



July 23, 2009

Ms. Yolande Norman
Materials Decommissioning Branch
Division of Waste Management and Environmental Protection
Office of Nuclear Materials Safety and Safeguard
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Dear Ms. Norman:

This letter, sent on behalf of the U.S. Army, Jefferson Proving Ground (JPG), addresses two questions raised by the U.S. Nuclear Regulatory Commission (NRC) Staff during a teleconference on 15 December 2008 with the U.S. Army (Mr. Paul Cloud) and Science Applications International Corporation (SAIC). The teleconference was convened to discuss the 6 November 2008 letter in which the Army proposed the standard operating procedure (SOP No. ST-IP-0018, Rev. 5) for conducting the JPG partition coefficient (K_d) study. The letter described the site- and uranium-specific analysis parameters for NRC's review and approval. Essentially, the two questions raised during the December 2008 teleconference are paraphrased as follows:

- (1) How will the Army ensure that solubility limits, if exceeded, will not contribute to an overestimation of sorption?
- (2) Which samples will be selected for the K_d study and what is the basis for their selection?

During the teleconference, the Army agreed to provide NRC the list of samples recommended for the adsorption and desorption tests along with the supporting rationale after the analytical laboratory results are available, but before commencing the K_d study. In addition, the Army will provide information about uranium solubility as it pertains to the evaluation of samples for the JPG K_d study. This information is provided below for NRC's review and approval.

The K_d study will provide input on how the uranium is distributed between the solid and aqueous phases both within impacted soils beneath and adjacent to penetrators and in un-impacted (background) soils. Understanding how the uranium is distributed and the tendency to adsorb or desorb are critical to fate and transport predictions. The K_d measurements will be completed on samples representing a wide range of observed soil types and concentrations (observed or expected in both soil and groundwater). Because not all conditions may be readily apparent, literature values may be used to further supplement or support the measured K_d s at the site.

The desorption tests will provide a measure of how much uranium may partition from impacted soils into precipitation that contacts or migrates through impacted soils. Some precipitation may be taken up by plants, evaporate, or migrate vertically to groundwater or laterally with overland flow. The impacted soil also may migrate via overland flow (erosion). Coupling the desorption information with the leachability study on the penetrators will allow the

determination (or estimation) of the time frame and relative magnitude of uranium mass released from the impacted soils. The adsorption tests will provide a measure of how much uranium migrating in soil moisture or groundwater will adsorb or adhere to the soil matrix.

1. Solubility Affects on Sorption

In the December 2008 teleconference, concern was raised that aqueous concentrations could exceed the solubility limit for uranium. It is possible that solid precipitants or complexes in the soil might not be distinguishable from the products adsorbed to the soil within the study. This in effect would generate high values for K_d that if applied to clean soil, or areas of lower concentrations, would over-predict adsorption rates and possibly under-predict the transport of uranium within the soil.

To address this concern, one needs to first examine the way in which the test results will be utilized for modeling purposes at the JPG site. If the soil/water mixture is in equilibrium, the results of the adsorption tests and desorption tests will yield the same values. However, in practice, many factors, including the precipitation mentioned above, will influence these values yielding different distribution coefficients for each test. Though this is true, one does gain valuable information on the system by investigating them separately and in practice, applying them differently. For modeling purposes, the values associated with adsorption testing will be used for the clean soil materials and will dictate how dissolved phase DU moves through the system and adsorbs/desorbs from the soil. Since desorption testing will most likely involve some forms of dissolution from precipitants, it will not yield a value of K_d that will reflect only adhesion to soil particles. In other words, the resulting K_d tests will not be limited to pure sorption processes; instead, the K_d tests will include non-sorption processes that could alter the resulting values for K_d . Therefore, it will not be easily applied to the system away from the source locations, but will be very useful in determining source loading of DU into the system as well as source-zone K_d values. Due to this application of the K_d within the modeling structure, solubility limits are not an issue for desorption testing.

