Attachment 2.9-7 Technical Memorandum: Radiological Vegetation, Soils, and Sediment Sampling

TECHNICAL MEMORANDUM

TO: Ur-Energy Inc.

FROM: AATA International, Inc.

DATE: April 2010

SUBJECT: Radiological Vegetation, Soils, and Sediment Sampling

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1.0 INTRODUCTION

AATA collected samples of vegetation, soils, and sediment from the Lost Creek Permit Area between September 2008 and July 2009, which were analyzed for various radiological parameters by Energy Laboratories, Inc. (ELI) in Casper, Wyoming. The results of these sampling efforts are presented in this memorandum.

2.0 VEGETATION SAMPLING

As detailed in Sections 2.8.1 and 3.6.1 of the Technical Report and Environmental Report, respectively, two vegetation types were identified in the Permit Area. Both of these vegetation types are dominated by Big Sagebrush. The vegetation samples for radiological analysis were collected primarily from upland sites; **Figure VSS-1** is a photograph of a typical vegetation sampling location.

Methods: The sampling objective was to quantify baseline radiological characteristics of vegetation in several portions of the Permit Area, including vegetation downwind of the Plant, in areas of potential radon deposition, and in areas of different baseline gamma activity. **Figure VSS-2** shows the 2008 and 2009 vegetation sampling locations.

Downwind of the Plant - Sites A, B, and C were sampled in summer 2008, and the results presented in a technical memorandum from AATA International to Ur-Energy dated January 16, 2009 (LC ISR, LLC Response to RAI 2.9 #3); these sites were not re-sampled in 2009.

Areas of Potential Radon Deposition - Sites D and E correspond with the areas with highest predicted radon-daughter activity during operations, as modeled by MILDOS; the rectangular sampling areas are oriented to maximize coverage of predicted high radon areas.

Areas of Different Baseline Gamma Activity - Sites F, G, H and I correspond with high gamma readings during the initial site gamma scan, although it should be noted that sites F and H have been disturbed by the drilling program since that study. The sampling areas for sites F, G, H and I are oriented to maximize coverage of high gamma areas. Site J represents low gamma and predicted radon daughter activity; the sampling site is oriented to maximize coverage of low gamma areas.

Samples were collected from sites D, E, F, G, H, I, and J three times during the 2009 growing season at two to three week intervals: June 24 and 25, July 9 and 10, and July 28 and 29. During the first sampling event, a transect was established along the north- or northeastern boundary of each area, and grazing fodder within 16.5 feet (5 meters) of those transects was sampled. During

subsequent sampling events, the transect in each area was relocated 33 ft (10 meters) to the south or southwest, and parallel to the first transect.

Sagebrush, rabbitbrush, succulents, and other non-grazing vegetation were avoided, since they are generally not consumed by cattle, and therefore any radionuclides that might be present in shrubs or succulents are less likely to enter the human food chain. In addition, sampling of shrubs (especially sagebrush) can be detrimental to the plant survival. Historical data at a different uranium project in Wyoming shows that levels of uranium (U-nat), lead-210 (Pb-210), polonium-210 (Po-210), radium-226 (Ra-226), and thorium-230 (Th-230) are very similar between grasses and sagebrush (Conoco, 1980 in EMC, 2007). ELI analyzed the vegetation samples for these five parameters.

Results: Analytical results for vegetation samples are presented in **Table VSS-1**. Pb-210 ranged from 1.2E-4 to 1.5E-3 µCi/kg (average = 4.6E-4 µCi/kg), Po-210 ranged from 2.8E-6 to 3.3E-5 µCi/kg (average = 1.4E-5 µCi/kg), Ra-226 ranged from 5.4E-5 to 5.5E-4 µCi/kg (average = 1.4E-4 µCi/kg), Th-230 ranged from 6.4E-6 to 7.1E-5 µCi/kg (average = 2.0E-5 µCi/kg), and U-nat ranged from 0.019 to 0.15 mg/kg (average = 0.048 mg/kg). Original lab reports are included in **Addendum VSS-1**.

