contamination will be surveyed for and appropriately documented.

Contamination Surveys for Personnel leaving Restricted Areas

Personnel who are exiting a restricted area are required to perform a contamination survey to ensure contamination control. The requirements for when personnel need to perform the survey and the procedure for performing the survey are outlined in the TR Section 5.7.6.2. A formal procedure is also included in the Radiation Protection Program. Additional to the requirements set forth in the TR Section 5.7.6.2, personnel must perform a survey using instrumentation which is capable of detecting potential beta-gamma contamination. Thus the survey will be accomplished using a Ludlum Model 2360 ratemeter/scalemeter/data logger coupled to a Ludlum Model 43-93 probe, or equivalent survey instrumentation, as this instrumentation allows for the detection of alpha and beta contamination. The action limits and applicable regulatory limits are provided in the section below titled "Applicable Limits".

Contamination Surveys for Equipment or Material

A Ludlum Model 2360 ratemeter/scalemeter/data logger with a Ludlum Model 43-93 alpha/beta probe and a Ludlum Model 19 or Ludlum Model 9-3, or equivalent survey instrumentation, will be utilized for contamination surveys of equipment or materials which are to be released to unrestricted areas. The procedure for contamination surveys for equipment or materials is outlined in the TR Section 5.7.6.3.1, and a formal procedure is set forth in the Radiation Protection Program. The action limits and applicable regulatory limits are provided in the section below titled "Applicable Limits".

Applicable Limits

The applicable regulatory limits for alpha and beta-gamma contamination on personnel exiting a restricted area, or for the release of equipment or material for unrestricted use, will be those limits set forth in NRC's FC 83-23, Enclosure 2, Table 1. Per the discussion in the TR Sections 5.7.6.3.2 and 5.7.6.2.1, the limits to be used for beta-gamma contamination in relation to U-Nat, U-235, U-238, and associated decay products are identical to those for alpha contamination as outlined in NRC's Regulatory Guide 8.30 Table 2. **The additional stipulation outlined in footnote "f" of Table 1 of Enclosure 2 to NRC's FC 83-23 does not require additional surveying (See "Response to RAI No. 1" included in Attachment 1 of this submittal).**

The internal action level for alpha contamination levels for personnel exiting a restricted area is outlined in the TR Section 5.7.6.2. This internal action level will now apply to alpha and beta-gamma contamination levels. The goal is no personal contamination above background levels. The TR Section 5.7.6.2 states that a typical alarm setting for personnel exiting a restricted area would be 20 cpm above background. Thus an internal limit of 20 cpm above background will initially be used. The internal limit may be changed at the RSOs' discretion. Any contamination on personnel exiting a restricted area is considered removable, and thus the 1,000 dpm/ **100** cm^2 limit applies. The exception to the 1,000 dpm/ **100** cm^2limit as discussed in NRC's Regulatory Guide 8.30 is the soles of the shoes, which has a limit of 5,000 dpm/ **100** cm^2. Detailed procedures for removal of contamination should levels be elevated above the action level are provided in the TR Section 5.7.6.2.1. The inclusion of surveying for beta-gamma contamination will not change the procedures outlined in the TR Section 5.7.6.2.1.

The internal action level for release of equipment and materials for unrestricted use will **initially be 90% of the regulatory limits** to ensure that released equipment or materials will not exceed the applicable limits. **The internal action level will be modified within 3 months of the beginning of operations (See "Response to RAI No. 6" included in Attachment 1 of this submittal).**

Attachment 3

REVISED "INSTRUMENT SPECIFICATIONS AND ADDITIONAL CONSIDERATIONS"

Note: The revisions to the originally submitted "Attachment 2" to Strata's July 27, 2015 letter are denoted by being bolded. Much of the analysis presented in the original submittal has been re-evaluated in the current submittal and thus has been removed.

