October 15, 2015

Mr. Michael Griffin
Vice President of Permitting, Regulatory
and Environmental Compliance
Strata Energy, Inc.
PO Box 2318
Gillette, WY 82717-2318

SUBJECT: 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

Dear Mr. Griffin:

By letter dated July 27, 2015, Strata Energy, Inc. (Strata) submitted a license amendment request that addresses license condition (LC) 12.8 of its Materials License SUA-1601.

The NRC staff has completed its technical review of the information and provides the enclosed requests for additional information (RAIs). A draft safety evaluation report (SER), which includes open items that correspond to each RAI, is also enclosed. The purpose of enclosing the draft SER with the RAIs in this case is to provide additional clarity and context for the NRC staff's requests. Upon receipt of Strata's reply, the staff will continue its evaluation and notify Strata in writing of its results.

In accordance with 10 CFR 2.390 of the NRC's "Agency Rules of Practice and Procedure" a copy of this letter will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html.

If you have any questions regarding this action, please contact me at 301-415-0697 or by e-mail at John.Saxton@nrc.gov.

Sincerely,

/RA/

John Saxton, Hydrogeologist
Uranium Recovery Licensing Branch
Division of Decommissioning, Uranium Recovery
and Waste Programs
Office of Nuclear Material Safety
and Safeguards

Docket No.: 040-09091
License No.: SUA-1601

Enclosures:
1. Requests for Additional Information on Strata's July 27, 2015, License Amendment Request
2. Draft Safety Evaluation with Open Items

cc: D. Schellinger WDEQ

If you have any questions regarding this action, please contact me at 301-415-0697 or by e-mail at John.Saxton@nrc.gov.

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NAME	DBrown	RBurrows (e-mail)	JSaxton	SAchten	BVonTill	JSaxton
DATE	10/6/15	10/13/15	10/14/15	10/14/15	10/15/15	10/15/15

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Requests for Additional Information (RAI)
Strata Energy, Inc. (Strata) Ross In Situ Recovery (ISR) Project
Request for License Amendment to Remove License Condition 12.8

Request for Additional Information (RAI) No. 1 (Draft SER Open Item 1)

Request
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).

Regulatory Basis
LC 12.8 of Materials License SUA-1601 (NRC 2014) states:

> Prior to the preoperational inspection, the licensee shall develop a survey program that will meet the requirements of 10 CFR Part 20, Subpart F to detect beta-gamma contamination on personnel exiting restricted areas and to detect beta-gamma contamination in unrestricted and restricted areas. The licensee shall provide, for NRC staff review and approval, the surface contamination detection capability (scan MDC) of the radiation survey meters used in surveys for releasing equipment and materials to unrestricted use or personnel contamination. In the scanning mode, the detection capability for any expected alpha and beta radiation shall be provided in terms of dpm per 100 cm^2.

Description
In Attachment 3 to its July 27, 2015 letter, Strata stated that it would use a Ludlum Model 19 or Ludlum Model 9-3 to detect potential contamination from radionuclides emitting gamma radiation. In Attachment 4 of its July 27, 2015 letter, Strata stated that contamination surveys for equipment and material which are to be released to unrestricted areas will be performed with the 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. Strata also stated that its applicable limits for beta-gamma contamination include the additional stipulation in footnote "f" of Table 1 of Enclosure 2 to NRC's FC 83-23 (NRC 1993). The release limits in footnote "f" 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 centimeter (cm), and a maximum radiation level associated with surface contamination resulting from beta-gamma emitters of 1.0 mrad/hr at 1 cm.

The Ludlum Model 19 is a sodium iodide detector that is not designed to detect for beta contamination. Therefore, its use is not appropriate to detect average radiation levels associated with surface contamination resulting from beta-gamma emitters. The Ludlum Model 9-3 is an ion chamber with a retractable beta shield, which is designed to detect beta-emitting contamination. However, the Model 9-3 has a lower limit of detection of 0.2 milliRoentgen per hour (mR/hr), which is not below the release limit in footnote "f" of NRC's FC 83-23 for average radiation levels associated with surface contamination resulting from beta-gamma emitters of 0.2 mrad/hr at 1 cm. Therefore, Strata should identify an instrument with lower limits of detection below the limits in footnote "f" of NRC's FC 83-23 for average radiation levels associated with surface contamination resulting from beta-gamma emitters.

Request for Additional Information (RAI) No. 2 (Draft SER Open Item 2)

Request
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 (cm^2), in accordance with license condition (LC) 12.8.

Regulatory Basis
LC 12.8 of Materials License SUA-1601 (NRC 2014) states:

> Prior to the preoperational inspection, the licensee shall develop a survey program that will meet the requirements of 10 CFR Part 20, Subpart F to detect beta-gamma contamination on personnel exiting restricted areas and to detect beta-gamma contamination in unrestricted and restricted areas. The licensee shall provide, for NRC staff review and approval, the surface contamination detection capability (scan MDC) of the radiation survey meters used in surveys for releasing equipment and materials to unrestricted use or personnel contamination. In the scanning mode, the detection capability for any expected alpha and beta radiation shall be provided in terms of dpm per 100 cm^2.