Based on the above descriptions, the solubility issues of concern to the JPG site deal with the suitable range of concentrations for use in the adsorption testing alone. Based on this, a literature search was performed in an effort to quantify the solubility limit of uranium. Some documents reported solubility limits for uranium as high as 10 to 20 mg/L (ORNL 1993, UNEP 2003). While this suggests that uranium is soluble in water under natural conditions, it is unknown how relevant this range of solubility limits is to JPG soils since the highest measured levels of total uranium in JPG water samples are orders of magnitude below these levels. Therefore, as laid out in the 6 November 2008 letter, the samples will be spiked with uranium concentrations ranging from approximately 100 to 1,000 $\mu\text{g/L}$ to simulate the range of concentrations of soil pore water that may occur below DU penetrators. These concentrations are determined to be below the solubility limit of uranium and, therefore, will not cause interference in the distribution coefficient results by precipitation of uranium.

The Army is planning to confirm the results of the K_d study and potentially evaluate temporal impacts that are beyond the limited timeframe available for the K_d study through geochemical modeling. USEPA 1999 supports using this approach and includes an example where MINTEQA2 was used to calculate saturation indexes to examine the apparent increase in

uranium K_d values due to the precipitation of uranium-containing solids and not to uranium adsorption.

2. Sample Selection and Rationale

During the month of October 2008, the Army collected 585 samples from multiple depths at 140 different locations. Overall, total uranium concentrations ranged from -3.25 ± 2.28 pCi/g to $40,694 \pm 238$ pCi/g. The highest detected result was from a sample (JP-PNAC-008/0.0 to 0.25' BLS) collected directly above a partially buried DU penetrator (see picture to the right) located in the remnants of the center trench (i.e., formed due north of the 500-Center firing position). The October 2008 sampling included the collection of soil for the site-specific uranium adsorption and desorption tests across the three soil-type groupings present in the JPG Depleted Uranium (DU) Impact Area. The following summary table, which also was included in the 6 November 2008 letter, provides an overview of the number of samples for each of the 24 tests.



Table 1. Summary of Adsorption and Desorption Testing for the JPG K_d Study

Test	Avonsburg/Cobbsfork	Cincinnati/Rossmoyne	Grayford/Ryker	Total
Adsorption	Soil from 2 background locations	Soil from 2 background locations	Soil from 2 background locations	6
Desorption	8 above/under penetrators	8 above/under penetrators	2 above/under penetrators	18
Total	10	10	4	24

2.1. Adsorption Testing Sample Selection

The first component of the K_d study includes using six different background soil samples spiked with radiotracers or stable tracers to conduct the adsorption tests. Ninety-four samples were collected from depths ranging from surface to 4 feet below land surface (BLS) at 24 background locations. Total uranium concentrations ranged from 1.03 ± 0.242 pCi/g (found in Cincinnati/Rossmoyne soil) to 3.76 ± 0.808 pCi/g (found in Grayford/Ryker soil). As discussed during the December 2008 teleconference, the Army recommended selecting surface soil samples from each of the three soil type groupings with the lowest total uranium concentration selected along with the deepest sample collected from that same location. The following table identifies these samples and summarizes the respective total uranium concentrations for each of the six samples proposed for the six adsorption tests.

Table 2. Proposed Samples for Adsorption Testing

Soil Types	Site ID / Depth BLS (feet)	Total Uranium Concentration (pCi/g)
Avonsburg/Cobbsfork	JP-SAC-004 / 0.0 to 0.5	1.30±0.296
Avonsburg/Cobbsfork	JP-SAC-004 / 2.0 to 4.0	1.36±0.308
Cincinnati/Rossmoyne	JP-SCR-002 / 0.0 to 0.5	1.08±0.250
Cincinnati/Rossmoyne	JP-SCR-002 / 2.0 to 4.0	1.72±0.393
Grayford/Ryker	JP-SGR-001 / 0.0 to 0.5	1.15±0.266
Grayford/Ryker	JP-SGR-001 / 2.0 to 4.0	1.88±0.420

2.2 Desorption Testing Sample Selection

Ninety-six soil samples were collected from under 24 DU penetrators from various depths extending from ground surface (just above penetrators located immediately below ground surface) to 6 feet BLS. Concentrations ranged from 15.4+/-13.3 pCi/g in sample JP-PNAC-005/1.0 at 2.0' BLS to 40,694+/-238 pCi/g in sample JP-PNAC-008/0.0 at 0.25' BLS. Eighteen desorption tests will be conducted using soil obtained from under DU penetrators. Based upon the distribution of soils within the impact area, 8 desorption tests each will be completed for the Avonsburg/Cobbsfork soils and Cincinnati/Rossmoyne soils, and 2 desorption tests will be completed for the Grayford/Ryker soils.

