January 6, 2016

Mr. Larry Teahon, Manager
SHEQ
Cameco Resources
Crow Butte Operation
86 Crow Butte Road
P.O. Box 169
Crawford, NE 69339-0169

SUBJECT: U.S. NUCLEAR REGULATORY COMMISSION VERIFICATION REGARDING LICENSE CONDITION 11.11, CROW BUTTE RESOURCES, INC., CRAWFORD, NEBRASKA, LICENSE NO. SUA-1534 (TAC NO. L00762)

Dear Mr. Teahon:

By letter dated January 2, 2015 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15009A031), Cameco Resources Crow Butte Operation (Cameco) submitted to the U.S. Nuclear Regulatory Commission (NRC) staff a response to license condition (LC) 11.11 of SUA-1534 providing information on its proposed operational airborne effluent and environmental monitoring program for the Crow Butte Project for NRC written verification. The NRC staff previously accepted this response for a detailed technical review (refer to NRC letter dated April 2, 2015 (ML15090A526)). Subsequent to the NRC staff's acceptance of the January 2, 2015, response, Cameco submitted additional responses in letters dated June 30, 2015 (ML15217A332) and September 21, 2015 (ML15310A373) and e-mails dated November 24, 2015 (ML15335A040) and December 4, 2015 (ML15341A030). The original January 2, 2015, letter and subsequent revisions are collectively referred to as the submittal.

The NRC staff has completed its technical review of the licensee's submittal. This letter transmits the NRC staff's review and verification that the requirements of LC 11.11 have been met.

The NRC staff's review of Cameco's response to LC 11.11 is documented in the enclosed evaluation. The evaluation documents the NRC staff's conclusion that Cameco's proposed airborne effluent and environmental monitoring program for the Crow Butte Project meets the requirements of 10 CFR 20.1302, 10 CFR 20.1501, 10 CFR 40.65 and 10 CFR Part 40, Appendix A, Criteria 7 and 8, and is protective of public health, safety and the environment.

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, please contact me at 301-415-6443, or by e-mail at Ronald.Burrows@nrc.gov.

Sincerely,

/RA/

Ronald A. Burrows, Project Manager
Uranium Recovery Licensing Branch
Division of Decommissioning, Uranium Recovery,
and Waste Programs
Office of Nuclear Material Safety
and Safeguards

Docket No.: 40-8943
License No.: SUA-1534

Enclosure:
The NRC Staff Verification of Airborne Effluent
and Environmental Monitoring Program

cc: D. Miesbach, NDEQ
D. Pavlick, CBR

If you have any questions, please contact me at 301-415-6443, or by e-mail at Ronald.Burrows@nrc.gov.

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DATE	12/10/2015	12/17/2015	1/6/2016	1/6/2016

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U.S. Nuclear Regulatory Commission
Staff Verification of Airborne Effluent and Environmental Monitoring Program
Cameco Resources Crow Butte Operation
License Condition 11.11
Source Material License SUA-1534

BACKGROUND

By letter dated November 5, 2014 (NRC, 2014a), the U.S. Nuclear Regulatory Commission (NRC) staff renewed Crow Butte Resources, Inc.'s (CBR's or the licensee's) Source and Byproduct Materials License SUA-1534 (license) for the extraction and recovery of uranium source material at its Crow Butte *In Situ* Recovery (ISR) Project. License Condition (LC) 11.11 of the renewed license requires CBR to submit an operational airborne effluent and environmental monitoring program for NRC staff's written verification. Specifically, LC 11.11 requires the licensee to submit the following information:

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

B. Evaluate the member(s) of the public likely to receive the highest exposures from licensed operations consistent with 10 CFR 20.1302;

C. Discuss and identify how radon (radon-222) progeny will be factored into analyzing potential public dose from operations consistent with 10 CFR Part 20, Appendix B, Table 2; and,

D. Discuss how, in accordance with 10 CFR 20.1501, the occupational dose (gaseous and particulate) received throughout the entire License Area from licensed operations will be accounted for, and verified by, surveys and/or monitoring.

