April 17, 2017

Mr. Ron Linton, Project Manager
Decommissioning & Uranium Recovery Licensing Directorate
Division of Waste Management & Environmental Protection
Office of Federal & State Materials & Environmental Management Programs
U.S. Nuclear Regulatory Commission
11545 Rockville Pike
Mail Stop T7-E18
Rockville, Maryland 20852-2738

Re: Response to RAIs, License Condition 11.3 (TAC NO. J00711)
Materials License SUA-1341, August 1, 2016

Dear Mr. Linton:

In response to your letter of August 1, 2016, request for additional information (RAI's) for the June 5, 2015, Uranium One submittal (ML15040A077) please find the requested information as they pertain to License Condition 11.3 for Material license SUA-1341.

Uranium One has reviewed Enclosure 2 of the August 1, 2016 letter and are in agreement with the NRC evaluations of the following:

1. In-Plant air sample compliance with 10 CFR 20.1204
2. Environmental particulate air samplers at Christensen Ranch
4. Evaluating the highest public dose in accordance with 10 CFR 20.1302
5. Accounting for radon progeny in public dose assessments
6. Accounting for occupational dose in all licensed areas

Uranium One with this submittal is addressing the concerns noted within Enclosure 2 identified in Item 3 Accounting for air effluent quantities in accordance with 10 CFR 40.65 and RAIs 1-4 identified in the Enclosure 1 of the August 1, 2016 letter regarding License Condition 11.3.

If you have any questions or need additional clarification on any information provided, please do not hesitate to contact me at 307-233-6330.

Sincerely,

Scott Schierman
HSE Manager
Uranium One Americas

cc: Greg Kruse – Manager, U.S. Operations
Rick Kukura – Mine Manager

Uranium One USA, Inc.
907 N. Poplar Street, Suite 260
Casper, Wyoming 82601
tel +1 307-234-8235 • **fax** +1 307-237-8235
www.uranium1.com

U. S. Nuclear Regulatory Commission Staff Request for Additional Information on Uranium One USA, Inc. Submittal dated June 5, 2015, Regarding License Condition 11.3.a, Materials License SUA-1341; Docket No. 040-08502

Background

Uranium One USA, Inc.'s (Uranium One) revised response to LC 11.3.a. is provided in a letter dated June 5, 2015 (Uranium One 2015). The U.S. Nuclear Regulatory Commission (NRC) staff has started a technical review of the June 5, 2015, letter, and requires additional information to complete its review. The NRC staff has summarized Uranium One's proposal in Table 1 below. Upon organizing Uranium One's proposed survey methodology in the table to more clearly summarize sample types, locations, and frequencies, the NRC staff observed several deficiencies.

RAI No. 1. Radon progeny

Request for Additional Information

Please describe how effluent quantities of radon progeny will be estimated.

Regulatory Basis

Title 10 of the Code of Federal Regulations (10 CFR) Part 40.65, "Effluent monitoring reporting requirements," requires licensees to specify the quantity of each of the principal radionuclides released to unrestricted areas in liquid and in gaseous effluents during the previous six months of operation.

Description

With regard to Uranium One's proposed Method 1 and Method 2 estimates of air effluent quantities of radon and radon progeny using the ASTM D 5072-92 approach, which would apply to Christensen Ranch satellite facility, wellfields, and deep disposal well houses, Uranium One did not state how it would estimate quantities of radon progeny released. For example, for purposes of estimating effluent quantities of both radon and its short-lived progeny, when radon is measured, Uranium One may conservatively assume that short-lived radon progeny are in equilibrium with radon.

RESPONSE TO RAI #1:

Method 1 for radon effluent monitoring as presented in Uranium One's June 5, 2015 response to NRC request for additional information (RAI) regarding License Condition 11.3, has been revised to assume secular radiological equilibrium between radon gas (radon) and its short-lived decay products (progeny) when only the radon gas is measured. A complete revised version of Method 1 is provided as Attachment 1 to this response. With respect to the previously proposed alternative method for radon effluent monitoring (Method 2), that method has been withdrawn from consideration and Uranium One will rely only on Method 1 for radon effluent monitoring. The response to RAI #1 is as follows:

Method 1

As previously proposed, the quantity of radon gas effluent from the Christensen Ranch satellite facility and Irigaray processing plant will be based on the differential between measured radon gas in incoming lixiviant, and measured radon gas in outgoing reinjection and disposal solutions (i.e. radon-in-water measurement using ASTM D 5072-9). For simplicity, this approach is referred to herein as the "mass-balance" approach, and it accounts for all point and diffuse sources of radon gas releases at the

Christensen Ranch satellite ion-exchange (IX) plant, as well as subsequent releases at the Irigaray processing plant due to transfers of loaded IX resin and processing of associated uranium into yellowcake product. For disposal solutions fed through the RO unit and the degas column (ISR bleed solutions) before being routed to the deep disposal well or RO evaporation ponds, radon-in-water will be sampled just before the RO unit and all dissolved radon in this disposal stream will be conservatively assumed to be released to the environment as there may be further releases from the RO evaporation ponds that cannot be readily measured. With respect to radon progeny, the NRC's recommended assumption of radiological equilibrium has been incorporated into Method 1 in that the amount of radon progeny released to the environment is assumed equivalent to that of radon gas as estimated based on measurements of radon gas. This applies to releases based on the mass-balance approach (semi-annual radon-in-water measurements), as well as for releases not accounted for by the mass-balance approach.