As noted in *Field Sampling Plan (FSP) Addendum 7 – Depleted Uranium Impact Area Site Characterization: Soil Sampling and Analysis, Corrosion Study, Partition Coefficient Study, Modeling Overview, and Slug Testing*, three penetrators were selected for leachability testing. The three penetrators that are being used for leachability testing that commenced in June 2009 include: JP-PNAC-005 (found in Avonsburg/Cobbsfork soil), JP-PNCR-008 (found in Cincinnati/Rossmoyne soil), and JP-PNGR-001 (found in Grayford/Ryker soil). The basis for selecting these penetrators was covered in the Army's 16 March 2009 letter entitled *Selection of Depleted Uranium Penetrators for Leachability Testing, U.S. Army Jefferson Proving Ground, Madison, IN*. Since the K_d study will support the fate and transport evaluation resulting from the corrosion of DU penetrators, soil samples associated with these penetrators were chosen for desorption testing. The total uranium results for soil samples collected under these penetrators are presented in Table 3. These samples represent 10 of the 18 total samples that will be included for desorption testing. Though four samples exist in the Grayford/Ryker soil type below penetrator JP-PNGR-001, only two soil samples, are proposed. The Grayford/Ryker soil type is not a prevalent soil type at the JPG site (representing approximately 11 percent of the DU Impact Area) and though important due to its proximity to surface water bodies, not deemed to be as necessary as data from the Avonsburg/Cobbsfork and Cincinnati/Rossmoyne classifications. No further samples will be examined from the Grayford/Ryker soil formation since the percentage selected (11 percent) is roughly equivalent to the amount of Grayford/Ryker soil present within the DU Impact Area.

Table 3. Proposed Samples for Desorption Testing Collected Under DU Penetrators

Soil Types	Site ID / Depth BLS (feet)	Total Uranium Concentration (pCi/g)
Avonsburg/Cobbsfork	JP-PNAC-005 / 0.0 to 0.5	460±64
Avonsburg/Cobbsfork	JP-PNAC-005 / 0.5 to 1.0	295±59
Avonsburg/Cobbsfork	JP-PNAC-005 / 1.0 to 2.0	15.4±13
Avonsburg/Cobbsfork	JP-PNAC-005 / 2.0 to 4.0	51.7±8.2
Cincinnati/Rossmoyne	JP-PNCR-008 / 0.0 to 0.25	12,396±97
Cincinnati/Rossmoyne	JP-PNCR-008 / 0.25 to 0.75	5,094±59
Cincinnati/Rossmoyne	JP-PNCR-008 / 0.75 to 1.25	531±22
Cincinnati/Rossmoyne	JP-PNCR-008 / 1.25 to 1.75	133±10
Grayford/Ryker	JP-PNGR-001 / 0.0 to 0.5	4,181±73
Grayford/Ryker	JP-PNGR-001 / 1.0 to 2.0	71.6±10

With a relatively robust data set resulting from the initial 10 K_d tests, the remaining 6 tests can be used to further explore ancillary issues related to K_d . For example, higher and/or lower concentrations could be tested to expand the overall distribution of potential K_d values. In addition, it might be prudent to select samples with elevated or reduced levels of organic matter or different particle sizes (sand, silt, or clay).

Selecting samples that represent the entire range of detected concentrations is desirable to address the full potential for desorption in soil in the JPG DU Impact Area. Selecting samples above the 50th percentile will show stakeholders that sample selection was not biased. Additionally, information gleaned from desorption testing will primarily be used in evaluating the amount of DU near the source location that is available to dissolve/desorb back into solution for further migration. For these modeling purposes, it is not important to know if that contaminant is coming from precipitate or from adhesion to soil particles, only that it is available to be brought back into solution.

In an effort to cover a representative range of concentrations from the lowest detected concentration in each soil type to higher levels (i.e., 0th, 25th, 50th, 75th, and 95th percentile), the specified samples in Table 3 were examined to determine gaps. Additional data points were chosen based on these gaps and all samples proposed for desorption testing along with their respective percentile ranks are presented in Table 4.