Instrumentation Specifications

Any potential contamination from radionuclides emitting gamma radiation will be detected using a Ludlum Model 19 or Ludlum Model 9-3, or equivalent instrumentation. The Model 19 is a highly sensitive uR meter, while the Model 9-3 is an air ionization chamber for areas with elevated gamma radiation. The Model 19 has a measuring range of background to 5mR/hr. The Model 9-3 has the ability to perform beta-gamma dose rate measurements from background to 50 R/hr. The Model 9-3 also has a 1,000 mg/cm^2 retractable beta shield which will allow for beta measurement with a 7 mg/cm^2 shield. Per the manufacturer's specification, the Model 9-3 and Model 19 have readings within 10% of true value.

Any potential removable contamination will be detected using a Ludlum Model 3030, or equivalent instrumentation. The Model 3030 is a sample counter capable of detecting both alpha and beta radiation. The Model 3030 consists of a detector of ZnS(Ag) adhered to plastic scintillation material. The window is 0.4 mg/cm^2 aluminized mylar with an active and open area of 20.3 cm^2. The sample holder is capable of holding a sample with up to a 5.1 cm diameter. The efficiency (4pi) of the detector for alpha is listed as 32% for Th-230, 39% for U-238, and 37% for Pu-239. The efficiency (4pi) of the detector for beta is listed as 8% for C-14, 27% for Tc-99, 29% for Cs-137, and 26% for Sr/Y-90. The background is 3cpm or less for alpha, and typically 50 cpm or less for beta (in a 10 uR/hr field).

Any potential contamination from radionuclides emitting alpha and/or beta radiation will be detected using a Ludlum Model 2360 ratemeter/scalemeter/data logger coupled with a Ludlum Model 43-93 alpha/beta probe, or equivalent instrumentation. The Model 43-93 probe is a ZnS(Ag) adhered to 0.0254 cm thick plastic scintillation material. The efficiency of the probe is 20% of Pu-239, 15% of Tc-99, and 20% of Sr/Y-90. The window is 1.2 mg/cm^2 metalized polyester. The background is rated as 3 cpm or less for alpha, and 300 cpm or less for beta.

Additional Considerations

As stated in the **Revised** Beta-Gamma Contamination Control Survey Program, the static sample will be the determinant in deciding if the contamination is above applicable limits. However, proper scanning techniques emphasizing the need for **a 0.5 cm/s scan rate** while scanning will be addressed during radiation training and in the appropriate operating procedures.

The counting time for static sampling will **initially be 1.5 minutes** to ensure adequate detection time, and the counting time will be stipulated in the appropriate operating procedures. **The counting time will**

potentially be revised within three months of operations once additional information and equipment is obtained (See "Response to RAI No. 6" in Attachment 1 of this submittal). The use of a scalemeter as opposed to a ratemeter will be beneficial in ensuring the **1.5** minute sample count time is utilized. The instrument additionally has an alarm feature, which will aid in alerting scanning personnel that the contamination levels are above prescribed limits.

Additionally, Strata will utilize the recommendations set forth in NUREG-1507 to ensure that a scan of the personnel, equipment, or material is performed to maximize the instrument's ability to detect the radioactive contamination.

Specifically, as prescribed in NUREG-1507 Section 4.1, Strata has purchased radionuclide sources for calibration of instruments which emit radiation at energies most closely resembling those encountered at UR facilities. Strata has purchased a Th-230 source for calibration for alpha radiation, and a Sr-90 source for calibration for beta radiation. **Strata will additionally purchase a C-14 source for calibration for lower energy beta radiation.**

As well, Strata's procedures for personnel, equipment, or material scanning of potential contamination state that the probe face should be held $1/8^{th}$ of an inch (0.3125 cm) from the material being scanned. This ensures that the probe is far enough away from the material that the probe face will not get contaminated, while also ensuring that the probe is able to detect the maximum amount of contamination potentially present. This is consistent with the data displayed in NUREG-1507, Table 4.4 and Table 4.5. Although the tables were populated using a gas proportional detector as opposed to the proposed ZnS detector, the overarching principle is still illustrated, namely improved detection efficiency if the detector is closer to the source.