For radon gas and progeny releases not accounted for by the mass-balance monitoring approach, including releases from recovery wellheads in the wellfields, and releases from wellfield header houses and the deep disposal well house (modular buildings), Uranium One has revised Method 1 to include passive quarterly monitoring of radon gas with alpha track etch detectors in a representative subset of recovery wellhead boxes (5 representative wellheads per operational wellfield) and within each modular building. For wellfield releases, Uranium One will conservatively assume that the average rate of air released to the environment from each recovery wellhead is equivalent to the typical air sampling flow rate employed for radon progeny measurements with the modified Kusnetz method (e.g. 2 liters per minute). This assumption was recently approved by the NRC for the same application at another ISR facility (NRC, 2015). This release rate, along with the elapsed time of the monitoring period and the radon gas concentration measured with track etch detectors in the wellhead boxes, will be used to calculate estimates of radon gas released from each wellhead.

Because it would be unrealistic and inaccurate to assume that all radon gas measured with track etch detectors within wellhead boxes and modular buildings will be attributable to ISR operations, a "net" concentration of radon attributable to operational radon releases from each wellhead will be estimated by subtracting the average ambient background concentration in local outdoor air[1], from the radon concentration measured with track etch detectors within each recovery well box (i.e. Uranium One will assume that the background concentration of radon within each wellhead box is equivalent to that of measured background radon in local outdoor air, and will not attribute this background radon to ISR operations). The total radon progeny release from the wellfields will be assumed equivalent to the total measured/calculated release of radon gas from the wellfields (i.e. assumed equilibrium). Additional details of this aspect of Method 1 are provided in Attachment 1.

Releases from wellfield header houses and the deep disposal well house will be estimated in a manner similar to that of wellfields, except that the release rate to outside air will be based on the total flow rate of all ventilation fans within each modular building. Also, the "net" concentration of radon attributable to operational radon releases within each modular building (e.g. during bag filter exchanges) will be estimated by subtracting the average ambient background concentration in local outdoor air[1], from the radon concentration measured with track etch detectors within each modular building (i.e. Uranium One will assume that the background concentration of indoor radon within each modular building is equivalent to that of measured background radon in local outdoor air, and will not attribute this background radon to ISR operations). Additional details of this aspect of Method 1 are provided in Attachment 1.

With respect to radon gas and radon progeny releases from spills, the most recently measured concentration of dissolved radon gas in the type of solution involved in a given spill (e.g. pregnant

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[1] As measured with track etch detectors at local upwind environmental air monitoring station AS-1 (Table Mountain background).

lixiviant, reinjection fluid, etc.), will be multiplied by the estimated volume of solution spilled in order to calculate the amount of radon gas released to the atmosphere. It will be assumed for this calculation that all dissolved radon gas in the spilled solution is released to ambient air, and that the amount of radon progeny released is equivalent to that of the radon gas (i.e. assumed equilibrium).

In summary, Method 1 has been revised to now involve measurements only of radon gas, and respective estimates of effluent releases will be assigned to radon progeny releases based on an assumption of radiological equilibrium between the measured radon gas and short-lived radon progeny in air. Under Method 1, direct measurement of radon progeny with the modified Kusnetz method has been entirely eliminated (radon progeny measurements for purposes of estimating occupational doses to workers will continue in applicable facilities as normal, but these data will not be used as part of effluent monitoring). A complete revised version of Method 1 is included as Attachment 1 to this RAI response submittal.

Method 2

This formerly proposed alternate method for monitoring radon effluents has been withdrawn from consideration as an approach essentially equivalent to Method 1 has recently been approved by NRC at another ISR facility (NRC, 2015) and is thus believed sufficient to produce acceptable estimates of operational releases to the environment of radon gas and radon progeny.

References

U.S. Nuclear Regulatory Commission (NRC). 2015. Letter from NRC to Uranium One regarding "U.S. Nuclear Regulatory Commission verification of Strata's response to License Condition 12.7, ROSS In-situ Recovery (ISR) Project, Crook County, WY, Source Material License SUA-1601, Docket No. 040-09091, TAC J00735." Letter dated November 19, 2015. ADAMS accession number ML15302A405.