Description
In its July 27, 2015 letter (Strata 2015), Strata failed to describe, in terms of disintegrations per minute (dpm) per 100 square centimeters (cm^2) in accordance with license condition (LC) 12.8, the methodology it would use to determine the detection capability for any expected alpha and beta contamination. Instead, in its letter, Strata committed to "re"calculate the detection capabilities, using data obtained while in operation, within six (6) months of the start of operations to verify that the radiation detection instrumentation is adequate. Strata's request to postpone meeting the requirements of LC 12.8 until after it begins operations at the Ross ISR Project is not acceptable. Furthermore, in lieu of providing the information required by LC 12.8, in Attachment 3 of its July 27, 2015, letter, Strata cited two examples of contamination control programs proposed by other ISR facilities, including the Lost Creek Project amendment request dated July 12, 2013 (LCI 2013), and a Nichols Ranch ISR Project submittal dated February 18, 2014 (Uranerz 2014). NRC has not approved the Lost Creek Project request, but has approved the Nichols Ranch submittal.

The information provided by Strata regarding the Nichols Ranch ISR Project program is inconsistent with Strata's program in two regards. First, citing the Nichols Ranch ISR Project submittal, Strata described a maximum allowable background count rate detected by the Ludlum Model 43-93 to reach a minimum detectable concentration of 900 dpm beta per 100 cm^2. However, the action level Strata committed to in Attachment 4 to its July 27, 2015, letter is 75% of the regulatory limit, or 750 dpm per 100 cm^2. Therefore, the information regarding the Nichols Ranch ISR Project is insufficient to show that Strata's detection capabilities will be below its proposed action level limits. Second, Strata also stated that the Nichols Ranch ISR Project count time for surveys is 30 seconds, whereas Strata committed in its July 27, 2015, letter, to a static count time of 1 minute. As a result, Strata should describe the detection capability for alpha and beta radiation for its proposed instruments and using assumptions consistent with its own contamination control program. In accordance with LC 12.8, the detection capability shall be provided in terms of dpm per 100 cm^2.

RAI No. 3 (Draft SER Open Item 3)

Request
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.

Regulatory Basis
The regulatory basis for RAI No. 3 is the same as RAI No. 1. Also, as noted in acceptance criterion 5.7.6.3(4) of NUREG-1569 (NRC 2003), applicants must adequately describe monitoring equipment by type, specification of the range, sensitivity, calibration methods and frequency, availability, and planned use. The application must demonstrate that the ranges of sensitivity for monitoring equipment will be appropriate to expected facility operation.

Description
In its July 27, 2015, letter, Strata did not describe counting efficiencies in accordance with NRC guidance and industry standards. NRC guidance in NUREG-1507 describes an acceptable approach for determining counting efficiencies, including the ISO 7503-1 approach for determining source efficiencies. An acceptable approach to determine counting efficiencies for mixtures of radionuclides, or weighted counting efficiencies, is provided in NUREG-1575. In addition, Strata has not provided adequate justification for why natural uranium and its short-lived progeny would be the only contaminants encountered at the Ross ISR Project.

RAI No. 4 (Draft SER Open Item 4)

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

Regulatory Basis
The regulatory basis for RAI No. 4 is the same as RAI No. 1. Also, as noted in acceptance criterion 5.7.6.3(4) of NUREG-1569 (NRC 2003), applicants must adequately describe monitoring equipment by type, specification of the range, sensitivity, calibration methods and frequency, availability, and planned use. The application must demonstrate that the ranges of sensitivity for monitoring equipment will be appropriate to expected facility operation.

Description
In its July 27, 2015, letter, Strata explained that it would use a high-energy beta-emitter (strontium-90) to calibrate the Ludlum Model 3030 and Model 43-93 instruments (Strata 2015). The NRC staff previously recommended that calibration sources should be selected that emit alpha or beta radiation with energies similar to those expected of the contaminant in the field (NRC 1998). In addition, the most representative calibration source would be one prepared from the radioactive material being assessed in the field (NRC 1998). ISO-8769, "Reference Sources for the Calibration of Surface Contamination Monitors," provides recommendations on calibration source characteristics (ISO 1988).

A strontium-90 calibration source is not appropriate for calibrating the Ludlum 43-93 for detection of beta particles with lower maximum emission energies than that of protactinium-234m, such as the beta particles from decay of thorium-234 and thorium-231. Therefore, unless Strata uses either an alternative calibration source or an appropriate additional source (e.g., carbon-14 with a maximum beta energy of 156 keV) to calibrate the Ludlum 43-93 at those energies, it should not credit the instrument's response to those energies when estimating minimum detectable concentrations and surface contamination levels. Not crediting the instrument's response to lower energy beta particles has the effect of discounting the efficiency of the detector.

RAI No. 5 (Draft SER Open Item 5)

Request
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

Regulatory Basis
The regulatory basis for RAI No. 5 is the same as RAI No. 1. Also, as noted in acceptance criterion 5.7.6.3(4) of NUREG-1569 (NRC 2003), applicants must adequately describe monitoring equipment by type, specification of the range, sensitivity, calibration methods and frequency, availability, and planned use. The application must demonstrate that the ranges of sensitivity for monitoring equipment will be appropriate to expected facility operation.

Description
The residence time of the proposed Ludlum 43-93 over a contaminated area is an important factor in determining scan MDCs for both alpha and beta contamination. One approach that would be acceptable to NRC is to calculate a residence time used in MDC equations by dividing the shortest dimension of the detector used to perform the scan (e.g., approximately 7 cm for the Ludlum Model 43-93 proposed by Strata) by a scan rate controlled by training and operating procedures (e.g., 1 centimeter per second).

RAI No. 6 (Draft SER Open Item 6)

Request
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 cm^2).