By letter dated January 2, 2015 (Cameco, 2015a), and as revised by letters dated June 30, 2015 (Cameco, 2015b) and September 21, 2015 (Cameco, 2015c) and e-mails dated November 24, 2015 (Cameco, 2015d) and December 4, 2015 (Cameco, 2015e) (collectively considered "the submittal"), the licensee submitted to the NRC staff a response to LC 11.11, and addressed the NRC staff's Request for Additional Information (RAI), providing information on its operational airborne effluent and environmental monitoring program for the Crow Butte Project.

The purpose of this evaluation is limited to the NRC staff reviewing the proposed operational airborne effluent and environmental monitoring program. The NRC staff previously evaluated other aspects of the licensee's effluent and environmental monitoring program, as documented in the Safety Evaluation Report (SER) for the renewed license (NRC, 2014a) and the verification of the operational soil sampling program (NRC, 2015).

REGULATORY REQUIREMENTS

The requirements related to an operational airborne effluent and environmental monitoring program are found in 10 CFR 20.1302, 10 CFR 20.1501, 10 CFR 40.65 and 10 CFR Part 40, Appendix A, Criteria 7 and 8. The NRC staff evaluated Cameco's submittal against the acceptance criteria in Section 5.7.7.3 of NUREG-1569, Standard Review Plan for In Situ Leach Uranium Extraction License Applications.

TECHNICAL EVALUATION

In accordance with LC 11.11, the licensee submitted an operational airborne effluent and environmental monitoring program to address the requirements of 10 CFR 20.1302, 10 CFR 20.1501, 10 CFR 40.65 and 10 CFR Part 40, Appendix A, Criteria 7 and 8. The NRC staff reviewed the licensee's program for compliance with these requirements. This evaluation presents the results of this review.

LC 11.11 A. *Discuss how, in accordance with 10 CFR 40.65, the quantity of the principal radionuclides from all point and diffuse sources will be accounted for, and verified by, surveys and/or monitoring.*

As required by 10 CFR 40.65, a licensee is required to submit a semiannual report that specifies the quantity of radionuclides released to unrestricted areas in liquid and in gaseous effluents.

The licensee identified three primary sources of airborne effluents at the Crow Butte Project. These sources include the main plant, wellfield, and the wellhouses.

Main Plant

In its submittal, the licensee provided a description of its facility and operations that had the potential for releasing gaseous and particulate radionuclides to unrestricted areas. Additional information on the licensee's facility related to effluents can be found in its license renewal application (refer to Section 3 and 4 of Cameco, 2007) and its description of the ventilation system for the Crow Butte facility (Cameco, 2014, and Crow Butte clarification to Comment 2 for RAI 1 in Cameco, 2015c).

Radon and radon progeny

To derive the quantity of radon and radon progeny (radon "progeny" are also referred to as radon "daughters") released from the main plant, the licensee will take measurements within the main plant and at tank vents that are directed outside of the main plant. In this manner, the licensee will account for all radon and radon progeny released from this effluent source. The details of these efforts are described below.

Within the main plant, the licensee will measure radon gas using track etch detectors at six different locations to determine the ambient radon gas concentrations (for a description of a typical radon track etch detector, see Landauer, 2013 and page 11 of UR Energy, 2013). The licensee uses the modified Kusnetz method to determine working levels as approved in its current license (for a description of this program, refer to Section 5.7.4.3.2 of the SER (NRC,

2015)). Working level measurements measure the activity of short-lived radon progeny. The short-lived radon progeny deliver the majority of the dose in a typical radon exposure scenario. After the concentrations of the radon and radon progeny are measured, the licensee will calculate a total ambient facility effluent by applying the flow rate for each of the facility exhaust fans and assuming that the fans are operational 100 percent of the time.

