UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

May 18, 2016

Mr. John Cash, Vice President
Lost Creek In-Situ Recovery, LLC.
5880 Enterprise Drive, Suite 200
Casper, WY 82609

SUBJECT: DEFICIENCIES IN LICENSE AMENDMENT APPLICATION, LOST CREEK IN-SITU RECOVERY PROJECT, SWEETWATER COUNTY, WYOMING, LICENSE NO. SUA-1598, DOCKET NO. 040-09068

Dear Mr. Cash:

On April 15, 2015, the U.S. Nuclear Regulatory Commission (NRC) notified Lost Creek In-Situ Recovery, LLC. (LCI) that the staff had identified technical deficiencies in the KM Horizon and Lost Creek East license amendment requests and had terminated its acceptance review (NRC's Agencywide Documents Access and Management System (ADAMS) Accession No. ML15093A261). For both amendment requests, the deficiencies identified were related to the characterization and performance of the confining unit (K shale) that separates the KM horizon production zone from the underlying aquifer (L horizon).

As a follow-up to the April 2015 letter, the staff contacted you by phone to underscore the importance of demonstrating that production fluids can be contained within the production zone and that characterization of confining units was essential to that demonstration. Additionally, staff shared information on how a similar issue was addressed at a different site. LCI stated that it understood the staff's concerns and indicated it was planning several potential actions to address these issues including conducting additional drilling, aquifer testing, and hydrologic modeling.

On February 10, 2016, LCI submitted revisions to the Lost Creek KM Horizon and Lost Creek East amendment requests to address the NRC's previously identified deficiencies (ADAMS Accession No. ML16056A543). The primary revision to the amendment requests is the addition of Attachment D6-5 to Volume 8 which presents the results from site-specific groundwater modeling analyses based on existing data (no new site characterization data were submitted). LCI stated that the focus of the groundwater modeling analyses was to demonstrate hydraulic control, both horizontally and vertically of production and restoration fluids.

On March 7, 2016, the NRC initiated an acceptance review of the revised amendment requests (ADAMS Accession Nos. ML15044A173 and ML16056A543). During the acceptance review, deficiencies were identified that prevent the NRC from accepting the application for detailed technical review. These deficiencies include incomplete characterization of the confining unit that underlies the KM horizon and an inadequate demonstration that KM horizon production fluids can be contained within the production zone. The vertical confinement or hydraulic isolation between the ore production zone and upper and lower aquifers is essential to safely conducting in situ recovery operations. Section 2.7.1 of NUREG-1569 reflects this position and indicates that, the characterization of the site hydrology must be sufficient to establish the

potential effects of in situ recovery operations, including the control and prevention of excursions, on adjacent groundwater resources. LCI was previously notified of these deficiencies in April 2015. Additional details regarding the identified deficiencies are enclosed.

Given the above deficiencies, the application is not acceptable for docketing and the staff has terminated its acceptance review. NUREG-1569, Standard Review Plan for In Situ Leach Uranium Extraction License Applications, states: "The application will be considered complete for docketing if the information provided is complete, reflects an adequate reconnaissance and physical examination of the regional and site conditions, and provides appropriate analyses and design information to demonstrate that the applicable acceptance criteria will be met."

If LCI intends to pursue these amendments, LCI should respond within 30 days of receipt of this letter with the information to address these deficiencies. The NRC staff would also be willing to meet with you to discuss this matter.

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 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 by telephone at (301) 415-6722, or by e-mail at Chad.Glenn@nrc.gov.

Sincerely,

/RA/

Chad Glenn, Sr. Project Manager
Uranium Recovery Licensing Branch
Division of Decommissioning, Uranium Recovery
and Waste Programs
Office of Nuclear Material Safety
and Safeguards

Docket No.: 040-09068
License No: SUA-1598

Enclosure:
Examples of Deficiencies in Lost Creek KM Horizon
and Lost Creek East Amendments

cc: Mr. Brian Wood, WDEQ
Mr. John Russell, BLM

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Enclosure:
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ADAMS Accession No.: ML16106A019

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Examples of Deficiencies
in the Lost Creek KM Horizon and Lost Creek East Amendments

Characterization of the Lost Creek East Amendment Area

In the U.S. Nuclear Regulatory Commission's (NRC) April 2015 letter (NRC's Agencywide Documents Access and Management System (ADAMS) Accession No. ML15093A261), staff noted that for the Lost Creek East amendment request, water level data for the L horizon was not collected during the aquifer pumping tests conducted in the KM horizon. As a result, the hydraulic properties of the confining unit (K shale) that separates the KM and L horizons cannot be evaluated. Because this L horizon water level data was not collected, staff indicated that NUREG-1569 acceptance criterion 2.7.3(3), which states: "The applicant should describe all hydraulic parameters used to determine expected operational and restoration performance," was not met. Additionally, in its April 2015 letter, staff noted that page D6-23 of Volume 8b states: "*L Horizon is the underlying aquifer to the KM Horizon, but will require additional hydrologic characterization*."