Figure VSS-3 shows that the mean measured level of each parameter increased between the first sample in late June and the final sample in late July. For all parameters except Po-210, the mean value for the early July sample was greater than the initial mean value, and less than the final mean value. Increased radiological activity and uranium concentrations over time may be due to vegetation becoming more dormant as summer progressed.

As shown in **Figure VSS-4**, the sites with high background gamma activity (F, G, H, and I) also averaged higher levels of all parameters except Po-210 than sites with lower background gamma (D, E, and J). The isotopes that were most markedly elevated at the high gamma sites were Ra-226 (90% higher) and Th-230 (42% higher).

3.0 SURFACE SOILS SAMPLING

Methods: The sampling objective was to quantify baseline radiological characteristics of surface soils in portions of the permit area that represent a wide range of background gamma activity and modeled radon deposition. Surface soil samples were collected from within the vegetation sampling sites D, E, F, G, H, I, and J on June 24 and 25, 2009. Soil sample locations are shown in **Figure 2**. The samples from sites D and E were collected at the center of the highest radon isopleths, as modeled by MILDOS, and field located using GPS. The precise location of the

remaining sites was determined in the field using a hand-held NaI detector. The surface soil samples at sites F, G, H and I were collected from the area with the highest gamma reading. The surface soil sample at site J was collected adjacent to the LCDS-W soil profile sampling site, in the undisturbed area with the lowest gamma reading. This location was chosen so that background gamma measurements, vegetation samples, soil profile samples, and surface soil samples were all collected at a single site.

Ten surface soil sub-samples were collected at each site along 33 x 33 foot (10 x 10 m) sampling grids, as described in Section 2.9.1.1 and Figure 2.9-2 of the Technical Report. Sub-samples were collected to a depth of 6 inches (15 cm), then composited into a single sample. After the soils were sampled, 70-80 gamma readings were taken along the scan trajectories shown in Figure 2.9-2 of the Technical Report. These readings were later repeated due to QA/QC concerns with the NaI detector used on June 24 and 25, 2009. ELI analyzed samples for U-nat, Ra-226, Th-230, and Pb-210.

Results: Analytical results for surface soil samples are presented in **Table VSS-2**. Pb-210 was present in detectible concentrations in only one sample, Ra-226 ranged from 1.3 to 6.5 pCi/g (average = 3.6 pCi/g), Th-230 ranged from 0.8 to 5.2 pCi/g (average = 2.3 pCi/g), and U-nat ranged from 2.1 to 23.6 mg/kg (average = 8.5 mg/kg). Original lab reports are included in **Addendum VSS-1**.

The soil sampling locations for sites F,G, H, I, and J were determined in the field with an NaI detector. The gamma measurements showed an unexpectedly high degree of variability when soil samples were collected on June 24 and 25. It was later determined that the instrument had a faulty coaxial cable, and not all instrument readings were reliable. Gamma measurements were repeated at each surface soil sampling site on July 9 and 10, and the average of these readings at each site are presented in **Table VSS-2**.

Because the surface soil sites were selected using unreliable gamma readings, sites F, G, H, and I do not all represent areas of elevated background gamma activity: the mean gamma at soil sites H and I was 27.6 and 38.9 µR/hr, respectively, as compared to 45.2 and 48.2 9 µR/hr at sites F and G. An unintended consequence is that the surface soil sampling sites represent a wide spectrum of gamma values, from 26.3 to 48.2 µR/hr. The linear regressions in **Figure VSS-5** show strong and statistically significant ($p < 0.005$) correlations between Ra-226, Th-230, and U-nat in the surface soils and background gamma activity.

4.0 SOIL PROFILE SAMPLING

Methods: The sampling objective was to characterize the baseline radiological characteristics of the soil profile in the soil types underlying and surrounding the Plant site. A detailed soil survey in September 2008 identified three distinct soil types within a half mile (0.8 km) of the Plant Site: Pepal Sandy Loam, Poposhia Loam, and Teagulf Sandy Loam. **Figure VSS-6** shows the soil profile sampling sites. Soil profiles were excavated and sampled at sites LSDS-C, LCDS-CE, and LCDS-S in September 2008. Additional samples were collected in December 2008 from locations LCDS-N, LCDS-E, and LCDS-W, which are approximately 2500 feet (750 m) from the center of the plant site. Each horizon was sampled according to the depth intervals identified in nearby soil profiles during the Summer 2006 soil survey. All samples were analyzed by ELI for Pb-210, Ra-226, Th-230, and U-nat.