In addition to measuring the ambient levels of radon in the main plant, the license will also use a scintillation cell to measure radon gas at each tank vent (for a description of a typical scintillation cell, see the technical specifications in Uranerz, 2014). These radon gas measurements will be performed at a minimum of once per quarter and taken during the highest predicted concentrations. Radon progeny will be measured concurrently with radon gas from the tank vents. After the concentrations of the radon and radon progeny are measured, the licensee will calculate a total tank vent effluent by applying the flow rate for each of the tank vent exhaust fans.

Particulates

The licensee is required by LC 10.8 to conduct isotopic analyses for alpha- and beta-emitting radionuclides at each in-plant air particulate sampling location to demonstrate compliance with 10 CFR 20.1204(g). This is discussed in further detail in the NRC staff's evaluation of LC 11.11 D below.

For the purposes of responding to LC 11.11 A, the licensee utilized the results of the isotopic analyses for alpha- and beta-emitting radionuclides and applied the flow rate of air from the main plant exhaust fans (approximately 49,780 cubic feet per minute, not including tank vents) to derive an annual activity of these radionuclides released from this source. The licensee took actual measurements of natural uranium, thorium-230, radium-226, and lead-210. The activities of thorium-234 and polonium-210 were derived based on the measured activities of natural uranium and lead-210, respectively, and assuming equilibrium conditions.

Effect of Open Doors on Effluent Measurements

The NRC staff observes that the main plant at the Crow Butte facility includes several large roll-up, garage style doors (refer to Tank Vent Locations and Piping Revised Figure of Cameco, 2015c). In response to an RAI regarding this potential flow path, the licensee referred to its ventilation study of the Crow Butte facility (for a description of the testing methodology, equipment, and results, refer to Cameco, 2014). The licensee's ventilation study concluded that as the doors were moved to various positions, air velocity, and also air flow, measurements did not vary more than approximately 10 percent. According to the licensee, this is comparable to typical variations in air flow operation over the course of time. As a result, the licensee concluded that the flow of air through the main facility is primarily through the vents and blowers and not the doors themselves.

Based on the data presented by the licensee, the NRC staff has reasonable assurance that the licensee's proposed approach for measuring radon and its progeny and particulates from the main plant, as described above, will be effective in determining total effluents from this source.

Wellfield

Radon and radon progeny

The licensee identified two potential sources of radon in the wellfield. The first potential source of radon is when wellheads are opened to the atmosphere to depressurize a wellhead that has become pressurized (for a typical uranium recovery production wellhead, see Figure 3.1-7 of Strata, 2010). When these wellheads are depressurized, the licensee will obtain a grab sample using a scintillation cell. The licensee has committed to sampling at least one wellhead per quarter.

The other potential sources of radon in the wellfields include unplanned releases of process fluids resulting from spills. The amount of radon released will be estimated based on the amount of fluid released and an estimate of the concentration of radon in the process fluid. The licensee will assume that all radon in the fluid is released to the atmosphere.

Particulates

The NRC staff has determined that the wellfield is not a significant source of annual particulate emissions. While it is possible for contaminants in the process fluids to become airborne at some point in the future, for example after a spill has dried and the soil in the location of the spill has been disturbed, it is not expected that this will contribute significantly to quantities required to be reported in accordance with 10 CFR 40.65. In any case, particulates released in this scenario will be monitored by the licensee's environmental monitoring stations. The licensee's environmental monitoring program for air particulates is described in Section 5.8.7 of Cameco, 2009 and in the Figure titled "Regional Sampling Locations" in Cameco, 2015f.

Based on the description of its operations and the methodology presented by the licensee, the NRC staff has reasonable assurance that the licensee's proposed approach for determining the amount of radon and its progeny released from the wellfield, as described above, will be effective in determining total effluents from this source.

