May 18, 2007

Mr. Jeff Lux, Project Manager
Tronox Worldwide, LLC
Cimarron Corporation
P.O. Box 268859
Oklahoma City, OK 73126-8859

SUBJECT: SUMMARY OF APRIL 20, 2007 MEETING REGARDING GROUNDWATER BIOREMEDIATION AT THE CIMARRON FACILITY IN CRESCENT, OKLAHOMA

Dear Mr. Lux:

Enclosed is a summary of the subject meeting and the U.S. Nuclear Regulatory Commission staff's recommendations for a path forward for each of the groups of deficiencies that were discussed at the meeting. If you have any questions regarding this letter, please contact me at (301) 415-6664 or by e-mail at klk@nrc.gov.

Sincerely,

/RA/

Kenneth L. Kalman, Project Manager
Materials Decommissioning Branch
Division of Waste Management
and Environmental Protection
Office of Federal and State Materials
and Environmental Management Programs

Enclosure:
Summary of 04/20/07 Meeting

Docket No.: 70-925
License No.: SNM-928

cc: Cimarron distribution list

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Cimarron Corporation Distribution List:

Karen Morgan
Cimarron Corporation
P.O. Box 315
Crescent, OK 73028

Mike Broderick
Radiation Management Section
Waste Management Division
Department of Environmental Quality
707 North Robinson
Oklahoma City, OK 73102-6087

**SUMMARY OF APRIL 20, 2007 NRC/CIMARRON MEETING
REGARDING GROUND-WATER BIOREMEDIATION AT THE CIMARRON FACILITY**

Attendees

NRC

Keith McConnell, DWMEP
Ken Kalman, DWMEP
John Bradbury, DHLWRS
Jacob Philip, RES
Hans Arlt, EPPAD
Rebecca Tadesse, DWMEP
Jon Peckenpaugh, DWMEP
Tom Nicholson, RES
Mark Fuhrman, RES

Cimarron

Jeff Lux
Michael Logan

(via telephone)

Karen Morgan (Tronox - Cimarron)
Jim Crawford (Tronox)
Harry Newman (Lucas-Newman Science and Technology)
Barbara Lucas (Lucas-Newman Science & Technology)
Art Lucas (Lucas-Newman Science & Technology)
Rick Callahan (Lucas-Newman Science & Technology)

Oklahoma Department of Environmental Quality (via telephone)

Mike Broderick
David Cates
Jerry Matthews
Paul Davis

Pacific Northwest National Laboratory

Phil Long
Steve Yabusaki

U.S. Department of Energy

R. Todd Anderson

Arcadis

Boyce Clark
Erhardt Werth
Jeff Gillow

ENSR

Mike Meenan
James Cao
Maya Desai

Summary of Technical Discussions, Resolution and Path Forward Suggestions

Background

The Cimarron Corporation License Amendment Request (License No. SNM-928, Docket No. 70-925) dated December 11, 2006, was reviewed by the U.S. Nuclear Regulatory Commission (NRC) staff. Seventeen significant technical deficiencies were identified which are considered to be due to technical oversights and lack of information in critical areas for demonstrating long-term performance. The review utilized information from the Pacific Northwest National Laboratory (PNNL) technical letter report "Evaluating the Efficacy of Uranium Bioremediation in the Subsurface: Technical Bases and Performance Indicators" (PNNL-16385). This report documents lessons learned from a U.S. Department of Energy (DOE)-funded pilot bioremediation field program for immobilizing uranium in sediments within an alluvial flood plain. The NRC staff review also used information from Regulatory Guide 4.15 (Interim Revision 2) "Quality Assurance for Radiological Monitoring Programs (Inception Through Normal Operations to License Termination) - Effluent Streams and the Environment."

On April 20, 2007, NRC and Cimarron Corporation met at NRC Headquarters in Rockville Maryland to discuss the technical deficiencies identified by the NRC staff. Meeting attendees included: Cimarron staff and their contractors; NRC staff from the Office of Federal and State Materials and Environmental Management, the Office of Regulatory Research and the Office of Nuclear Material Safety and Safeguards; and DOE program manager and PNNL scientists. State regulators from the Oklahoma Department of Environmental Quality participated via telephone.