Results: Analytical results for soil profile samples are presented in **Table VSS-3**. Pb-210 was present in detectible concentrations in only one sample, Ra-226 ranged from 0.8 to 2.8 pCi/g (average = 1.6 pCi/g), Th-230 ranged from 0.1 to 2.7 pCi/g (average = 1.1 pCi/g), and U-nat ranged from 0.52 to 4.84 mg/kg (average = 2.26 mg/kg). The highest values for Pb-210, Ra-226, and Th-230 occurred in the deepest sample from location LCDS-C, 33-60 inches. With the exception of location LCDS-C, Ra-226 generally decreased with depth, whereas Th-230 increased with depth at four of the six locations. The highest U-nat concentration occurred in the deepest sample from location LCDS-N, 33-40 inches, but there was no trend with depth that was generally consistent among the sampling locations. There also was no clear association between isotope activity or uranium concentration and soil type.

Five of the U-nat results were qualified by the laboratory; the reporting limit on those samples was increased due to sample matrix interference (generally caused by dilution). Because U-nat was present in concentrations that exceeded the reporting limit, the sample matrix interference is not believed to have affected the results. Original lab reports are included in **Addendum VSS-1**.

5.0 SEDIMENT SAMPLING

As detailed in Sections 2.7.1 and 3.5.1 of the Technical Report and Environmental Report, respectively, there are three watersheds in the Permit Area (**Figure VSS-7**). The associated drainages are naturally ephemeral and primarily flow (if at all) during spring snowmelt, when saturated overland flow when soil moisture is at a maximum. The drainages are typically incised three to six feet and are ten to fifteen feet wide near the downstream boundary of the Permit Area. The bed material in the larger draws is sandy textured and non-cohesive, and the draws are typically vegetated with sagebrush.

Methods: The sampling objective was to quantify the baseline radiological characteristics of the alluvium at the upstream and downstream Permit Area boundaries. Six sampling locations were selected on the three primary drainages, as shown in **Figure VSS-7**. An additional sampling location was selected at the Crooked Well Reservoir, a small on-site impoundment of East Battle Spring Draw which traps sediment when there is flow in the drainage.

Samples were collected on December 15, 2008, when the bed material was completely dry, but light snow had accumulated in some of the drainages (**Figure VSS-8**). At each sampling location, a transect was established across the channel or reservoir, and any snow was carefully removed. Ten to twenty subsamples were collected at a constant interval along the transect, to a depth of approximately three inches (eight cm). Subsamples were composited in a Ziploc bag, and analyzed by ELI for U-nat, Ra-226, Th-230, and Pb-210.

Results: Analytical results for sediment samples are presented in **Table VSS-4**. Pb-210 was not present in detectible concentrations, Ra-226 ranged from <0.2 to 1.3 pCi/g (average = 0.8 pCi/g, calculated with non-detects as half the detection limit), Th-230 ranged from <0.1 to 2.5 pCi/g (average = 1.0 pCi/g, calculated with non-detects as half the detection limit), and U-nat ranged from 1.0 to 5.0 mg/kg (average = 2.2 mg/kg). The highest concentrations of Th-230 and U-nat, and the second-highest concentration of Ra-226 occurred at site LCSS-6, Crooked Well Reservoir, which traps suspended and bedload sediment during runoff events. Within the same drainage, isotope and uranium concentrations were not consistently higher at either the upstream or downstream sampling locations. Original lab reports are included in **Addendum VSS-1**.

6.0 REFERENCES

Conoco, Inc. 1980. Environmental Report for the Sand Rock Mill Project, Campbell County, Wyoming. Docket No. 40-8743. July, 1980.

EMC (Energy Metals Corporation US). 2007. Application for US NRC Source Material License, Moore Ranch Uranium Project. Technical Report, Volume II. NRC website, ADAMS accession number ML072851268