The revisions to the Lost Creek East amendment request submitted in February 2016 did not include any new characterization data. In its transmittal letter, Lost Creek In-Situ Recovery, LLC (LCI) stated that additional characterization within the Lost Creek East amendment area is not warranted at this time based on the following:

(1) Five KM horizon aquifer pumping tests that included monitoring of L horizon water levels have been conducted in the currently licensed footprint;

(2) Review of the geologic data in the vicinity of these five tests indicates that the character of the K shale at these locations is consistent with the character of the K shale throughout the Lost Creek and Lost Creek East properties;

(3) The groundwater flow model included with the February 2016 submittal was calibrated using data from aquifer pumping tests which included monitoring of the L horizon water levels (within the Lost Creek property); and

(4) Additional aquifer pumping tests will be performed for each mine unit. These tests will include monitoring of the L horizon (if the KM horizon is the production zone).

The above proposed use of analog data in lieu of site-specific data is not adequately supported by pumping tests, analyses and/or other measurement techniques to determine the hydrologic properties of the local aquifers and aquitards that affect or may be affected by the proposed ISR activities and therefore are not sufficient to meet NUREG-1569 site characterization acceptance criterion 2.7.3(3).

With respect to the future hydrologic testing to be conducted at each mine unit, Section 5.7.8 of NUREG-1569, indicates that the intent of the well field testing conducted as part of the operational phase groundwater monitoring program (i.e., the testing LCI references in listed item (4) above) is to serve as a verification and confirmation of the site conceptual model developed through site characterization, not as substitute for site characterization.

Enclosure

The NRC notes that the ability to safely conduct in-situ recovery (ISR) operations within the KM horizon is strongly dependent upon the integrity of the confining K shale unit, and therefore characterization of the K shale is essential. Moreover, it does not appear any L horizon wells have been installed within the Lost Creek East amendment area to collect water level or water quality data, both of which are NUREG-1569 acceptance criteria (acceptance criteria 2.7.3(4) and 2.7.3(5)).

Groundwater Flow Model Calibration

The three-dimensional, 11-layer model described in Attachment D6-5 and subsequently referred to in this letter as the model report, was calibrated using three data sets: one static water level data set and two KM horizon aquifer pumping test data sets. The aquifer pumping tests were conducted within the footprint of the currently licensed area. No justification was given for assuming the pumping test data collected for the currently licensed area are representative of the requested expansion area to the east.

A total of 109 hydraulic conductivity zones were assigned within the model. Page 13 of the model report states that the assignment of these zones allowed for greater flexibility during parameter estimation but provides no further geologic justification for the large number of zones assigned. After some initial manual adjustment of the parameters was conducted, PEST, a parameter estimation software program, was used to adjust the parameters to minimize the difference (i.e. the residuals) between the model predicted values and the measured data from the calibration data sets. The model report does not discuss if the parameter value ranges were constrained during calibration.

The NRC staff has concerns that conducting model calibration in this manner has resulted in "over-calibration" of the model. From ASTM Standard D5981-96, "*Over-calibration is the fine-tuning of input parameters to a higher degree of precision than is warranted by the knowledge or measurability of the physical hydrogeologic system and results in artificially low residuals."*

The NRC staff's concern that the model is over-calibrated is based on the following points:

- Domenico and Schwartz (1990) state, that in general, horizontal hydraulic conductivity (K_x) is equal to or greater than vertical hydraulic conductivity (K_z) (i.e. $K_x/K_z \geq 1$). The ratio K_x/K_z is referred to as the vertical anisotropy ratio. Table 3 of the model report indicates that 21 of the 109 hydraulic conductivity zones included in the model have vertical hydraulic conductivity values that exceed the horizontal conductivity value (i.e. $K_x/K_z < 1$). In some zones, the vertical hydraulic conductivity exceeds the horizontal by more than a factor of 40. Anderson and Woessner (1992) state that vertical anisotropy ratios ranging from 1 to 1,000 are common in model applications. The vertical anisotropy ratios in the calibrated model exceed those typically used and range from 0.01 to 160,990.