Regulatory Basis
The regulatory basis for RAI No. 6 is the same as RAI No. 1. Also, as noted in acceptance criterion 5.7.6.3(4) of NUREG-1569 (NRC 2003), applicants must adequately describe monitoring equipment by type, specification of the range, sensitivity, calibration methods and frequency, availability, and planned use. The application must demonstrate that the ranges of sensitivity for monitoring equipment will be appropriate to expected facility operation.

Description
In its July 27, 2015, letter, Strata stated that it would use a strontium-90 calibration source, a static survey residence time of one minute, and that the Ludlum 43-93 background count rate would be about 300 counts per minute (cpm) (Strata 2015). In one example, NRC staff estimated the Ludlum Model 43-93 weighted counting efficiency for natural uranium in aged

yellowcake using a strontium-90 calibration source as 9.6%. The staff's estimate of the detection capability (MDC) is about 900 dpm per 100 cm^2, which is higher than Strata's proposed action level of 75% of the regulatory limit (or 750 dpm per 100 cm^2).

References

ISO (International Organization for Standardization). 1988. ISO-8769, "Reference Sources for the Calibration of Surface Contamination Monitors." ISO: Geneva, Switzerland. 1988.

LCI (Lost Creek ISR, LLC). 2013. Letter from J. Cash, LCI to J. Saxton, NRC RE: Lost Creek Project, NRC License SUA-1598, Docket No. 40-9068, Amendment Request to Remove License Conditions 12.10, 12.11 and 12.12. ADAMS Accession No. ML13282A381.

NRC (U.S. Nuclear Regulatory Commission). 1993. "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material," U.S. Nuclear Regulatory Commission, April 1993, ADAMS accession No. ML003745526.

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.

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.

NRC (U.S. Nuclear Regulatory Commission). 2003. NUREG-1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications." ADAMS Accession No. ML032250177.

NRC (U.S. Nuclear Regulatory Commission). 2006. NUREG-1757, Volume 2, Revision 1, "Consolidated Decommissioning Guidance: Characterization, Survey, and Determination of Radiological Criteria," September 2006.

NRC (U.S. Nuclear Regulatory Commission). 2014. Materials License No. SUA-1601, Washington, DC. ADAMS Accession No. ML14069A335.

NRC (U.S. Nuclear Regulatory Commission). 2015a. Letter from NRC to Mr. M. Griffin, Strata Energy, Inc., Re: Staff's Comments and Request for Additional Information on Submittals Regarding License Conditions 12.6, 12.7, and 12.8, Ross ISR Project, Crook County, WY, Source Material License SUA-1601, Docket No. 040-09091, TAC J00735, dated July 23, 2015. ADAMS Accession No. ML15190A156.

Uranerz (Uranerz Energy Corporation). 2014. Letter from M. Thomas, Uranerz to R. Linton, NRC, RE: Uranerz Energy Corporation, Nichols Ranch Project, Source Materials License SUA-1597, Docket No. 040-09067, Pre-operational License Condition 12.9, email correspondence only, dated March 4, 2014. ADAMS Accession No. ML14064A0128.

Draft Safety Evaluation for Strata Energy, Inc., Request for License Amendment to Remove Preoperational License Condition 12.8 from Materials License SUA-1601; Docket No. 040-09091

This is a U.S. Nuclear Regulatory Commission (NRC) staff draft safety evaluation with open items for a March 1, 2015, request by Strata Energy, Inc. (Strata) to remove pre-operational license condition 12.8 from NRC Materials License SUA-1601 (Strata 2015a).

<u>Background</u>

In Section 5.7.6.2.1 of its 2011 Technical Report (TR), Strata stated, with regard to personnel contamination, "Since any beta-gamma contamination at an ISR [in-situ recovery] (or uranium mill) must be associated with alpha emitting nuclides, no special monitoring or survey for beta-gamma emitters are required." (Strata 2011). In Section 5.7.6.3.1.1 of the NRC staff's January 2014 safety evaluation report (SER), NRC staff stated that Strata's description of personnel contamination surveys is acceptable to the staff, except with respect to beta-gamma contamination surveys (NRC 2014b). The NRC staff made a similar finding in Section 5.7.6.3.1.2 of its SER that the plant contamination survey program does not address the potential for beta-gamma contamination. As a result of these deficiencies, NRC staff included pre-operational license condition (LC) 12.8 requiring Strata to develop, prior to the NRC pre-operational inspection, a survey program for beta-gamma contamination for personnel contamination from restricted areas and plant area contamination that will meet the requirements of 10 CFR Part 20, Subpart F.

LC 12.8 of Materials License SUA-1601 (NRC 2014a) states:

> Prior to the preoperational inspection, the licensee shall develop a survey program that will meet the requirements of 10 CFR Part 20, Subpart F to detect beta-gamma contamination on personnel exiting restricted areas and to detect beta-gamma contamination in unrestricted and restricted areas. The licensee shall provide, for NRC staff review and approval, the surface contamination detection capability (scan MDC) of the radiation survey meters used in surveys for releasing equipment and materials to unrestricted use or personnel contamination. In the scanning mode, the detection capability for any expected alpha and beta radiation shall be provided in terms of dpm per 100 cm^2.

In Attachment 2 to its March 1, 2015, letter, Strata provided information in response to LC 12.8 (Strata 2015a). Specifically, in Section 4.0, "License Condition 12.8," of its March 1, 2015, letter, Strata described its approach and commitments as described in Section 5.7 of its Technical Report and provided additional information to address the issues identified in LC 12.8.