The PNNL scientists began the meeting with an overview of their letter report on "Evaluating the Efficacy of Uranium Bioremediation in the Subsurface: Technical Bases and Performance Indicators." Their briefing focused on the technical basis used by NRC staff to review the *in situ* bioremediation plan proposed for the Cimarron site, and illustrated their insights using field study observations from the Old Rifle and Hanford 300-Area sites.

The meeting discussions then focused on the NRC staff identified technical deficiencies which were grouped into seven categories. The following narrative highlights those deficiencies, summarizes the meeting discussions, and provides a recommended path forward by the NRC staff.

Group 1 - Deficiencies 1,2, 3, and 6
(Focused on transient or event-based impacts, primarily but not exclusively involving the vadose zone.)

Deficiency 1

A major issue that should have been considered in the Decommissioning Plan (DP) is the potential impact of Cimarron River flooding on the re-mobilization of uranium after the in-situ bioremediation has been performed. [This issue had been earlier identified by the NRC staff, and the licensee attempted to address this issue in their October 26, 2006 Response to NRC Staff Comments on the Conceptual Site Model (please see Specific Comments #5 and Parking

Lot Issues #16 in the response)]. In their response, the licensee provided dates of five Cimarron River floods between 1986 and 2006 that inundated portions of the uranium contaminant plume area in Burial Ground #1 (BG #1) area. If similar floods with these frequencies were to occur during the 1,000-year compliance period, approximately 250 flood events would cover this plume area. The licensee also indicated that the flooding conditions persisted for three to four days. Therefore, the frequency and duration of these flood events justify an evaluation in the DP of potential re-mobilization of uranium by oxygen or other chemicals introduced to the vadose and saturated zones in the BG #1 and Western Alluvial (WA) areas due to flood waters from the Cimarron River.

Deficiency 2

Attachment (2) to the DP outlines the ground-water flow model. This model only considers steady-state flow and does not consider transient recharge and flow conditions which may affect uranium transport. Furthermore the model considers river flow conditions as constant surface-water elevations and does not consider seasonal flow variations. The DP needs to provide an understanding of the dynamics of the environmental processes that will control and influence uranium behavior. Similarly, the flow dynamics occurring in the principal transport pathways to compliance points need to be considered, especially for directional changes in the regional and local ground-water flow fields.

Deficiency 3

The DP report is lacking in not considering transient and dynamic processes and events which influence geochemical conditions. These processes and events should include local recharge due to rainfall, surface-water flow changes due to drought, and seasonal and periodic flooding. These event-driven processes can affect ground-water gradients, flow rates, water table fluctuations which may induce changes to the ground-water chemistry. Recharge at the site can be highly transient, and should not be represented in the ENSR ground-water flow model as a percentage of mean annual precipitation. Furthermore, this recharge can also affect the geochemistry and microbial activity by introducing oxygen, carbon, nitrates and other chemical constituents.

Deficiency 6

If a considerable source of the residual uranium is in the unsaturated zone, characterization and modeling of the unsaturated flow and transport conditions is also warranted. The DP does not discuss unsaturated zone characterization and modeling. This characterization relates to the earlier discussion on ground-water recharge and water-table fluctuations. The capillary fringe which lies directly above the water table is dynamic and represents a transition zone for the ground-water flow, geochemistry and microbial activity.

Summary of Discussions

The NRC staff stressed the need to consider episodic ground-water recharge due to flooding of the Cimarron River and local runoff flooding due to intense and/or prolonged precipitation. The regional ground-water flow model assumed steady-state conditions that included average (or normal) river conditions and ground-water recharge as a percentage of annual precipitation.

The NRC staff expressed the need for monitoring and modeling of episodic flooding and seasonal recharge to determine if ground-water flow conditions varied and what affect it had on transport and water quality. For example, site-specific monitoring data can identify the range of water table fluctuations and determine what transient changes can be correlated to river stage and precipitation. It was agreed that ground-water flow and transport modeling can be steady-state and general at the beginning, to be followed by refinements of more detailed site-specific models that include parameter estimation and calibration using the monitoring data. These detailed models should consider the affects of flooding and recharge.