Wellhouses

Radon and radon progeny

A wellhouse (also known as a wellfield header house) is a structure in the wellfield that the licensee uses to control the fluid (i.e., lixiviant) flow to and from wells in the mine unit production patterns (for a typical uranium recovery wellhouse, see Figure 3.1-9 of Strata, 2010). The licensee will measure radon in the wellhouses using track etch detectors with a six-month exposure time. The licensee will use the average radon concentration along with the flow rate of the wellhouse exhaust fan to determine the total radon released from the wellhouses. Four production and four restoration wellhouses will be monitored annually in this manner. The wellhouse exhaust fans are operated on a continual basis. The average radon emissions from each of these groups of wellhouses (i.e., production and restoration) will be attributed to the remaining operational wellhouses in each of these groups. The wellhouses to be sampled in each group will be rotated annually so that each wellhouse is sampled over time.

Radon daughters will be measured semi-annually in the wellhouses where radon gas is being measured. The licensee will determine the total radon daughters released in the same manner as the radon gas using the flow rate of the wellhouse exhaust fan.

Particulates

The licensee will estimate the emission of particulate releases based on isotopic analyses of semiannual air particulate samples performed in each of the wellhouses that are monitored for radon. The exhaust rate of the wellhouses will be the same as described above for the radon emissions.

Based on the description of its operations and the methodology presented by the licensee, the NRC staff has reasonable assurance that the licensee's proposed approach for determining the amount of radon, its progeny and particulates released from the wellhouses, as described above, will be effective in determining total effluents from this source.

Based upon the review conducted by the NRC staff as indicated above, the information provided in Cameco's submittal meets the applicable acceptance criteria of Section 5.7.7.3 of NUREG-1569 and the requirements of 10 CFR 20.1302, 10 CFR 20.1501, 10 CFR 40.65 and 10 CFR Part 40, Appendix A, Criteria 7 and 8.

LC 11.11 B. *Evaluate the member(s) of the public likely to receive the highest exposures from licensed operations consistent with 10 CFR 20.1302.*

The licensee utilized the MILDOS-AREA computer code to estimate the location and dose to the maximally exposed member of the public. The MILDOS-AREA computer code calculates the radiological dose commitments received by individuals within an 80-km radius of an operating uranium recovery facility. For a detailed description of the MILDOS-AREA computer code, or to obtain a copy, see the reference in ANL, 2015.

As inputs to the MILDOS-AREA model, the licensee evaluated the radon source terms at its site, categorized as either a mine unit (Mine Units 2-10) or the Central Processing Plant (CPP). To obtain estimated release rates, the licensee input values into MILDOS-AREA for ore grade, radium-226 content in ore, flow rates, etc. For a description of MILDOS-AREA input parameters, see the MILDOS-AREA User's Guide in ANL, 2015. The licensee also performed a sensitivity analysis to determine if the wellfields were best represented by a point source or an area source geometry. Actual environmental monitoring data from the Crow Butte site were compared to MILDOS-AREA predictions to make this determination. Based on this analysis, the licensee concluded that the wellfields were best represented by an area source geometry.

To determine the maximum estimated dose from its operations, the licensee included actual and potential receptors in its analysis. Actual receptors included nearby residents with full-time occupancy. Potential receptors included members of the public that could spend at least 50 hours per year in the vicinity of the site. The potential receptors were determined by the licensee to include a delivery person (130 hours per year), and ranchers performing haying (160 hours per year) and cattle (416 hours per year) activities. These potential receptors were modeled at various locations and distances around the CPP. In addition, the licensee modeled 265 locations throughout the site assuming 2000 hours per year occupancy.

Based on the MILDOS-AREA modeling discussed above, the maximum estimated dose from the licensee's operations occurs at the Gibbons residence. The maximum estimated dose is 30.6 mrem/year. The MILDOS-AREA estimate includes the external dose from groundshine and cloudshine as a result of airborne releases and therefore represents an estimate of the total effective dose equivalent (TEDE). The regulatory limit of the TEDE to a member of the public specified in 10 CFR 20.1301 is 100 mrem/year.