However, in its March 1, 2015, letter, Strata was deficient by not describing the detection capability of equipment used to both release equipment and materials to unrestricted use and assess personnel contamination before personnel exit restricted areas in terms of dpm per 100 cm^2, as required by LC 12.8. The specific item that NRC required for staff review and approval is the surface contamination detection capability (scan MDC) of radiation survey meters used in surveys for releasing equipment and materials to unrestricted use or personnel contamination. In accordance with the license condition, this information was to be provided in terms of disintegrations per minute (dpm) per 100 cm^2. Strata described several aspects of its survey program, such as personnel dosimetry, surface contamination limits, and technical parameters of survey equipment, but it did not describe the detection capability of equipment used to release equipment and survey personnel in terms of dpm per 100 cm^2.

By letter dated July 23, 2015, NRC staff requested additional information (RAI-1) regarding Strata's March 1, 2015, letter and the deficiency described above (NRC 2015a). In this RAI, staff explained that SER Section 5.7.6.3.2 (NRC 2014b) documented the basis for and purpose of LC 12.8. The purpose of LC 12.8 is that the licensee demonstrate, using specific information about surface equipment and procedures proposed for use at the Ross ISR Project, that the scan minimum detectable concentration will be sufficiently low to meet or exceed the guidance in the Guidelines (NRC 1993) and Regulatory Guide 8.30, Table 2 (NRC 2002) for both alpha contamination and beta/gamma contamination. The NRC staff explained that factors which should be considered in estimating scan MDCs are addressed in Section 6.7.2 of NUREG-1575 (NRC 2000) and NUREG-1507 (NRC 1995). The NRC staff noted that it has previously approved a program description which included consideration of scan MDCs (NRC 2014c).

By letter dated July 27, 2015, Strata responded that NRC staff did not address the main point of Strata's March 1, 2015, letter:

> "…namely that only those beta-gamma surveys which were committed to in the Strata Technical Report (TR) (Strata 2011) would be conducted until characterization studies demonstrated that additional beta-gamma surveys for contamination control were required. Of particular interest, Strata's TR only committed to doing contamination surveys for alpha radiation for personnel exiting restricted areas." (Strata 2015b).

Strata's July 27, 2015, statement does not address the deficiencies with this approach described by NRC staff in its 2014 SER, which were the basis for license condition 12.8. However, Strata included additional information in two attachments to its July 27, 2015, letter: Attachment 3, "Instrument Specifications and Additional Considerations," and Attachment 4, "Beta-Gamma Contamination Control Survey Programs." A summary of this information and the staff's evaluation is provided below.

Evaluation

With regard to surveys for external radiation, the applicable release limits are the average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters of 0.2 mrad/hr at 1 cm and 1.0 mrad/hr at 1 cm, respectively (NRC 1993a). In Attachment 3 to its July 27, 2015, letter, Strata stated that it would use a Ludlum Model 19 or Ludlum Model 9-3 to detect potential contamination from radionuclides emitting gamma radiation. In Attachment 4 of its July 27, 2015, letter, Strata stated that contamination surveys for equipment and material which are to be released to unrestricted areas will be performed with the 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. Strata also stated that its applicable limits for beta-gamma contamination include the additional stipulation in footnote "f" of Table 1 of Enclosure 2 to NRC's FC 83-23 (NRC 1993a). The release limits in footnote "f" are an average radiation level associated with surface contamination resulting from beta-gamma emitters of 0.2 mrad/hr at 1 cm, and a maximum radiation level associated with surface contamination resulting from beta-gamma emitters of 1.0 mrad/hr at 1 cm.

Strata described the detection capability of the Model 19 by stating that is a highly sensitive μR meter with a measuring range of background to 5 mR/hr. However, the Model 19 only measures gamma radiation, and could not be used measure beta-emitting contamination on surfaces. The Model 9-3 proposed by Strata is an air ionization chamber for areas with elevated gamma radiation with a range up to 50 R/hr. The Model 9-3 has a retractable beta shield which allows for measurement of beta-emitting contamination on surfaces using a 7 mg/cm^2 shield. The lowest indicated range of the Model 9-3 is 0.2 mR/hr, which is not lower than the applicable release limits for average radiation levels associated with surface contamination resulting from beta-gamma emitters of 0.2 mrad/hr at 1 cm. **Open Item 1. Strata must 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 1993a).**

With regard to surveys for removable contamination, in Attachment 3 of its July 27, 2015, letter, Strata explained that removable contamination levels would be measured using a Ludlum Model 3030, or equivalent instrumentation. Strata did not describe the detection capability of the Model 3030 as required by LC 12.8, but rather provided additional information which can be used to calculate detection capability in terms of dpm per 100 cm^2. **Open item 2. Strata must describe the methodology it will use to determine the detection capability of the Model 3030 in terms of dpm per 100 cm^2 as required by LC 12.8.**

Strata summarized the manufacturer's specifications for the Model 3030 by stating that the 4π alpha counting efficiency is 32% for thorium-230, 39% for uranium-238, and 37% for plutonium-239. Similarly, Strata stated that the 4π beta counting efficiency is 8% for carbon-14, 27% for technetium-99, 29% for cesium-137, and 26% for strontium-90 / yttrium-90. The Ludlum Model 3030 has background count rates of 3 counts per minute (cpm) or less for alpha-emitting radionuclides, and typically 50 cpm or less for beta-emitting radionuclides in a 10-μR/hr gamma radiation field. In Attachment 4 of its July 27, 2015, letter, Strata explained that it will perform weekly filter paper smear tests for both alpha and beta removable contamination in the general plant and unrestricted areas in accordance with commitments in TR Section 5.7.6.1.2.