RAI No. 2. Sample frequencies

Request for Additional Information

Please describe sample frequencies for the Christensen Ranch de-gas column radon-in-water measurements and the deep disposal well house radon-in-water measurements.

Regulatory Basis

10 CFR 40.65, "Effluent monitoring reporting requirements," requires licensees to specify the quantity of each of the principal radionuclides released to unrestricted areas in liquid and in gaseous effluents during the previous six months of operation.

Description

With regard to Method 2 for both the Christensen Ranch de-gas column radon-in-water measurements and the deep disposal well house radon-in-water measurements using the ASTM D 5072-92 approach, Uranium One did not specify sample frequencies.

RESPONSE TO RAI #2:

Method 2 has been withdrawn from consideration as noted above in the response to RAI #1. The outgoing streams of solutions to be sampled for radon-in-water under the mass-balance approach (as detailed above in the response to RAI #1), include solutions being recycled for reinjection back into

the wellfields, and system bleed solutions to be disposed of in the deep disposal well or RO evaporation ponds. The frequency of sampling for both of these solution streams will be semi-annually to match the sampling frequency proposed for sampling of radon-in-water for incoming pregnant lixiviant. As indicated in Method 1 (see Attachment 1), the sampling locations for these two outgoing solution streams will be as follows:

1) At the outgoing trunk line containing ALL reinjection solutions being returned to the wellfields as part of the ISR mining process.

2) At a sample port located just before bleed stream solutions pass through the reverse osmosis (RO) unit and subsequent degas column. This bleed stream is subsequently routed to the deep disposal well or the RO evaporation ponds, but because subsequent releases of radon to the atmosphere from the RO ponds would be difficult to measure, all dissolved radon-in-water in this bleed stream will be conservatively be assumed to be released to the atmosphere (little of this radon-in-water is expected to actually be released to the atmosphere).

There will be not be separate samplings of radon-in-water at the degas column and at the deep disposal well house and as mentioned by NRC in this RAI – the entire outgoing bleed stream will be sampled only once as indicated in bullet 2 above.

RAI No. 3. Sample methodology

Request for Additional Information

Please describe an acceptable method for surveys of radon-222. Regulatory Basis

10 CFR 40.65, "Effluent monitoring reporting requirements," requires licensees to specify the quantity of each of the principal radionuclides released to unrestricted areas in liquid and in gaseous effluents during the previous six months of operation.

Description

With regard to Method 2 (and Method 1 for bag filter changes in modular buildings), as observed by NRC staff in comments on a similar plan (NRC 2015), the methodology proposed by Uranium One to estimate quantities of radon and radon progeny in air effluent for the Christensen Ranch satellite building, Irigaray central processing facility, resin truck, modular buildings, and well fields (production wells) is not correct. The modified Kusnetz method measures only radon progeny (i.e., working levels), not radon. In locations where only radon gas escapes from the ISR process in well-ventilated spaces, short-lived radon progeny concentrations in air will not be in equilibrium with concentrations of radon. This means that radon gas concentrations will be higher than would be estimated by measuring short-lived radon progeny alone and assuming that radon and its short-lived progeny are in equilibrium. A direct measurement of radon by track-etch detectors would be an acceptable approach in these areas. For purposes of estimating effluent quantities of both radon and its short-lived progeny, when radon is measured, Uranium One may conservatively assume that short-lived radon progeny are in equilibrium with radon. Uranium One may choose to adjust the frequency of track-etch measurements to meet target detection limits.

RESPONSE TO RAI #3:

Uranium One agrees with NRC's assessment, and has revised Method 1 to include direct measurement of radon gas as applicable (ASTM D 5072-9 for measurement of radon-in-water in process/disposal solutions, and alpha track etch detectors for measurement of radon-in-air within applicable structures), and will employ an assumption of radiological equilibrium between radon gas

and its short-lived radon progeny when using radon gas measurements alone to estimate effluent releases of both radon gas and radon progeny. Full details of Method 1, including accounting for radon gas and radon progeny releases from all potential sources, are provided in Attachment 1.

RAI No. 4. Surveys methods when measurements are not practicable

Request for Additional Information

Please describe an acceptable method for surveys of radon-222 in resin trucks and spills.

Regulatory Basis

10 CFR 40.65, "Effluent monitoring reporting requirements," requires licensees to specify the quantity of each of the principal radionuclides released to unrestricted areas in liquid and in gaseous effluents during the previous six months of operation.

