August 26, 2014

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SUBJECT: U.S. NUCLEAR REGULATORY COMMISSION REVIEW OF FINAL REPORT: VEGETATION SAMPLING FOR DEPLETED URANIUM, SCHOFIELD BARRACKS, OAHU, HAWAII (DOCKET NUMBER 040-09083)

Dear Dr. Cherry:

In April 2014, the U.S. Nuclear Regulatory Commission (NRC) completed its review of the U.S. Army (the Army) Vegetation Sampling Plan for Depleted Uranium at Schofield Barracks, Oahu, Hawaii (ADAMS Package ML14083A460) dated January 15, 2014, which the Army had submitted in accordance with License Condition 23 of source material license SUC-1593 (ML 14027A075). In the cover letter transmitting NRC staff comments on the plan, the NRC found the plan acceptable contingent upon the Army's ability to adequately address the comments identified in Section 4.4 of NRC's Technical Evaluation Report (TER). The NRC staff stated in Section 4.4 of the TER: "Given the ambiguities present in Table 2-2, the staff finds that the Army should include in the documentation of the sampling results a clear description of the methodology used for determining the final sample locations."

On May 29, 2014, the Army submitted a final report, "Final Report: Vegetation Sampling for Depleted Uranium at Schofield Barracks, Oahu, Hawaii," dated March 2014 (ADAMS ML14157A245). However, the final report did not adequately address the ambiguities that the NRC identified previously. Therefore, the conditions upon which the NRC's acceptance of the plan depended have not been met.

The Army concludes in section 8.0 of the final report that "there is no potential for the release of DU [depleted uranium] from the site as vegetation ash during controlled burns, or as dead or decaying vegetation." However, as explained in the enclosure to this letter, the Army has not provided a sufficient discussion and analysis in support of that conclusion. Therefore, the NRC staff finds that the final report does not sufficiently support the Army's conclusion.

Due to: (i) the ambiguities in the sampling plan and (ii) inadequate discussion and analysis of the results, the NRC staff requires additional information in order to reach a conclusion relative to License Condition 23.

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 concerning the NRC staff comments, please contact me at 301-415-6722 or by e-mail at chad.glenn@nrc.gov.

Sincerely,

/RA/
Chad Glenn, Senior Project Manager
Materials Decommissioning Branch
Decommissioning and Uranium Recovery
Licensing Directorate
Division of Waste Management
and Environmental Protection
Office of Federal and State Materials
and Environmental Management Programs

Docket Number: 040-09083
License Number: SUC-1593

Enclosure:
NRC Comments on the Army's Final Report

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NRC Staff Comments on the Army's Final Report

Ambiguities Related to Primary and Alternate Sample Locations

- The NRC staff pointed out in Section 4.4 of the Technical Evaluation Report (TER) that it was unclear if the Army planned to sample from both the Primary and Alternate locations if the Army found elevated gamma readings in both the Primary and Alternate locations (NRC, 2014). Table 3-1 of the original sampling plan listed two primary locations in Area 6 (Primary #1, Primary #2), each with two alternate locations (Alternate #1-1, Alternate #1-2, Alternate #2-1, and Alternate #2-2) (Cabrera Services, 2013). Two coordinates (Easting and Northing) were given for each location. However, the final report shows that the Army sampled from two 10-square-meter areas within Area 6 (Cabrera Services, 2014). The final report lists two 10-square-meter areas: "Area 1-2" and "Area 2-3." It is unclear which of the Primary or Alternate locations these correspond to in Table 3-1 of the original plan. In addition, the Northing and Easting Coordinates from the original plan to the final report do not correspond.
- The Army provides the contours (representing z-score ranges) of a previous gamma scan for the entire Area 6 in Figure 2-2 of the original sampling plan (Cabrera Services, 2013). The Army should also have included the counts per minute (cpm) data results from this previous gamma scan.
- Section 3.2 of the sampling plan states "Field measurements will be performed prior to sampling in order to locate vegetation sample positions in areas most likely to have DU contamination in soil (Area 6)". It is the NRC's interpretation that Section 3.2 of the sampling plan indicated that a second gamma walkover scan of *each* 10-square-meter area (Primary #1, Primary #2, Alternate #1-1, Alternate #1-2, Alternate #2-1, and Alternate #2-2) would be performed prior to sampling in order to locate vegetation sample positions. The final report provides gamma scan data for only two alternate areas and the background reference area instead of for each10-square-meter area.
- It is unclear if the Army intended to perform a second gamma scan on all the Primary and Alternate locations in Table 3-1 of the original plan. Appendix D of the final report provides the raw data results of the Gamma Walkover Survey Data for Alternative Area 1-3, Alternative Area 2-3 and the Background Reference Area (Cabrera Services, 2014). It does not provide gamma survey results for other areas. If they were taken, the gamma readings in the other areas should be included. If the Army did not take gamma readings in the other alternate areas, the Army should describe the reason for not doing so.