With regard to surveys for both fixed and removable contamination for personnel exit surveys and equipment and material released from restricted areas, in Attachments 3 and 4 of its July 27, 2015, letter, Strata stated that it would assess contamination using a Ludlum Model 2360 ratemeter / scalemeter / data logger coupled with a Ludlum Model 43-93 alpha / beta probe, or equivalent instrumentation. As described by Strata in Attachment 4 of its July 27, 2015, letter, this instrument would be used for special surveys during maintenance activities; contamination surveys for personnel leaving restricted areas; and contamination surveys for release of equipment or material. In Attachment 4, Strata stated that the Ludlum Model 2360 alarm setting for contamination surveys for personnel leaving restricted areas will be initially 20 cpm above background and changed at the RSO's discretion. The action level for release of equipment and materials for unrestricted use will be 75% of the regulatory limits. As with the Model 3030 described above, Strata did not describe the detection capability of the Model 3030 as required by LC 12.8, but rather provided additional information which can be used to calculate detection capability in terms of dpm per 100 cm^2. **See Open item 2 above. Strata must describe the methodology it will use to determine the detection capability of the Ludlum Model 2360**

ratemeter / scalemeter / data logger coupled with a Ludlum Model 43-93 alpha / beta probe in terms of dpm per 100 cm^2 as required by LC 12.8.

While Strata stated it did not know the efficiency or background count rates of the Ludlum Model 43-93 alpha/beta probe it would use, because it had not yet been received its instruments, Strata cited submittals from Lost Creek Project and Nichols Ranch ISR Project to describe these values. In addition, Strata summarized the Nichols Ranch ISR Project estimates of surface contamination detection capability and stated that the NRC staff reviewed and approved these estimates. Citing the manufacturer's literature, Strata stated that the Ludlum Model 43-93 alpha/beta probe has an efficiency of 20% for plutonium-239, 15% for technetium-99, and 20% for strontium-90. Strata also stated that the background counts rates are 3 counts per minute (cpm) or less for alpha-emitting radionuclides, and 300 cpm or less for beta-emitting radionuclides.

Citing the results of the Nichols Ranch ISR Project estimates of surface contamination detection capability (Uranerz 2014), Strata committed to maintain gamma exposure rates less than 30 μR/hr in areas where scans are performed. Strata stated that a 1-minute static survey will be the determinant in deciding if contamination is present above acceptable levels, and that radiation training will address the need for controlled, slow speeds while performing scan surveys. Strata also explained that it will use a scalemeter, rather than a ratemeter, to ensure static surveys are collected for at least one minute.

With regard to calibration of the Model 3030 and Model 43-93, Strata stated that it has purchased a thorium-230 source for alpha radiation and a strontium-90 source for beta radiation. Strata explained that its procedures will specify a 1/8-inch distance between the probe and the material being scanned to ensure the probe is not contaminated but that "the probe is able to detect the maximum amount of contamination potentially present."

The NRC staff's evaluation of this additional information provided by Strata in its July 27, 2015, letter is provided below. This evaluation focuses on four factors that are important to ensuring that radiation survey equipment and methods for uranium contamination are sufficiently sensitive to detect contamination at acceptably low levels. These factors are: (1) accounting for mixtures of radionuclides; (2) estimating counting efficiencies of survey equipment; (3) the energy of radiation emitted from calibration sources; and (4) the use of both scans (i.e., sweeping the detector across a contaminated surface) and static (i.e., fixed) surveys to detect contamination.

Mixtures of radionuclides

In Section 5.7.3.1.1 of its technical report (Strata 2011), Strata committed to confirm that natural uranium is the primary radioactive material of concern in both airborne particulate samples and yellowcake processed at the Ross ISR Project. This assumption regarding airborne contamination will be verified by air sampling and analysis in accordance with LC 10.16 (NRC 2014a) and commitments in Section 5.7.3 of Strata's TR regarding characterization of yellowcake (Strata 2011). However, natural uranium and its short-lived progeny are not the only potential contaminants on surfaces, equipment, and personnel at an ISR facility. Lixiviant solutions will also contain radium-226 and potentially long-lived isotopes of thorium. Therefore, NRC staff finds that Strata has not accounted for mixtures of radionuclides likely to be present in contamination at its Ross ISR Project. This is being tracked as Open item 2 in this draft safety evaluation report, which is described below.

Counting efficiencies of Ludlum Model 3030 and 43-93

Of the many radionuclides for which Strata provided efficiencies for the Ludlum Model 3030, the efficiencies for uranium-238 alpha particles (39%) and strontium-90 / yttrium-90 beta particles (26%) are closest to those for predominant radionuclides present in natural uranium. In its July 27, 2015, letter, Strata also cited only the so-called "4π" instrument efficiencies cited by the manufacturer for the Ludlum Model 43-93, which accounts for the intrinsic efficiency of the instrument to detect radiation emitted into all directions from an ideal source (e.g., a flat and polished calibration source). These are idealized counting efficiencies which do not take into account source effects, such as the absorption or scattering of radiation in the paper filter being surveyed.

An appropriate consideration of the counting efficiencies of the Ludlum Model 3030 and Model 43-93 would take into account a number of factors, including absorption or scattering of radiation on the surface of the item being surveyed, the distance between the surveyed item and the detector, and the intrinsic efficiency of the detector to detect radiation incident upon it (i.e., instrument efficiency).