Table 4. Proposed Samples for Desorption Testing

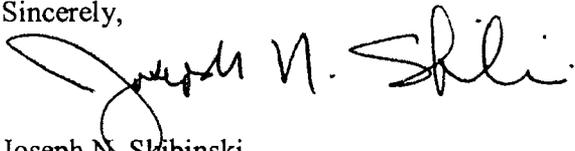
Soil Types	Site ID / Depth BLS (feet)	Total Uranium Concentration (pCi/g)	Rationale
Avonsburg/Cobbsfork	JP-PNAC-007 / 0.0 to 0.35	30,472± 250	95 th percentile detected result under penetrators in this soil type
Avonsburg/Cobbsfork	JP-PNAC-010 / 0.0 to 0.15	11,466± 127	75 th percentile detected result under penetrators in this soil type
Avonsburg/Cobbsfork	JP-PNAC-003 / 0.5 to 1.0	2,691± 155	64 th percentile detected result under penetrators in this soil type
Avonsburg/Cobbsfork	JP-PNAC-005 / 0.0 to 0.5	460±64	Leachability testing penetrator (47 th percentile)
Avonsburg/Cobbsfork	JP-PNAC-005 / 0.5 to 1.0	295±59	Leachability testing penetrator (38 th percentile)
Avonsburg/Cobbsfork	JP-PNAC-009 / 1.5 to 2.5	146±12	25 th percentile detected result under penetrators in this soil type
Avonsburg/Cobbsfork	JP-PNAC-005 / 2.0 to 4.0	51.7±8.2	Leachability testing penetrator (11 th percentile)
Avonsburg/Cobbsfork	JP-PNAC-005 / 1.0 to 2.0	15.4±13	Leachability testing penetrator (2 nd percentile)
Cincinnati/Rossmoyne	JP-PNCR-008 / 0.0 to 0.25	12,396±97	Leachability testing penetrator (92 nd percentile)
Cincinnati/Rossmoyne	JP-PNCR-002 / 0.0 to 0.5	6,437±68	75 th percentile detected result under penetrators in this soil type
Cincinnati/Rossmoyne	JP-PNCR-008 / 0.25 to 0.75	5,094±59	Leachability testing penetrator (72 nd percentile)
Cincinnati/Rossmoyne	JP-PNCR-009 / 1.0 to 1.25	1,880±55	50 th percentile detected result under penetrators in this soil type
Cincinnati/Rossmoyne	JP-PNCR-001 / 1.0 to 2.0	836±25	42 nd percentile detected result under penetrators in this soil type
Cincinnati/Rossmoyne	JP-PNCR-005 / 0.5 to 1.0	591±23	25 th percentile detected result under penetrators in this soil type
Cincinnati/Rossmoyne	JP-PNCR-008 / 0.75 to 1.25	531±22	Leachability testing penetrator (22 nd percentile)
Cincinnati/Rossmoyne	JP-PNCR-008 / 1.25 to 1.75	133±10	Leachability testing penetrator (8 th percentile)
Grayford/Ryker	JP-PNGR-001 / 0.0 to 0.5	4,181±73	Leachability testing penetrator (93 rd percentile)
Grayford/Ryker	JP-PNGR-001 / 1.0 to 2.0	71.6±10	Leachability testing penetrator (7 th percentile)

3. References

- ORNL (Oak Ridge National Laboratory). 1993. Solubility Measurement of Uranium in Uranium-Contaminated Soils. Prepared by S.Y. Lee, M. Elless, and F. Hoffman.
- UNEP (United Nations Environment Programme). 2003. Depleted Uranium in Bosnia and Herzegovina, Post-Conflict Environmental Assessment. Copyright© 2003, United Nations Environment Programme. March.
- USEPA (U.S. Environmental Protection Agency). 1999. Understanding Variation In Partition Coefficient, K_d , Values. Volume II: Review of Geochemistry and Available K_d Values for Cadmium, Cesium, Chromium, Lead, Plutonium, Radon, Strontium, Thorium, Tritium (3H), and Uranium. U.S. Environmental Protection Agency, Office of Radiation and Indoor Air and Office of Environmental Restoration, Washington, DC. August.

If you have any questions, please contact Mr. Paul Cloud, Jefferson Proving Ground (JPG) License Radiation Safety Officer, U.S. Army JPG at (410) 436-2381, E-mail address: paul.d.cloud@us.army.mil.

Sincerely,

A handwritten signature in black ink, appearing to read "Joseph N. Skibinski". The signature is fluid and cursive, with a large initial "J" and a long, sweeping underline.

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SAIC Central Records Project File (transmittal memo only)