- Additionally, page 7 of the model report indicates that the range of horizontal hydraulic conductivity values (0.9-2.2 feet/day) estimated from KM horizon aquifer pumping tests should be considered overestimates of the actual values because the KM horizon behaves as a leaky aquifer but non-leaky analytical methods were used. However, staff observes that 16 zones in the calibrated model that represent the KM horizon (model layers 3, 4 and

5) have horizontal hydraulic conductivity values that exceed the range reported based on the pumping tests (in some cases by a factor of 4.5). There is no justification provided for the use of these higher KM horizon hydraulic conductivity values or the atypical vertical anisotropy ratios. This calls into question the value of the predictions made using this model. As reported by Freyberg (1988), good calibration does not ensure good prediction.

- Additional simulations, which ASTM Standard D5981-96 terms "application verification," that could serve as an indicator of model over-calibration were not performed. ASTM Standard D5981-96 defines application verification as "*using the set of parameter values and boundary conditions from a calibrated model to approximate acceptably a second set of field data measured under similar hydrologic conditions."* It appears the data from the KPW-2 and KPW-1A aquifer pumping tests referenced in LCI's February 2016 transmittal letter could serve as application verification data sets to assess the predictive accuracy of the calibrated model.

Predictive Groundwater Model Simulations

The model report describes the site-specific groundwater modeling analyses conducted to demonstrate that under normal operating conditions, vertical excursions from the KM horizon production zone into the underlying aquifer (L horizon) will not occur. In these analyses, the calibrated model was used to simulate a portion of a hypothetical wellfield located within the currently licensed footprint.

Comparison of model report Figure 19 and amendment request Plate D5-3b (of Volume 7) suggests that the simulated wellfield is generally located in an area of greater confining unit (K shale) thickness. The thickness could not be quantified during the acceptance review because an isopach map of the K shale thickness in the vicinity of the simulated wellfield was not presented in the model report.

As stated in the amendment request (e.g. pages D5-10 and D6-5 of Volume 7) the K shale may be sporadically absent locally. Comparison of the location of potential areas of KM horizon production presented in Plate D5-1a (of Volume 7) to the isopach map of the K shale (Plate D5-3b of Volume 7) indicates that areas of thin to zero K shale thickness exist within the areas of potential KM horizon production. It is, therefore, unclear how these predictive simulations are representative of the entire KM Horizon and Lost Creek East amendment area footprints. In their analyses, LCI does not propose a minimum K shale thickness required to safely conduct ISR operations in the KM horizon.

Due to the deficiencies described above, the NRC staff finds that the predictive groundwater modeling simulations do not acceptably describe the ability to control the migration of lixiviant from the production zones to the surrounding environment and therefore do not meet NUREG-1569 acceptance criterion 3.1.3(5)(f)(i).

Potential Issues with Restoration of the KM Horizon

If during restoration of the KM horizon, groundwater concentrations cannot be returned to background levels, an Alternate Concentration Limit (ACL) may be applied for, provided the ACL is as low as is reasonably achievable and considers practicable corrective actions. The

proposed ACL at the point of compliance must result in a hazardous constituent concentration that is protective of human health and the environment at the point of exposure. In ISR operations, the point of exposure is defined as the aquifer exemption boundary.

Because the application states that the L horizon is the underlying aquifer to the KM production zone, it would not be included within the exempted aquifer. It would, therefore, be considered as a point of exposure. Given the leaky, thin and discontinuous nature of the K shale confining unit that separates the KM horizon from the L horizon, any well installed and pumped in the L horizon could induce flow from the KM horizon production zone into the L horizon well. Moreover, the thin and discontinuous nature of the K shale would likely provide little attenuation of constituent concentrations of KM horizon water migrating across this unit to a point of exposure in the L horizon. LCI should consider this issue when planning ISR operations and restoration of the KM horizon.

References

Anderson, M.P. and W.W. Woessner. 1992 Applied Groundwater Modeling: Simulation of Flow and Advective Transport. New York: Academic Press.

ASTM Standard D5981-96 (2008), "Standard Guide for Calibrating a Groundwater Flow Model Application," ASTM International, West Conshohocken, PA, 2008, DOI: 10.1520/D5981-96R08, www.astm.org.

Domenico, P.A., and F.W. Schwartz. 1990. Physical and Chemical Hydrogeology. John Wiley & Sons, New York.

Freyberg, D.L. 1988. An exercise in groundwater model calibration and prediction. Groundwater 26, No. 3: 350-360.