To account for source effects, the NRC staff has endorsed (NRC 1998, 2006) the approach in the International Organization for Standardization's (ISO) Guide 7503–1, "Evaluation of Surface Contamination," (ISO 1988a) for calculating counting efficiency for alpha and beta particles. The ISO approach defines the counting efficiency for alpha and beta particles as the product of the instrument efficiency, ε_i, and the source efficiency, ε_s. In the ISO approach, the instrument efficiency (ε_i) is the ratio of the instrument's net reading (in counts per minute, or cpm) to the surface (2π) emission rate of a source for radiation of a given energy under given geometric conditions. The source efficiency (ε_s) is the ratio of the surface emission rate of a source to the radiation production rate in the source. The product of the instrument efficiency and the source efficiency ($\varepsilon_{i} \times \varepsilon_s$) describes the <u>counting efficiency</u> of the instrument.

The NRC staff has previously endorsed the ISO 7503-1 (ISO 1988a) approach for assigning default surface efficiencies based on particle type (alpha or beta) and energy (beta only) (NRC 2006, 1998). Specifically, the ISO 7503-1 recommendation is to use a source efficiency of 0.5 for maximum beta energies exceeding 0.4 MeV, and to use a source efficiency of 0.25 for maximum beta energies between 0.15 and 0.4 MeV and for alpha-emitters (ISO 1988a). Source efficiencies may be determined experimentally or simply selected from the guidance contained in ISO 7503-1 (NRC 1998).

An example of a calculation of weighted counting efficiencies using the Ludlum Model 43-93 is provided in the next section for yellowcake contamination (natural uranium and its short-lived progeny only). The same principles and methods are applicable to calculating counting efficiencies for the Ludlum Model 3030 for surveys of removable surface contamination, and for other mixtures of radionuclides, such as those present in lixiviant. **Open item 3. As part of calculating minimum detectable concentrations for methods and radiation detection equipment proposed for use at the Ross ISR Project, Strata must provide radionuclide-weighted counting efficiencies for the major radionuclide mixtures likely to be**

encountered at the Ross ISR Project. This should include, at a minimum, radionuclide mixtures for lixiviant and yellowcake.

Where a mixture of radionuclides is present, the overall weighted counting efficiency of the Ludlum 43-93 can be calculated, as shown in Table 1 for alpha particles in aged yellowcake.

The estimated weighted counting efficiency of the Ludlum 43-93 for beta particles in aged yellowcake is shown in Table 2. In Table 2, the maximum beta energy of the Th-234 103 keV emission is less than the 150 keV threshold described in ISO (1998a) and is assigned a value of zero.

Calibration sources

As stated above, Strata stated that it has purchased a thorium-230 alpha calibration source which emits alpha particles with energies of 4.68 MeV (76%) and 4.62 MeV (24%) and a strontium-90 beta calibration source with a maximum beta energy associated with its short-lived yttrium-90 progeny of 2,270 keV. The thorium-230 emission energies are between the major emission energies for uranium-234 (4.77 MeV) and uranium-238 (4.20 MeV). The strontium-90 / yttrium-90 maximum beta energy is nearly the same as the maximum beta energy for protactinium-234m (bold-faced in Table 2), the predominant (i.e., largest contributor to detector response) short-lived beta-emitting progeny of uranium-238.

The NRC staff previously recommended that calibration sources should be selected that emit alpha or beta radiation with energies similar to those expected of the contaminant in the field (NRC 1998). In addition, the most representative calibration source would be one prepared from the radioactive material being assessed in the field (NRC 1998). ISO-8769, "Reference Sources for the Calibration of Surface Contamination Monitors," provides recommendations on calibration source characteristics (ISO 1988b).

The NRC staff endorsed (NRC 2006, 1993b) previous versions of the American National Standards Institute (ANSI) standard N323AB–2013, "Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments." (ANSI 2013). ANSI standard N323AB–2013 recommends that single point calibrations are only valid for applications to field measurement energies that are greater than the calibration energy (ANSI 2013).

The NRC staff finds that the radiation emission energy of the thorium-230 and strontium-90 calibration sources selected by Strata are close to the emission energies of isotopes of uranium and its short-lived progeny (as shown above in Tables 1 and 2) to calibrate the Ludlum Model 3030 and Ludlum Model 43-93 for use at an ISR facility. However, the strontium-90 source is not appropriate for calibrating the Ludlum Model 3030 and Ludlum 43-93 to detect beta particles with lower maximum emission energies than that of protactinium-234m, such as the beta particles from decay of thorium-234 and thorium-231. Therefore, unless Strata uses either an alternative source or an appropriate additional source (e.g., carbon-14 with a maximum beta energy of 156 keV) to calibrate the Ludlum 43-93 at those energies, it should not credit the instrument's response to those energies when estimating minimum detectable concentrations and surface contamination levels. Not crediting the instrument's response to lower energy beta particles has the effect of discounting the efficiency of the detector. An example value of 9.6% for the response of the Ludlum 43-93 to protactinium-234m is used by NRC staff below to assess the detection capability of the instrument. **Open item 4. Strata should clarify how it**

will use the strontium-90 calibration source to determine weighted counting efficiencies for beta-emitting progeny of natural uranium.