A staged approach similar to that discussed in the PNNL letter report was recommended by the NRC staff. The first phase would be pilot studies with detailed monitoring that would provide a proof-of-concept. The second stage would use samples taken from the treated zone of the pilot studies for laboratory analysis involving columns studies and solid phase analysis to confirm the long-term effectiveness of the third phase of large-scale in situ bioremediation activities. Monitoring the two pilot studies, at the front of the burial area plume and in the centroid of the Uranium plume, would require establishment of performance indicators. These indicators could be based on both the bench-scale experiments and modeling parameters to be predicted and confirmed.

Oklahoma officials identified the local aquifer as a class I aquifer which implies that drinking water standards may be the water quality objective following remediation. NRC acceptance criteria is presently 180 pCi/l for site decommissioning acceptance.

Heterogeneities in the alluvial deposits were discussed. The presence of clays and local stratification of fine detritus may influence where and how sorptive sites affect water quality and transport. The alluvial deposits have considerable sand and are thought to be highly permeable and porous. Ground-water flow velocities vary but appear to be quite low due to very small gradients away from the escarpment and proximal to the river. Estimates of subsurface water and contaminant fluxes through the vadose zone to the underlying capillary fringe and water table could be obtained using site monitoring data of water levels, and precipitation at selected indicator wells.

Long-term modeling to examine the affects of river flooding and recharge scenarios was discussed. Dose modeling of a resident farmer scenario who develops a well and irrigates the alluvial floodplain was also raised. The affects of these and other scenarios to change ground-water flow and water quality conditions that could re-mobilize the uranium was discussed.

Recommendations for Path Forward

Ground-water modeling needs to consider site-specific ground-water recharge and to estimate fluxes through the vadose zone to the local capillary fringe and water table. NRC staff strongly recommends installation and operation of a Class A meteorologic station to measure site-specific precipitation and conditions to estimate recharge. Monitoring of selected indicator wells can determine the range of water table fluctuations and its relationship to river stage and local precipitation and runoff. Ground-water modeling needs to interface with geochemical modeling to determine water and contaminant fluxes, flow directions, residence times, and transport. Well logs and core samples should be examined in detail to identify local heterogeneities in the alluvial deposits for both hydrogeologic and geochemical modeling. For the vadose zone, *seasonality of uranium leaching and associated geochemistry needs to be monitored. Details on the benchscale and pilot studies need to be provided. Performance indicators such as dissolved oxygen, pH, oxidation-reduction potential, acidity, dissolved iron and uranium should be identified and monitored. NRC staff and Cimarron licensee agreed to further technical discussions.*

Group 2 - Deficiencies 4 and 5
(Requests for Cimarron to provide NRC Staff with electronic data files used in creating and calibrating the models.)

Deficiency 4

The NRC staff will not be able to perform the detailed review of the licensee's ground-water flow models of the BG #1 and WA areas without the final calibration input and output files (electronic files) for the MODFLOW and MODPATH model runs using the GMS 6.0 modeling package. The licensee should provide these files with the appropriate documentation via CD or DVD so that the NRC staff can rerun these calibration runs independently.

Deficiency 5

The DP indicated that the MT3DMS code was used to develop a three-dimensional transport model. This transport model was based upon the ENSR's three-dimensional ground-water flow model using the MODFLOW code. The MT3DMS-based model was used to simulate geochemical transport during the in-situ bioremediation procedures. The transport models (i.e., for the BG #1 and WA areas) used outputs from the calibrated MODFLOW-based models. However, the DP did not provide any information on the calibration of these transport models. The DP needs to provide its calibration procedures for the transport models. In order to conduct independent reviews of the transport models, the NRC staff should be provided the final calibration input and output files (electronic files) to review the MT3DMS model runs. The licensee should provide these files with the appropriate documentation via CD or DVD so that the NRC staff can rerun these calibration runs independently.

Summary of Discussions

Calibration of the models cannot be achieved prior to further site monitoring. NRC staff focused on the integration of modeling with monitoring to identify performance indicators. NRC staff also discussed parameter estimation, calibration and validation that rely on site monitoring. Cimarron licensee agreed to data exchange including model inputs and results.

Recommendation for Path Forward

The NRC staff and Cimarron licensee agreed to further technical discussions to facilitate information and data exchanges concerning the cited models.