Description

With regard to Method 2 measurements of radon and radon progeny released from resin trucks at the Irigaray facility, NRC staff has determined that attempting to account for this effluent quantity by direct measurements of either radon progeny (modified Kusnetz method) or radon (track-etch device) is not practicable. As stated in Regulatory Position C.3.3, "Unmonitored Effluents," of Regulatory Guide 8.37, "ALARA Levels for Effluents from Materials Facilities," where monitoring is not practicable, the license should estimate the magnitude of the unmonitored effluents. For resin truck releases, an approach under Method 2 that would be acceptable to NRC staff would be to estimate radon effluent quantities by assuming that the concentration of radon in transfer water used to mobilize and transfer resin from the resin truck is no greater than the concentration of radon in the incoming lixiviant from the wellfields, and that 100 percent of the radon is released during. each transfer. For purposes of estimating effluent quantities of both radon and its short-lived progeny, when radon is measured, Uranium One could assume that radon is in equilibrium with its short-lived progeny.

With regard to Method 2 measurements of radon and radon progeny released from spills, Uranium One proposed in its June 5, 2015, letter (p. 8) that the modified Kusnetz method would be used to estimate radon emissions from spills. NRC staff finds that attempting to account for releases of radon and radon progeny from spills by direct monitoring of radon progeny in air (i.e., the modified Kusnetz method) after the spill has occurred is not reasonable or practicable. For spills, an acceptable approach under Method 2 for estimating radon effluent quantities would be to assume that the concentration of radon in water in the spill is no greater than the concentration of radon in the incoming lixiviant from the wellfields, and that 100% of the radon in the spill volume is released. For example, for purposes of estimating effluent quantities of both radon and its short-lived progeny, when radon is measured, Uranium One could assume that radon is in equilibrium with its short-lived progeny.

RESPONSE TO RAI #4:

Method 2 has been withdrawn from consideration as noted above in the response to RAI #1. With respect to radon gas and radon progeny releases from spills/leaks, the most recently measured concentration of dissolved radon gas in the type of solution involved in a given spill (e.g. pregnant lixiviant, reinjection fluid, etc.), will be multiplied by the estimated volume of solution spilled in order to calculate the amount of radon gas released to the atmosphere. It will be assumed for this calculation that all dissolved radon gas in the spilled solution is released to ambient air, and that the amount of radon progeny released is equivalent to that of the radon gas (i.e. assumed equilibrium). With respect to radon gas and radon progeny releases from resin trucks, this loss of radon to the atmosphere is

accounted for by the mass-balance approach described in Method 1. Full details of Method 1, including accounting for radon releases from spills/leaks, are provided in Attachment 1.

References

NRC (U.S. Nuclear Regulatory Commission) 2015. Letter from J. Saxton, NRC, to M. Griffin, Strata Energy, Inc., dated November 19, 2015, Re: U.S. Nuclear Regulatory Commission Verification of Strata's Response to License Condition 12.7, Ross In-Situ Recovery (ISR) Project, Crook County, WY, Source Material License SUA-1601, Docket No. 040-09091, TAC J00735. ADAMS Accession No. ML15278A110.

Uranium One 2015. Letter from S. Schierman, Uranium One, to R. Linton, NRC, dated June 5, 2015, Re: Request for Additional Information, License Condition 11.1, Part (a-d) Materials License SUA-1341, May 4, 2015. ADAMS Accession No. ML15181A357.

ATTACHMENT 1*

Revisions to June 5, 2015 Proposed "Method 1" for Monitoring of Radon and Radon Progeny

*Note: the material in this Attachment has been revised from the submittal to NRC dated June 5, 2015 in the section entitled "Replacement Text for January 20, 2015 Submittal". Respective Sections where no modifications have been made in conjunction with this submittal are not reproduced herein, and corresponding previous proposals remain in effect.

Uranium One Willow Creek ISR Project

License Condition 11.3

Uranium One will re-evaluate information contained in the following responses on an as needed basis to verify measurements and methods are adequately describing the current situations.

LC 11.3(A): *Discuss, in accordance with 10 CFR 40.65, how the quantity of the principal radionuclides from all point and diffuse sources will be accounted for and verified by, surveys and/or monitoring.*

Uranium One will characterize all point and diffuse sources with the assumption that calculated total inventory of principle radionuclides released to the environment due to ISR operations based on measurements taken in applicable ISR facilities and mine wellfield infrastructure at the Willow Creek ISR Project (including the Irigaray processing facility, Christensen Ranch satellite ion-exchange facility, and wellfield mine units), will be released to the environment completely, or will be emitted at the rate of the ventilation exhaust for fans located throughout the facilities. Emissions will refer to particulates, radon and radon progeny. This approach is expected to overestimate the amount of effluent released from these sources. Quantities of effluent released from the Willow Creek facilities will be reported on a semi-annual basis as is required by 10 CFR 40.65 and per License Condition (LC) 12.1.

Emissions from the Willow Creek facilities will be determined based on the following assumptions and measurements.