Ambiguities Related to Decision Rules for Sampling the Background Reference Area

- The NRC staff highlighted the ambiguities in Table 2-2 of the sampling plan in the TER (NRC, 2014). It is unclear how the Army planned to interpret the gamma readings in order to decide whether or not to collect a sample. The Army did not revise Table 2-2 to resolve the ambiguities in the final report. These ambiguities are discussed below under the next bullets and in the following section on Ambiguities Related to Decision Rules for Sampling the Impacted Area.
- It is unclear whether the Army followed a logical methodology for determining an appropriate background reference area.
- Table 2-2 in the original plan and final report is unclear about the rule for taking background samples. In the first row it directs taking a sample if the average FIDLER

reading is below 12,000 cpm. However, in the second row it instructs to take a sample if no individual area exceeding 12,000 cpm is identified. Finally, the third row directs taking a sample if the average FIDLER reading is less than three standard deviations above background.

- The final report, Section 6.1, states that, "for the reference area, count rates less than 12,000 cpm were reported, so the reference area was acceptable for background vegetation sampling," (Cabrera Services, 2014). This logic does not seem to match any of the rows in Table 2-2. If it is intended to match the first row, then Section 6.1 should state that the mean count rate was below 12,000 cpm. However, if the only requirement was for the mean count rate to be less than 12,000 cpm, then there does not appear to be any distinction between when it is appropriate to take a background sample and when it is appropriate to take a sample from an impacted area.

Ambiguities Related to Decision Rules for Sampling the Impacted Area

- It is unclear whether the Army followed a logical methodology for determining when to collect samples from the impacted area. In Table 2-2, the meaning of "average FIDLER readings" is unclear. If it refers to the average of the readings within the 10-square-meter area, it does not seem that the criteria in Table 2-2 were met for taking the samples. For example, Table 2-2 directs samples to be taken from Area 6 when "Average FIDLER reading less than 12,000 cpm but greater than three standard deviations above background." One could interpret this as the mean value of the readings within the 10-square-meter area must be greater than three standard deviations above the mean value for background. As shown in Section 6.1 of the final report, neither the mean of Area 1-3 (4,955 cpm) nor Area 2-3 (4,787 cpm) is three standard deviations above the background (Cabrera Services, 2014). Those mean values are not even above the mean of the background area (8,625 cpm). Therefore, if average FIDLER reading is intended to be the mean reading in the 10-square-meter area, one can conclude that the samples should not have been collected.
- Also, in Table 2-2, the meaning of "three standard deviations above background" is unclear. The NRC staff interprets this as three standard deviations above the mean of the readings for the background reference area. In Section 6.1 of the final report, the mean of the background area is 8,625 cpm and the standard deviation of the background area is 642 cpm (Cabrera Services, 2014). Therefore three standard deviations above background would be (3*642+ 8625 = 10,551 cpm).
- The final report introduces the concept of a "z-score" into the decision-making. Sections 3.1, 5.1, and 6.1 refer to the z-score without defining it or its relationship to the sampling methodology. Section 3.1 states that Figures 2-5, 2-6, and 2-7 display the z-score range and location for each measurement and Section 5.1 states that gamma walk-over survey data were analyzed to determine z-scores for each 10-square-meter sampling area. Section 6.1 states that areas were identified as acceptable for sampling if the z-score was greater than three (Cabrera Services, 2014). However, Table 2-2 does not use the term z-score. The z-score is based on the mean of the samples within the same area as the sample. It is (x-average)/standard deviation of data set. However, Table 2-2 states that samples should be taken if the average reading is greater than three standard deviations above background (not the mean of the dataset from the sample location). It appears that when the Army says "three standard deviations above background" in Table 2-2, it intends to say "z-score greater than three".