Group 3 - Deficiency 7
(QA/QC program.)

Deficiency 7

In the DP there is minimal discussion of quality assurance (QA) and quality control (QC) protocols. The DP does state that the QA program satisfies the applicable requirements of 10 CFR Part 50 Appendix B and Nuclear Quality Assurance, Level 1 (NQA-1) (see ASME NQA-1, 1994 reference). The DP should contain a detailed QA/QC program plan specific to characterization, monitoring and modeling to confirm the efficacy of the uranium bioremediation program. For instance, the QA for the radiological monitoring program could follow the guidance in Regulatory Guide (RG) 4.15. Details on the depth, spacing and location of both the injection and monitoring wells within the contaminant plumes needs to provided and based on model predictions. Information on data management, analysis and reporting should also be included. The most up-to-date and current guidance for QA/QC of radiological measurements can be found in RG 4.15 Interim Revision 2 "Quality Assurance for Radiological Monitoring Programs (Inception Through Normal Operations to License Termination) - Effluent Streams and the Environment." RG 4.15 provides a framework for the various activities that need to be developed and implemented to ensure the quality of data and results for confirming the long-term effectiveness of the uranium bioremediation process. If RG 4.15 is not utilized, then the DP needs to provide the framework, details and rationale for a QA/QC program to the NRC staff.

Summary of Discussions

Cimarron stated that they are committed to using RG 4.15 for the Cimarron project. However they also stated that discussions on the use of RG 4.15 for the project is included in their project submittal at various pertinent sections of the report. The NRC staff agreed to Cimarron's suggestion that the QA/QC sections included in the Cimarron submittal be part of a stand alone QA/QC document consistent with RG 4.15. Cimarron had a concern that strict compliance with RG 4.15 may result in inefficiencies in the conduct of the Cimarron project. The NRC staff response was that use of RG 4.15 should not result in inefficiencies and that NRC could assist Cimarron in QA/QC issues for the project. In this connection, NRC is planning a workshop, this summer, to familiarize licensees with use of the interim RG 4.15. Cimarron's attendance at the workshop could be useful. The Cimarron licensee representatives mentioned that Data Quality Objectives would be identified and are central to the QA/QC plan development.

Recommendations for Path Forward

Further discussions on development and review of a QA/QC plan for the phased effort (i.e., benchscale, pilot studies and full-scale field remediation) should be conducted between Cimarron, their contractors and NRC staff, particularly with NRC staff who routinely conduct QA/QC reviews. NRC staff expects a complete "stand alone" QA/QC notebook as indicated above. Cimarron licensee will be invited to the RG 4.15 workshop.

Group 4 - Deficiencies 8 and 9

(Ground-water and solid phase monitoring of the Cimarron site prior to, during remediation and post-decommissioning.)

Deficiency 8

A major issue not addressed in the DP is the difficulty in determining injection and subsurface distributions due to inhomogeneities in the soil and rock matrices. The PNNL report suggests a staged approach in which the injections and monitoring are done repeatedly to assure a three-dimensional spread of the reductants and additives into the subsurface, and for confirming that the reducing process is proceeding as designed. Furthermore, the need for additional wells, and modification to the scheduled frequency of injection and monitoring evolves from an analysis of the measurement of performance indicators within a staged approach. The DP needs to specify details on a staged approach and how decisions will be made based upon monitoring of the performance indicators.

Deficiency 9

The monitoring program for the proposed ground-water decommissioning, both the number of monitoring sites (i.e., 11 monitoring wells for the three uranium plumes, see page 36 of Arcadis report), and the frequency of monitoring (i.e., two years of quarterly monitoring, see page 36 of the Arcadis report) to check for re-mobilization of uranium is not adequate. The level of uncertainty associated with re-mobilization of uranium in the proposed in-situ bioremediation and decommissioning may need a more extensive and iterative monitoring program. Therefore, the proposed monitoring program in the DP needs to be justified for its adequacy to confirm long-term performance.