Radon

The amount of radon released to the environment from the Willow Creek facilities will be estimated in accordance with Method 1 as described below. Method 1 has been revised from the previous version (as submitted to NRC on June 5, 2015) based on requests for additional information (RAIs) from the NRC in a letter dated August 1, 2016 (NRC, 2016). The previously proposed alternate method (Method 2) has been withdrawn from consideration because an approach essentially equivalent to Method 1 has recently been approved by NRC at another ISR facility (NRC, 2015) and is thus expected to be sufficient to produce acceptable estimates of operational releases to the environment of radon gas (Rn-222) and its short-lived radioactive decay products (progeny). The quantities of radon gas and radon progeny emitted will be reported to the NRC in agreement with 10 CFR 40.65 and as per LC12.1.

Method Number 1

General Approach

The quantity of radon gas effluent from the Christensen Ranch (CR) satellite facility and Irigaray processing plant will be fundamentally based on the differential between measured radon gas in incoming pregnant lixiviant solutions, and measured radon gas in outgoing reinjection and disposal solutions. Samples of these solutions will be collected semi-annually and analyzed for dissolved radon-in-water using American Society for Testing and Materials test method ASTM D 5072-9 (a liquid scintillation counting technique).[1] For simplicity, this approach is referred to

[1] At some point, Uranium One may opt to purchase a Durridge Rad 7 instrument or similar technology that allows for onsite radon-in-water measurements.

herein as the "mass-balance" approach, and it accounts for all point and diffuse sources of radon gas releases at the CR satellite ion exchange (IX) plant, as well as subsequent releases at the Irigaray processing plant due to transfers of loaded IX resin and processing of associated uranium into yellowcake product. The mass-balance approach is based on the position that the only source of radon due to ISR operations originates in the ore bodies that are actively mined during the semi-annual monitoring period in question.

In addition to radon gas releases represented by the differential between incoming lixiviant solutions and outgoing solutions that are recycled in the ISR mining process for reinjection back into the wellfields, there is a small fraction of outgoing solutions (a "bleed" stream) that is diverted for disposal in order to maintain a hydraulic gradient in the wellfields towards the recovery wells. Bleed solutions are fed through a reverse osmosis (RO) water treatment unit and a degas column before being routed to the deep disposal well or RO evaporation ponds. This disposal stream will be sampled for radon-in-water just before the RO unit, and all dissolved radon in this outgoing stream will be conservatively assumed to be released to the environment as there may be further releases from the RO evaporation ponds that cannot be readily measured.

With respect to releases of radon decay products (progeny), radiological equilibrium between radon gas and its short-lived will be assumed and thus, the total amount of radioactivity from radon progeny released to the environment will be assumed equivalent to that of radon gas as estimated based on measurements of radon gas. This applies to releases based on the mass balance approach (semi-annual radon-in-water measurements), as well as for releases not accounted for by the mass-balance approach.

For radon gas and progeny releases not accounted for by the mass-balance monitoring approach, including releases from recovery wellheads in the wellfields[2], and releases from wellfield header houses and the deep disposal well house (modular buildings), Uranium One will conduct passive quarterly monitoring of radon gas with alpha track etch detectors in a representative subset of recovery wellhead boxes (5 representative wellheads per operational wellfield) and within each modular building. For wellhead releases, Uranium One will conservatively assume that the average rate of air released to the environment from each recovery wellhead is equivalent to the typical air sampling flow rate employed for radon progeny measurements with the modified Kusnetz method (e.g. 2 liters per minute).[3] This release rate, along with the elapsed time of the monitoring period and the radon gas concentration measured with track etch detectors in the wellhead boxes, will be used to calculate estimates of radon gas released from each wellhead.

Because it would be unrealistic and inaccurate to assume that all radon gas measured with track etch detectors within wellhead boxes and modular buildings will be attributable to ISR operations, a "net" concentration of radon due to operational radon releases from each wellhead will be estimated by subtracting the average ambient background concentration in

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[2] Injection wells are not vented to the atmosphere. Passive releases of radon from the wellfields are thus limited to recovery wellheads and header houses.

[3] This assumption was recently approved by the NRC for the same application at another ISR facility (NRC, 2015).

local outdoor air,[4] from the radon concentration measured with track etch detectors within each recovery well box (i.e. Uranium One will assume that the background concentration of radon within each wellhead box is equivalent to that of measured background radon in local outdoor air, and will not attribute this background radon to ISR operations). If the calculated "net" indoor radon concentration for a given wellhead is zero or a negative number, it will be assumed that no radon gas due to ISR operations was released from that wellhead, and a conservative value of zero will be used for averaging purposes. The average net radon release (as measured/calculated above) will be assigned to each individual operational recovery wellhead, and this value will be multiplied by the total number operational wellheads to represent the total amount of radon released from the wellfields due to ISR operations. The total radon progeny release from the wellfields will be assumed equivalent to the total measured/calculated release of radon gas from the wellfields (i.e. assumed equilibrium).