Table 1. Estimated Ludlum 43-93 alpha counting efficiency for aged yellowcake

Isotope	Energy[2] (MeV)	Uranium Fraction[1]	Branching Ratio[2]	Instrument Efficiency[3]	Surface Efficiency	Weighted Efficiency
U-238	4.15	0.485	.21	0.45	0.25	0.01146
U-238	4.20	0.485	.79	0.45	0.25	0.04310
U-234	4.72	0.493	.28	0.45	0.25	0.01153
U-234	4.77	0.493	.72	0.45	0.25	0.03993
U-235	4.21	0.022	.06	0.45	0.25	0.00015
U-235	4.37	0.022	.17	0.45	0.25	0.00042
U-235	4.40	0.022	.55	0.45	0.25	0.00136
U-235	4.60	0.022	.05	0.45	0.25	0.00012
	Alpha counting efficiency =					0.11

1 - Source: NRC 2015b
2 - Source: Table 2-2 of DOE 2009 (low yield radiations are not included)
3 - Assumed values. Actual values used here are to be determined during on site calibration using appropriate calibration sources with energies representative of the radionuclides in the contamination being measured.

Table 2. Estimated Ludlum 43-93 beta counting efficiency for aged yellowcake

Isotope	Energy[2] (keV)	Activity Fraction[1]	Branching Ratio[2]	Instrument Efficiency[3]	Surface Efficiency	Weighted Efficiency
Th-234	103	0.489	0.21	0	0	0
Th-234	193	0.489	0.79	0.2	0.25	0.01931
Pa-234m	**2290**	**0.489**	**0.98**	**0.4**	**0.5**	**0.09582**
Th-231	206	0.022	0.13	0.2	0.25	0.00014
Th-231	287	0.022	0.12	0.3	0.25	0.00020
Th-231	288	0.022	0.37	0.3	0.25	0.00062
Th-231	305	0.022	0.35	0.3	0.25	0.00058
	Beta counting efficiency =					0.12

1 - Source: NRC 2015b, renormalized to account only for beta-emitting progeny
2 - Source: Table 2-2 of DOE 2009 (low yield radiations are not included)
3 - Assumed values. Actual values used here are to be determined during on site calibration using appropriate calibration sources with energies representative of the radionuclides in the contamination being measured.

Regarding the geometry of the calibration source, one recommendation in ISO-7503-1 (ISO 1988a) is that the dimensions of the calibration source be sufficient to cover the active area of the detector. However, ANSI standard N323AB–2013 (ANSI 2013) provides guidance on using an array of small sources, or a single source, to develop an effective area source in the size and shape of the detector probe. As noted in Table 4.11 of NUREG-1507 (NRC 1998), the difference in instrument efficiency between a disc source and a distributed source is relatively small for zinc-sulfide (ZnS) detectors like the Ludlum 43-93, at least in the case of detecting alpha particles.

The licensee stated that its procedures for scanning potential contamination state that the probe face should be held 0.3 cm (1/8-inch) from the material being scanned. Tables 4.5 and 4.6 of NUREG-1507 (NRC 1998) indicate that there should be minimal difference in detector response to a distributed or disc source for both alpha and beta particles at the licensee's proposed scanning distance. In addition, Goles (1991) found that, assuming a 100 square centimeter contamination zone, the instrument minimum detectable concentrations for contamination distributed across an area would be nominally the same as if all surface contamination was concentrated at a single point. Goles stated that this is because the increased residence time of the detector over a distributed source during a scan compensates for the lower surface contamination of the distributed activity.

Therefore, the staff has reasonable assurance that the licensee can implement an adequate on-site calibration program for its contamination detection instruments using either area sources (e.g., 100 cm^2) or smaller point sources when the calibration is performed in accordance with accepted standards (e.g., ANSI standard N323AB–2013) using the scanning methodology proposed by the licensee.

Alpha Scans and Static Surveys

To assess whether the MDC for the Ludlum Model 3030 to detect removable alpha contamination is sufficiently low, staff used the formula for calculating the MDC for static surveys by Strom and Stansbury, as presented in Table 3.1 of NUREG-1507 (NRC 1998). This formula is as follows:

$$MDC = \frac{3 + 3.29\sqrt{\mathrm{R}_b t_g (1 + t_g/t_b)}}{(\text{counting efficiency})(t_g)}$$

where R_b is the background counting rate; t_g is the gross counting time; and t_b is the background counting time. Assuming Ludlum Model 3030 alpha background count rate of 3 cpm, an alpha counting efficiency of 11%, and a background and survey count time of 1 minute, NRC staff estimated an MDC of about 100 dpm / 100 cm^2. This value is acceptable because it's less than the 500 dpm / 100 cm^2 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). This value is also below Strata's proposed action level of 75% of the regulatory limit (e.g., < 75% of the removable alpha contamination limit of 1,000 dpm / 100 cm^2, or 750 dpm / 100 cm^2).

As stated above, Strata did not estimate the MDC of either alpha-emitting or beta-emitting contamination for the Ludlum Model 43-93. Instead, Strata provided a description of the manufacturer's specifications of the Ludlum Model 43-93. An acceptable methodology for calculating MDC for alpha surveys is outlined in NUREG-1507 (NRC 1995) and Abelquist (2014) (see **Open Item 2** above).