Summary of Discussions

The subsurface profiles at the Cimarron site include layers/lenses of clayey soils. The interparticle space between the clay particles are smaller than the width of the microbes. Accordingly any reduction of uranium within the clay lenses/layers will be problematic. The NRC staff mentioned that in a staged approach, allowance should be made for closer injection spacing in areas of the site containing fine soils to determine its effectiveness. The NRC staff also discussed the value of laboratory experiments e.g., column tests to determine the permeability and retardation affects due to clay materials on bioremediation processes and re-oxidation of product materials. The interpretation of the benchscale tests should consider the presence of these fine soils at the Cimarron site in order to be useful for the field scale. Ultimately, the spacing of the injection wells and the time sequence of the reagent injections will depend upon the site heterogeneities and geochemistry.

The phased approach would include a design study plans to include details on the pilot studies. For Burial Area 1, the design plans would identify where the pilot studies would occur (i.e., front and centroid of the uranium plume); identify the performance indicators to be monitored; monitor the PI and refine the models; collect cores for mineralogical analyses; specifics on the injection and monitoring well construction, placement, and injection procedures (flow rates and sequencing of reagents); and analysis of monitored performance indicators. For the re-oxidation phase, monitoring would help to determine any changes to the hydrogeologic properties (permeability and porosity), geochemistry, and persistence in the established bank of iron sulfides and possible generation of iron oxides.

Recommendations for Path Forward

In the staged approach, allowance should be made for closer injection spacing in areas of the site containing fine soils to determine its effectiveness. Well logs and core samples should be examined in detail to identify local heterogeneities in the alluvial deposits for both hydrogeologic and geochemical modeling, and to be factored into the pilot study plans. In addition laboratory experiments e.g., column tests and the interpretation of the results should consider the presence of these fine soils at the Cimarron site in order to be useful for the field scale.

Group 5 - Deficiencies 10, 11 and 12
(Western Areas of the site)

Deficiency 10

For the bioremediation of the Western Upland (WU) area, the DP should provide geologic logs, well or geoprobe statistics (e.g., well depths, well diameters, and ground-water elevations), and uranium concentrations in the monitoring wells and geoprobes (see Figure 4-13 from Conceptual Site Model (Revision - 01) Cimarron Site, Crescent, Oklahoma October 2006 by ENSR Corporation) installed during early 2006 in the Western Alluvial Area and WU areas to further characterize the uranium in the ground water.

Deficiency 11

The DP needs to provide additional information on the remediation procedure (see pages 25 and 26 of DP Attachment 1) of the ground-water system in the WU area where the licensee proposes to use infiltration and recovery trenches with treated ground water to remove uranium from the ground water.

Deficiency 12

The DP needs to provide additional information on the numerical ground-water flow model that ENSR developed to evaluate flow to a receptor trench in the WU area (see Comment #5 on page 3 of the October 26, 2006 Response to NRC Staff Comments on the Conceptual Site Model). The DP needs to specify whether this numerical model used or modified Arcadis's remediation procedure that uses infiltration and recovery trenches with treated ground water to remove uranium from the ground water. If it was used, the input and output files (electronic files) of the numerical model should be provided with the appropriate documentation via CD or DVD so that the NRC staff can rerun this model independently.

Summary of Discussions

Discussion focused on the infiltration and recovery trenches, and the ground-water seeps emanating at the sandstone-mudstone interface and surface-water runoff. Questions as to the ability of the recovery trench to collect runoff during extreme rainfall and runoff events were raised. Also the ability of the recovery trench to capture all uranium runoff resulting from any releases. The question of interflow within the hollow to create a possible bypass was discussed. Monitoring and sampling in the Western Uplands was also discussed. The models for the WU are relatively simplistic and need to verify the no-flow assumptions at the sandstone-mudstone interface and the functioning of the infiltration and recovery trenches.

Recommendations for Path Forward

Further teleconferences to identify details of the recovery trench and to discuss the analytical model and possible refinements based upon monitoring data. Infiltration and runoff estimates need to be developed using site-specific monitoring data.

<u>Group 6 - Deficiencies 13, 14, 15 and 17</u>
(Geochemical processes.)