The NRC staff observes that the licensee identified a new residence during its 2014 land use survey required by LC 11.2 (refer to the licensee's response to Administrative Issue 1. In Cameco, 2015c). This residence is referred to as "Edelman." According to the licensee, an air monitoring station was located near this residence in January, 2015, to begin monitoring this location as the nearest residence. The NRC staff will review the results of this monitoring during future planned inspections and reviews of its analysis of dose to individual members of the public required by LC 11.2.

Based on the description of its operations and the methodology presented by the licensee, the NRC staff has reasonable assurance that the licensee's approach for determining the maximally exposed member of the public, as described above, meets the requirements of 10 CFR 20.1302.

LC 11.11 C. *Discuss and identify how radon (radon-222) progeny will be factored into analyzing potential public dose from operations consistent with 10 CFR Part 20, Appendix B, Table 2.*

The licensee stated that compliance determination for the maximally exposed member of the public will be based upon measurements of the average radon concentration at the receptor location (Cameco, 2015c). The licensee also provided the following equation that it will use in calculating the dose from radon and its progeny to the maximally exposed member of the public:

$$D = DCF \sum_i C_i F_i T_i$$

Where:

D = annual dose (TEDE) (mrem/yr)

DCF = dose conversion factor for Rn-222 with 100% equilibrium factor with its progeny from 10 CRF 20 Appendix B - 500 mrem/yr per pCi Rn/L

C_i = annual average concentration of Rn-222 in air (pCi/L) at the receptor location

F_i = radon equilibrium factor at the receptor

T_i = occupancy factor for the receptor

The licensee will use a value of 50 percent (i.e., 0.5) for the equilibrium factor (F_i) and will determine the occupancy factor (T_i) based on an assessment of actual residency time. In an

attempt to mitigate uncertainty in the measurement method, the licensee will increase the number of track etch detectors at the background and receptor locations to six. (Cameco, 2015c)

The NRC staff finds the licensee's approach for including the dose from radon progeny in its exposure assessment of members of the public consistent with 10 CFR Part 20, Appendix B, Table 2, and the guidance in NRC, 2014b, and therefore acceptable.

LC 11.11 D. *Discuss how, in accordance with 10 CFR 20.1501, the occupational dose (gaseous and particulate) received throughout the entire License Area from licensed operations will be accounted for, and verified by, surveys and/or monitoring.*

The licensee described its methodology for accounting for, and verifying by surveys and monitoring, the occupational dose (gaseous and particulate) received by its workers throughout the entire License Area from its licensed operations.

Exposure to radon and radon progeny

The modified Kusnetz method is used to determine the number of working levels in the main plant (Cameco, 2015c). See NRC staff's evaluation for LC 11.11 A above for details on this program as well as Section 5.8.3.2 of Cameco, 2009. In addition, wellhouses and deep disposal well buildings will be sampled at least quarterly using the modified Kusnetz method (Cameco, 2015c). The licensee will determine routine occupancy times for the main plant by assuming 100 percent occupancy time for the entire twelve hour shift (Cameco, 2009). For wellhouses and deep disposal well buildings, occupancy times will be estimated based on time studies that will be evaluated annually (Cameco, 2015c). For wellfield personnel, the licensee reasoned that since the concentration of radon daughters is higher in the main plant than the concentration of radon daughters in the wellfield, and the difficulty in sampling all areas of the wellfield accurately, the license will use the concentration of radon daughters in the main plant and assign wellfield personnel 100 percent occupancy at the main plant concentration. The NRC staff reviewed measured working levels in the wellfield and the main plant (Cameco, 2015d, 2015e) and finds this method acceptable. Using the measured working levels and the occupancy times of the workers, the licensee will calculate the worker exposure as described in Section 5.8.4 of its renewal application (Cameco, 2009).