- It appears that the Army used the variability within a 10-square-meter area as the basis for whether or not to take a sample. However, the sampling plan implies that the area should have been compared to a separate non-impacted background reference area. If samples were taken solely based on z-score values, then the purpose of taking the background gamma readings and samples is unclear. The Army does not provide an adequate discussion of whether the gamma readings or samples from the impacted areas are different from those taken from the background reference area.

Comments on the Army's Conclusion

- The Army did not provide sufficient information to support the statement that the data show there is no potential for the release of depleted uranium (DU) from the site as vegetation ash during controlled burns for the reasons described in the bullets below.
- The Army attributes the DU in the one root sample that exceeded the specified action level to thigmotropism (i.e., the roots enveloping a separate uranium metal object) rather than to uptake or adsorption without providing data to support this hypothesis. The final report did not describe the Army's methodology for examining plants for thigmotropism.
- The Army states in Sections 2.3.1 of the sampling plan and final report that the DU at Schofield Barracks was introduced into the environment as uranium metal and fragments found were relatively intact and that because uranium metal oxidizes slowly in the environment and is relatively insoluble in water, the DU is generally considered immobile in the environment and therefore, has limited potential for uranium uptake by plants (Cabrera, 2013; Cabrera, 2014). As the NRC staff discussed in Section 4.4 of the TER (NRC, 2014), these statements contradict the following studies funded and/or submitted by the Army to the NRC previously:
    - The scoping investigation conducted at Schofield Barracks by Cabrera Services reported that oxidized DU fragments and small oxidation products in soils were observed at Schofield Barracks (Cabrera Services, 2008). As described in the LANL study at APG and YPG, dissolution of DU oxidation products in soils by surface runoff can result in DU uptake, attachment, or adsorption in the plants (Ebinger, 1996).
    - The NRC staff notes that prior studies conducted at ranges containing DU at Aberdeen Proving Ground (APG) showed uptake and/or adsorption of DU in plants (Ebinger et. al., 1996; Baltimore Sun, 2000; Henry, 2000). As stated previously (NRC, 2013), Ebinger et. al. confirmed the presence of DU in cattail, milfoil, pickerel weed, seston, and tadpoles at APG, which was attributed to uptake or adsorption (Ebinger et. al., 1996).
    - In another study, Edenspace Systems Corporation conducted an ecological risk assessment study at the Bomb Throwing Device (BTD) range at APG and demonstrated that phytoremediation was effective in removal of DU in soils at the BTD range (Henry, 2000; Baltimore Sun, 2000). The study, conducted over a five-month period in 1999, showed uptake of DU naturally by Indian mustard plants and that uptake increased from 2.32 mg/kg and 2.22 mg/kg during the normal growth phase (i.e., no addition of chemical chelate), to 14.4 mg/kg and 15.7 mg/kg of DU after the addition of chemical chelate (Henry, 2000).
- The Army states that although one washed leaf sample indicated a U-238 to U-234 ratio of 2.4 $\pm$ 2.4, no positive attribution of uranium can be made without more additional isotopic information. The Army should provide additional discussion regarding the

potential for this result to represent a sample with uranium from both natural and depleted uranium sources.

- Because prior studies at APG have shown the potential for uptake and/or adsorption in plants, and the final report lacks a sufficient discussion of the data to support the thigmotropism hypothesis, the staff finds that the Army has insufficiently provided data to support the theory that DU has not been incorporated into the root.

Other Formatting Comments

- The ratios in Table 6.4 in the final report are not legible because of the highlighting in green.
- The cross icon showing the location samples in Figures 2-2 through 2-7 should be transparent so that the gamma reading results directly beneath the icons can be seen.

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Cabrera Services, 2013. *Vegetation Sampling Plan for Depleted Uranium Schofield Barracks*, Oahu, Hawaii, June 2013, ADAMS Accession No. ML14027A076.

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