Deficiency 13

The geochemical conceptual model assumes that heterogeneous (between phases) and homogeneous (within a phase) equilibria are attained for the biologically-mediated reduction of oxidized species and minerals within the water-table aquifer by the addition of molasses. By introducing an excess of reductants into the system, the redox conditions will be buffered for an extended period of time. Key to this model is that the reduced constituents must remain immobile. The DP does not provide information on how the uranium currently associated with the solids will react when molasses is injected. If the uranium is presently sorbed to iron oxyhydroxides, conversion of these solid phases to sulfides could release more uranium into the ground water. Since the geochemical model assumes equilibria, it cannot predict whether the uranium will desorb or precipitate. Therefore, the conceptual models need to consider non-equilibrium conditions and its affect on uranium behavior.

Deficiency 14

The assumption that phases in the future would be more sorptive than those now present is unfounded. The licensee will need to provide evidence to support that assumption.

Deficiency 15

The DP indicates that uraninite will be precipitated first followed by iron sulfide (FeS) which would be laid down over the UO_2 as a FeS coating. Although geochemical modeling can be used to estimate <u>when</u> the various phases will precipitate, it can not estimate <u>where</u> the precipitate will form. The DP needs to provide supporting evidence for this coating process.

Deficiency 17

The DP needs to justify the assumption of equilibrium, and the lack of characterization of the solid phases present. The work plan in the DP indicates that mineralogical analyses will be performed using X-ray diffraction (XRD), and scanning electron microscopy (SEM) with energy dispersive X-ray probing to determine the presence of uraninite, hematite, calcite etc. For minerals that constitute less than 5% of the bulk, X-ray diffraction is unsuitable. Minor amounts of phases would be below detection limit using this tool. SEM and XRD methods could be used to help characterize the mineralogical phases at specific locations. Backscattered electrons can also be used to identify locations where uranium resides. Extraction procedures may also be appropriate for determining the association of uranium with the soil. [Methods employed by

Davis and Curtis (2003) on Naturita Site materials may be a useful reference, as well as the approaches described by Long and Yabusaki (2007).]

Summary of Discussions

In order to understand the potential for long-term influx of low concentrations of uranium into the treated zone, it is necessary to have estimates of the mass of uranium in the vadose zone (proximal to the trenches). We find in the report from Arcadis page 8 that a maximum concentration of 6.1 mg/kg uranium is present in the unsaturated zone. While we are reasonably confident that reducing conditions will precipitate uranium from within the plume, the presence of uranium in the vadose zone poses a slightly different problem. The uranium, possibly complexed with carbonate, may leach and flow into the treated zone over long times. Depending on the time-scale, the material that it contacts will be reduced (e.g. mackinawite) or, if significant weathering has taken place, it will be an iron oxide. Interactions of the "New" uranium from the vadose zone with the solids of the treated zone may be important if there are significant quantities of uranium present as a source term.

It is assumed that uranium in the aqueous phase of the plume will be precipitated as reducing conditions develop. There is some literature that indicates that mackinawite will oxidize before uranium does and therefore protects uranium from entering solution as long as some mackinawite is present. It is unclear what the uranium bearing phase will be. It will likely be uranium (IV) but the identity of the compound is not certain. There was some discussion that the uranium may be present, sorbed on bacterial walls. It may also be possible that a biologically generated uranium phosphate could form. Some unexpected uranium-bearing solid may control release of uranium to solution as the system returns to oxidizing conditions. Eventually the FeS mineral will oxidize to an Fe oxide. A value of K_d = 61 mL/g for this material was assigned through modeling oxidation of biogenerated FeS. Various temporal components of the conceptual geochemical model need to be tested and confirmed using field data from the pilot studies which would include laboratory analyses of materials generated through the in situ bioremediation process.

Recommendation for Path Forward

To assess the possibility that uranium retained in the vadose zone will slowly leach into the treated area, the mass of uranium present as a potential source needs to be estimated and the fraction of uranium that can be leached by percolating water also needs to be known.

Arcadis proposed a field test to determine process parameters by pumping reagent into the leading edge of the plume in a crescent shape to act as a wall against uranium movement in case of elution of uranium later in the processing. This is a good idea. We suggest that a second test be done in the core of the plume to ascertain that uranium will be precipitated as redox decreases. Associated with this should be monitoring of adjacent areas during and shortly after injections to assess the possibility of uranium elution.

It is unclear if the estimated K_d of 61mL/g has any relationship to reality without experimental benchmarking to the actual material.