Releases from wellfield header houses and the deep disposal well house will be estimated in a manner similar to that of wellfields, except that the release rate to outside air will be based on the total flow rate of all ventilation fans within each modular building. Also, the "net" concentration of radon attributable to operational radon releases within each modular building (e.g. during bag filter exchanges) will be estimated by subtracting the average ambient background concentration in local outdoor air, from the radon concentration measured with track etch detectors within each modular building (i.e. Uranium One will assume that the background concentration of indoor radon within each modular building is equivalent to that of measured background radon in local outdoor air, and will not attribute this background radon to ISR operations). If the calculated "net" indoor radon concentration for a given modular building is zero or a negative number, it will be assumed that no radon gas due to ISR operations was released from that modular building, and a conservative value of zero will be used for determination of the total radon release from all modular buildings.

With respect to radon gas and radon progeny releases from spills, the most recently measured concentration of dissolved radon gas in the type of solution involved in a given spill (e.g. pregnant lixiviant, reinjection fluid, etc.), will be multiplied by the estimated volume of solution spilled in order to calculate the amount of radon gas released to the atmosphere. It will be assumed for this calculation that all dissolved radon gas in the spilled solution is released to ambient air, and that the amount of radon progeny released is equivalent to that of the radon gas (i.e. assumed equilibrium).

In summary, Method 1 involves measurements only of radon gas, and respective estimates of effluent releases will be assigned to radon progeny releases based on an assumption of radiological equilibrium between the measured radon gas and short-lived radon progeny in air. Although direct measurement of radon progeny (e.g. with the modified Kusnetz method) is not applicable to effluent monitoring under Method 1, radon progeny monitoring will continue in applicable facilities as needed for evaluation of occupational exposures.

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[4] As measured with track etch detectors at local upwind environmental air monitoring station AS-1 (Table Mountain background).

Procedural Details

Incoming Solutions

Incoming lixiviant will be sampled and analyzed by a qualified third-party laboratory for dissolved radon (Rn-222) gas concentration using ASTM D 5072-92 or other suitable methods.[5] The ASTM test method allows for measurement of radon-in-water at concentrations above 2 Bq/L based on liquid scintillation counting (LSC). The un-aerated water will be placed in a vial with as little head space as possible to preserve the radon that is dissolved in solution at the time of sampling. At the laboratory, an aliquot of the sample will be placed into a LSC vial containing a special cocktail comprised of mineral oil and a scintillation "fluor" additive. The sample will be thoroughly mixed causing the radon to diffuse from the sample into the mineral oil due to radon's chemical affinity to the oil over the water. The sample will subsequently be counted on a Liquid Scintillation Counter to obtain the amount of radon in the sample. Other constituents such as Uranium should remain in the water and not diffuse into the mineral oil. There may be a slight positive bias at the surface of the two layers.

In order for this radon-in-water test method to be effective, care has to be taken on collecting the sample. It is important that the source of the water is coming through an un-aerated source. This minimizes the volatilization of radon before the sample can be counted. Additionally, the flow should be steady and consistent and not under pressure such that it mists causing radon to volatilize. Uranium One ensures this by collecting samples at special sample ports. The sample ports allow collection of solutions from pressurized lines with minimal volatilization of dissolved radon gas. An example of a typical sample port is shown in Figure 1 (the flow from the port is less or equal to that of a household faucet, and the pressure on the line at the time of sampling was 100 psi).

Figure 1

When sampling the water for dissolved radon gas, Uranium One will use a glass 1 L beaker to collect a sufficient quantity of the solution. A hose will be attached to the sample port and placed below the water surface to minimize loss of radon. Additionally, the glass beaker will be placed in a 5-gallon bucket to collect any spillage that may occur. All excess solution will be returned to the plant sump for further processing. At the time of sampling, a separate sample collection vial will be placed entirely under the water in the 1-L beaker and capped to essentially eliminate head space in the vial. The sample vial will be sent to a third party laboratory for analysis under proper chain-of-custody.

The incoming lixiviant will be sampled semi-annually at three different locations, including the plant modular building which represents all the incoming wellfield solutions, a sample port at the old CR Plant, and a sample port at the expansion part of the CR Plant. Between the three sample ports a representative weighted average concentration will be calculated. The lixiviant will be tested by a qualified third party laboratory. Once the concentration of the incoming lixiviant is known, a source term quantity for radon gas will be calculated by taking the total

[5] At some point, Uranium One may opt to purchase a Durridge Rad 7 instrument or similar technology that allows for onsite radon-in-water measurements.

amount of solution that entered the plant during the previous semi-annual period and the concentration provided by laboratory analysis using the following equation.

$$Radon\ Activity\ in\ Incoming\ Solutions\ (pCi) = \frac{pCi}{L} * \frac{L}{0.264 Gallons} * \frac{Gallons}{Minute} * Minutes$$