For alpha-emitting radionuclides, the scan MDC takes into account that the background response of most alpha detectors is very close to zero. At these low count rates, the probability of detecting alpha-emitting surface contamination is calculated using Poisson summation statistics. Equation 6-12 of NUREG-1575 describes the probability of observing a single count while passing the detector over a contaminated area. Abelquist (2014) defined the minimum alpha activity that can be detected by solving Equation 6-12 for "G", resulting in:

$$Alpha\ scan\ MDC = \frac{\left[-\ln\left(1 - P(n \geq 1)\right)\right] * 60}{\varepsilon_i \varepsilon_s t}$$

Where P(n≥1) is the probability of detecting a single count; ε_i is the instrument efficiency; ε_s is the surface efficiency; and t is the scan time (also referred to as residence time) in seconds. Assuming a P(n≥1) = 90% probability of detecting 1 count; a counting efficiency ($\varepsilon_{i\ x}\ \varepsilon_s$) of 0.11 (11%); and a residence time (i.e., t) of 7 seconds, the alpha scan MDC for this example is estimated to be just over 170 dpm / 100 cm^2. The staff's estimate of residence time is based on a scan rate of 1 cm/s over the smallest dimension of the detector, which is its approximate width of 7 cm. These values would be acceptable because they bound the 500 dpm / 100 cm^2 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). This value would also be below Strata's proposed action level of 75% of the regulatory limit (e.g., < 75% of the removable alpha contamination limit of 1,000 dpm / 100 cm^2, or 750 dpm / 100 cm^2). **Open item 5. Strata should quantify its proposed "controlled, slow speed" scan described by Strata in its July 27, 2015, letter, in terms of a residence time of the Ludlum Model 43-93 over a contaminated area.**

NRC staff also evaluated the MDC for static surveys using the same formula by Strom and Stansbury (1992) cited above, except that consideration of the probe area is added:

$$MDC = \frac{3 + 3.29\sqrt{\mathrm{R}_b t_g (1 + t_g/t_b)}}{(\text{counting efficiency})(t_g)\dfrac{probe\ area, cm^2}{100\ cm^2}}$$

The active probe area of the Ludlum 43-93 is 100 cm^2. Assuming a Ludlum Model 43-93 alpha background count rate of 3 cpm, a counting efficiency of 11% (see Table 1 above), and a background and survey count time of 1 minute, NRC staff estimated an MDC of about 100 dpm / 100 cm^2. This value would be acceptable because it is less than the 500 dpm / 100 cm^2 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). This value would also be below Strata's proposed action level of 75% of the regulatory limit for release of equipment and materials (e.g., < 75% of the removable alpha contamination limit of 1,000 dpm / 100 cm^2, or 750 dpm / 100 cm^2). NRC staff also finds that the typical alarm setting of 20 cpm for personnel contamination surveys using a Ludlum 43-93 corresponds to a contamination level of about 200 dpm / 100 cm^2, which is below acceptable contamination levels.

Beta Scans and Static Surveys

Similar to the staff's evaluation above for the Ludlum Model 3030 MDC for removable alpha-emitting contamination, staff used the same formula for calculating the MDC for surveys of beta-emitting contamination by Strom and Stansbury. Assuming the Ludlum Model 3030 beta background count rate of 50 cpm, a beta counting efficiency of 9.6%, and a background and survey count time of 1 minute, NRC staff estimated an MDC of about 400 dpm / 100 cm^2. This value is below Strata's proposed action level of 75% of the regulatory limit (e.g., < 75% of the removable beta contamination limit of 1,000 dpm / 100 cm^2, or 750 dpm / 100 cm^2).

An acceptable methodology for calculating MDC for beta scan surveys is also outlined in NUREG-1575 (NRC 2009) and Abelquist (2014). Equation 6-10 of NUREG-1575 provides a formula for estimating the scan MDC for beta/gamma-emitting radionuclides on structure surfaces:

$$Beta - Gamma\ Scan\ MDC = \frac{MDCR}{\sqrt{p}\varepsilon_i \varepsilon_s \frac{probe\ area, cm^2}{100\ cm^2}}$$

Where MDCR (minimum detectable count rate) is determined using equations 6-8 and 6-9 of NUREG-1575 (NRC 2009); p is the surveyor efficiency; ε_i is the instrument efficiency; ε_s is the surface efficiency; and the probe area is characteristic of the instrument. The active probe area of the Ludlum 43-93 is 100 cm^2. For a false positive rate of 0.60 (60%); true positive proportion of 0.95 (95%); a surveyor efficiency of 0.5; a counting efficiency ($\varepsilon_i \times \varepsilon_s$) for protactinium-234m of 0.096 (9.6% - see Table 2 above); a 7 second residence time; and 300 cpm background count rate, the beta scan MDC is estimated to be about 1,000 dpm / 100 cm^2. NRC guidance (e.g., Regulatory Guide 8.30) does not specify an acceptable MDC for beta-emitting contamination. However, this estimated MDC is above Strata's internal action level of 75% of the applicable removable surface contamination limit of 1,000 dpm / 100 cm^2 in Table 1 of Policy and Guidance Directive FC 83-23 (NRC 1993), and equal to the applicable removable surface contamination level of 1,000 dpm / 100 cm^2.

The beta static survey MDC calculated using a Ludlum Model 43-93 beta background count rate of 300 cpm, a counting efficiency of 9.6%, and a background and survey count time of 1 minute is about 900 dpm / 100 cm^2. This value is not acceptable because it is above Strata's proposed action level of 75% of the regulatory limit for release of equipment and materials (e.g., < 75% of the removable alpha contamination limit of 1,000 dpm / 100 cm^2, or 750 dpm / 100 cm^2). **Open Item 6. Strata should revise its contamination program to ensure that scan and static surveys for beta contamination are designed to ensure detection of beta contamination below Strata's proposed action level.**

Conclusion

The NRC staff finds that, as a result of the open items identified above, Strata has not adequately described its monitoring equipment sensitivity, calibration methods and frequency, and planned use, in accordance with LC 12.8.

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