Exposure to airborne particulates

The licensee will perform air sampling for particulate radionuclides in the wellhouses, deep disposal well buildings, and the main plant. The license stated that it will analyze for natural uranium, thorium-230, radium-226, and lead-210 on a semiannual basis. Worker exposure will be based upon air sample results and occupancy times for the area of exposure (i.e., main plant, etc.). For non-routine work, the licensee will evaluate the worker exposure through the use of a radiation work permit.

The NRC staff observes that the licensee is required by LC 10.8 of its current license (NRC, 2014a) to conduct isotopic analyses as follows:

10.8 The licensee shall conduct isotopic analyses for alpha- and beta-emitting radionuclides on airborne samples at each in-plant air particulate sampling location at a frequency of once every six months for the first two years and annually thereafter to ensure compliance with 10 CFR 20.1204(g). For any changes to operations, the licensee shall conduct an evaluation to determine if more frequent isotopic analyses are required for compliance with 10 CFR 20.1204(g).

In response to the NRC staff's RAI 9 and request for clarification, the licensee provided an analysis of other potential radionuclides that were not initially evaluated during its isotopic analyses. Specifically, the licensee evaluated thorium-234, protactinium-234m (both short-lived beta-emitting progeny of uranium-238), bismuth-210 (also a beta-emitter) and polonium-210 (an alpha-emitter). The licensee calculated the Derived Airborne Concentrations (DACs) for these additional radionuclides based on equilibrium activities with their parent radionuclides. Based on these calculations, the licensee determined that it had met the requirements of 10 CFR 20.1204(g).

For alpha-emitting radionuclides, the NRC staff agrees that the licensee has addressed the requirements of 10 CFR 20.1204(g). That is, by using gross alpha activity for determining airborne radioactivity, and using the analysis provided in its September 21, 2015, response (Cameco, 2015c), the licensee is using the total alpha activity of the mixture in determining the dose from these radionuclides as required by 10 CFR 20.1204(g)(1). The licensee also demonstrated that the disregarded alpha-emitting radionuclides are present at less than 10 percent of their respective DACs as required by 10 CFR 20.1204(g)(2). Lastly, the licensee demonstrated that the sum of all these percentages for alpha-emitting radionuclides in the mixture does not exceed 30 percent as required by 10 CFR 20.1204(g)(3).

However, the NRC staff observes that the licensee did not meet the requirement of 10 CFR 20.1204(g)(1) for beta-emitting radionuclides. Specifically, although the calculated DACs and associated doses are low, the licensee did not account for the activity of these beta-emitting radionuclides. As a result of the licensee's analysis, the licensee requested an exemption from 10 CFR 20.1204(g) for including beta-emitting radionuclides in occupational dose calculations. The NRC staff will not address this exemption request in this SER but will address the request in a separate licensing action. Until a decision is made on this exemption request, the licensee is required to comply with LC 10.8 for isotopic analyses and 10 CFR 20.1204(g) for all occupational doses.

Based on the description of its operations and the methodology presented by the licensee, as well as conditions in its license, the NRC staff has reasonable assurance that the licensee's approach for determining occupational dose (gaseous and particulate) received throughout the entire License Area from licensed operations, as described above, meets the requirements of 10 CFR 20.1501.

CONCLUSION

The NRC staff has reviewed the licensee's proposed operational airborne effluent and environmental monitoring program for consistency with the acceptance criteria in NUREG-1569. Based on the information provided in Cameco's submittal and the NRC staff's review discussed in this evaluation, the NRC staff concludes that the proposed operational airborne effluent and environmental monitoring program for the Crow Butte Project meets the requirement of 10 CFR 20.1302, 10 CFR 20.1501, 10 CFR 40.65 and 10 CFR Part 40, Appendix A, Criteria 7 and 8, and therefore the NRC staff has reasonable assurance that public health, safety and the environment will be protected.

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