Outgoing Solutions

The injection trunk line in the CR satellite plant modular building carries all barren solution that is to be reinjected back into the wellfield. A sample port will be installed on this line and the solution will be sampled in the same manner indicated above for incoming lixiviant solution. Samples of outgoing solution will also be analyzed using the ASTM D 5072-92 method (or other suitable methods) to obtain a radon concentration. Bleed solutions that are disposed of at the deep disposal well or RO evaporation ponds will be sampled at a sample port right before the reverse osmosis unit. This sample will also be analyzed using ASTM D 5072-92 method. Using the amount of reinjection solution going back to the wellfield, and disposal solution routed to the deep disposal well or RO ponds, the total activity of radon gas in the outgoing solutions streams will be calculated as follows.

$$Radon\ Activity\ in\ Outgoing\ Solutions\ (pCi) = \frac{pCi}{L} * \frac{L}{0.264 Gallons} * \frac{Gallons}{Minute} * Minutes$$

Although this equation applies to both outgoing solution streams (reinjection and disposal streams), respective quantities will be calculated separately as each value will be treated separately in the overall equation for releases of radon gas from all sources (presented later).

Other Radon Releases

For radon gas and progeny releases not accounted for by the mass-balance monitoring approach, including passive releases from recovery wellheads in the wellfields[6], and releases from wellfield header houses and the deep disposal well house (modular buildings), Uranium One will conduct passive quarterly monitoring of radon gas in air with alpha track etch detectors in a representative subset of recovery wellhead boxes (5 representative wellheads per operational mine unit) and within each modular building. The 5 wellheads to be monitored with track etch detectors in each mine unit will be randomly selected (e.g. with a random number generator). For wellfield releases, Uranium One will assume that the rate of air released to the environment from each recovery wellhead is equivalent to the typical air sampling flow rate employed for radon progeny measurements with the modified Kusnetz method (e.g. 2 liters per minute).[7] This release rate, along with the elapsed time of the monitoring period and the radon gas concentration measured with track etch detectors in the wellhead boxes, will be used to calculate estimates of radon gas released from each wellhead.

Because it would be unrealistic and inaccurate to assume that all radon gas measured with track etch detectors within wellhead boxes and modular buildings will be attributable to ISR operations, a "net" concentration of radon due to operational radon releases from each

[6] Injection wells are not vented to the atmosphere. Passive releases of radon from the wellfields are thus limited to recovery wellheads and header houses.

[7] This assumption was recently approved by the NRC for the same application at another ISR facility (NRC, 2015).

wellhead will be estimated by subtracting the average ambient background concentration in local outdoor air[8], from the radon concentration measured with track etch detectors within each recovery well box (i.e. Uranium One will assume that the background concentration of radon within each wellhead box is equivalent to that of measured background radon in local outdoor air, and will not attribute this background radon to ISR operations). If the calculated "net" indoor radon concentration for a given wellhead is zero or a negative number, it will be assumed that no radon gas due to ISR operations was released from that wellhead, and a conservative value of zero will be used for averaging purposes. The average net radon release (as measured/calculated above) will be assigned to each individual operational recovery wellhead, and this value will be multiplied by the total number operational wellheads to represent the total amount of radon gas released from the wellfields due to ISR operations. The equation for calculation of the total radon gas activity released from all operational wellheads is as follows:

$$WH_{Rn}\ Effluent\ (\mu Ci) = B * \left[Average\ Concentration\left(\mu\frac{Ci}{ml}\right) * Emission\ rate\left(\frac{ml}{min}\right) * Time\ (\text{min})\right]$$

Where WH_{Rn} Effluent = total amount of radioactivity in radon gas released to environment from all operational recovery wellheads in wellfields

B = total number of operational recovery wells in all mine units

Average Concentration = average *net* radon gas concentration from monitored wells (after subtraction of average value for Table Mountain background radon station AS-1)

Emission Rate = typical flow rate for Kusnetz radon progeny air sampling (e.g. 2 L/min)

Time = duration of semi-annual monitoring period

The total radon *progeny* effluent release from recovery wellheads in the wellfields will be assumed equivalent to the total effluent release of radon gas from all operational recovery wellheads as measured/calculated above (i.e. assumed equilibrium).