As part of the field test done in the core of the plume it will be important to understand the relationship among new uranium entering the system, the FeS and Fe oxides of the treated zone, and uranium precipitated in the treatment zone. To this end, sorption / leaching studies, (presumably column tests but batch tests might suffice) should be conducted on material cored from the treated zone. The Arcadis plan discusses analysis of the solid phase material so it is expected that samples will be taken. These additional sorption/leach tests are worth undertaking. Retention of new uranium (in the appropriate complex) should be determined on the reduced materials taken from the treatment zone. The leachability of uranium co-precipitated with FeS should be determined. Some material cored from the treated zone should be allowed to slowly oxidize and uranium concentrations in solution should be followed. Sorption of new uranium on the oxidized material should be determined to confirm the value of K_d*. Ripening of the generated materials is important with respect to solubility and sorption capacity of the treated materials. Retention of field sampling cores may be useful in future confirmation column studies to demonstrate long-term stability. We believe these tests, if carefully conducted, will allow confirmation of the processes invoked in this project.*

Group 7 - Deficiency 16
(Modeling)

Deficiency 16

The "Geochemical Modeling Evaluation" in the DP concludes that the highest concentration of uranium in the aquifer can be 1400 μ*g/L in as early as 155 years after the bioremediation. Using the conversion factor of 1.63 pCi/*μ*g, yields 2282 pCi/L. This value exceeds the 180 pCi/L required in the License. The modeling needs to justify that ground water containing this amount of uranium would be safe for a resident farmer.*

Summary of Discussions

The licensee agreed that a conservative "worst case" analysis may cause confusion and did not fully describe the long-term processes which may occur to re-oxidize the iron and uranium.

Recommendation for Path Forward

ARCADIS agreed to perform sequential extraction of uranium from the product materials. Solid phase analyses of the product materials should be conducted in order to determine the mineralogy of the uranium following the field pilot studies. Column studies can help verify the process and achieved mineralogies of the uranium and iron components.

Outstanding Issues

Bioremediation is a relatively unproven technology in regard to remediation of uranium contaminated groundwater. Although there are bench scale tests of it efficacy, actual field experience is limited to pilot tests at the DOE's Hanford Site 300 Area and the DOE's Rifle Site. Two pertinent questions that remain unanswered in the PNNL studies and the Cimarron proposal are: (1) Is bioremediation a sufficiently permanent solution to the problem of long-term stability of residual uranium to preclude elevated levels of contaminated ground water?

and (2) What performance indicators need to be monitored to demonstrate long-term performance of the uranium remediation at the site using in situ bioremediation to provide the NRC staff with sufficient confidence to terminate the license?

In recognition of these questions, Cimarron is proposing a series of pilot scale tests at its Crescent site before conducting the full scale bioremediation. The NRC staff estimates that the full scale bioremediation would not begin until some time between mid-2009 and mid-2012.

Cimarron's DP, which was approved in 1999, relied on the use of monitored natural attenuation (MNA) to address the groundwater issues but also allowed for the use of other technologies if MNA did not appear to be reducing uranium concentrations over time. Cimarron proposal to use bioremediation is based on its determination that bioremediation would be the most cost effective technology.

NRC staff is concerned with the amount of time that has been consumed and will be consumed regarding the questionable use of bioremediaton, when there are other proven technologies available.

Cimarron and NRC Staff agreed to a series of follow-up technical meetings to further discuss the technical issues identified during the meeting discussions. Cimarron will be responding in writing to the NRC staff's identification of deficiencies.

References

ASME NQA-1, (1994). "Quality Assurance Program Requirements for Nuclear Facilities (with Addenda)." American Society of Mechanical Engineers (ASME).

Davis, J.A. & Curtis, G.P., (2003). Application of Surface Complexation Modeling to Describe Uranium (VI) Adsorption and Retardation at the Uranium Mill Tailings Site at Naturita, Colorado, U.S. Nuclear Regulatory Commission, NUREG-CR- 6820.

Long, P.E. & Yabusaki, S.B., (2007). "Evaluating the Efficacy of Uranium Bioremediation in the Subsurface: Technical Bases and Performance Indicators." Pacific Northwest National Laboratory, PNNL-16385.