Releases from wellfield header houses and the deep disposal well house will be estimated in a manner similar to that of wellfields, except that the release rate to outside air will be based on the total flow rate of all ventilation fans within each modular building. Also, the "net" concentration of radon attributable to operational radon releases within each modular building (e.g. during bag filter exchanges) will be estimated by subtracting the average ambient background concentration in local outdoor air as measured with track etch detectors, from the radon concentration measured with track etch detectors within each modular building (i.e. Uranium One will assume that the background concentration of indoor radon within each modular building is equivalent to that of measured background radon in local outdoor air, and will not attribute this background radon to ISR operations). If the calculated "net" indoor radon concentration for a given modular building is zero or a negative number, it will be assumed that no radon gas due to ISR operations was released from that modular building, and a conservative value of zero will be used for determination of the total radon release from all modular buildings. The equation for calculation of the total radon activity released from modular buildings is as follows:

[8] As measured with track etch detectors at local upwind environmental air monitoring station AS-1 (Table Mountain background).

$$MB_{Rn}\ Effluent\ (\mu Ci) = \sum_{i=1}^{n}\left[Concentration\left(\frac{\mu Ci}{ml}\right) * Emission\ rate\left(\frac{ml}{min}\right) * Time\ (\text{min})\right]_i$$

Where MB_{Rn} Effluent = total amount of radioactivity in radon gas released to environment from all modular buildings (header houses and deep disposal well house)

i = calculated radon effluent released from i^{th} modular building

Concentration = average *net* radon gas concentration for i^{th} modular building (after subtraction of average value for Table Mountain background radon station AS-1)

Emission Rate = total ventilation rate for all exhaust fans in i^{th} modular building

Time = duration of semi-annual monitoring period

The total radon *progeny* effluent release from modular buildings will be assumed equivalent to the total release of radon gas from the modular buildings as measured/calculated above (i.e. assumed equilibrium).

With respect to radon gas and radon progeny releases from significant spills or leaks, the most recently measured concentration of dissolved radon gas in the type of solution involved in a given spill (e.g. pregnant lixiviant, reinjection fluid, etc.), will be multiplied by the estimated volume of solution spilled in order to calculate the amount of radon gas released to the atmosphere. It will be assumed for this calculation that all dissolved radon gas in the spilled/leaked solution is released to ambient air. The formula for this calculation is as follows:

$$SS_{Rn}\ (\mu Ci) = \sum_{i=1}^{n}\left[Concentration\left(\frac{\mu Ci}{ml}\right) * Spill\ Volume\ (ml)\right]_i$$

Where SS_{Rn} Effluent = total amount of radioactivity in radon gas released to environment from all solution spills/leaks

i = calculated radon effluent released from i^{th} spill/leak of solution

Concentration = most recently measured radon gas concentration in type of solution involved in i^{th} spill/leak

The total radon *progeny* effluent release from all solution spills/leaks within the semi-annual monitoring period will be assumed equivalent to the total release of radon gas from all spills/leaks as measured/calculated above (i.e. assumed equilibrium).

Calculation of Overall Radon Effluent Releases from All Sources

To summarize, the overall calculation of total semi-annual losses of radon gas to the environment from ISR operations (radon gas effluent) will be estimated by subtracting the dissolved radon gas in outgoing reinjection solutions from the radon gas in incoming pregnant lixiviant, and adding additional radon releases from the outgoing disposal solutions, along with releases from recovery wellheads, modular buildings, and from solution spills or leaks. The following equation will be used to calculate the overall emission of effluent radon gas during each semi-annual monitoring period:

$$Total\ Radon\ Effluent\ from\ all\ Sources\ (\mu Ci) = (S_{in} - S_{out}) + S_{disp} + WH_{Rn} + MB_{Rn} + SS_{Rn}$$

Where S_{in} = radon gas in incoming pregnant lixiviant solution (µCi)

S_{out} = radon gas in outgoing reinjection solution (µCi)

S_{disp} = radon gas released from outgoing disposal solutions (µCi)

WH_{Rn} = radon gas released from wellheads (µCi)

MB_{Rn} = radon gas released from modular buildings (µCi)

SS_{Rn} = radon gas released due to major solution spills/leaks (µCi)

Alternative Method Number 2

This formerly proposed alternate method for monitoring radon effluents has been withdrawn from consideration as an approach essentially equivalent to Method 1 has recently been approved by NRC at another ISR facility (NRC, 2015) and is thus believed sufficient to produce acceptable estimates of operational releases to the environment of radon gas and radon progeny. All previous discussion of Method 2 from the June 5, 2015 submittal from Uranium One to the NRC has been eliminated from this submittal and from any further consideration.

Particulates

All previous discussion of monitoring for radionuclides in air particulates from the June 5, 2015 submittal from Uranium One to the NRC has been retained without any additional edits or revision. That material is not repeated here (in response to August 1, 2016 RAI's from the NRC regarding License Condition 11.3), but corresponding proposals remain in effect.

References

U.S. Nuclear Regulatory Commission (NRC). 2016. Letter from NRC to Uranium One regarding "Uranium One, USA, Inc., Willow Creek Project, Campbell and Johnson Counties, Wyoming, Source Materials License SUA-1341, U.S. Nuclear Regulatory Commission Staff Comments on Submittals in Response to License Condition 11.3 (TAC No. J00711)". Letter received by Uranium One on August 1, 2016. ADAMS accession number ML ML16203A041.