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April 22, 1996

EES-13-04-96-1063

Dr. Colin A. Heath
CRWMS M&O Assistant General Manager for Program Integration
TRW Environmental Safety Systems, Inc.
2650 Park Tower Drive
Suite 800
Vienna, VA 22180

Dear Dr. Heath,

Submittal of Los Alamos Monthly Management Analysis Report for March 1996 (SCPB:NA)

Attached is the Los Alamos Monthly Management Analysis Report for March 1996. This report includes five sections:

(1) a summary of our technical efforts, including information on completion of contract deliverables and major problems;
(2) a summary of personnel changes;
(3) a list of any unusual current and/or anticipated financial performance problems;
(4) a list of programmatic issues that may impact the overall CRWMS M&O effort; and
(5) a summary of work planned for next reporting period.

The technical sections of this report have not received formal technical or policy review by Los Alamos or the YMP. Data presented in this document constitute predecisional information, should not be referenced, and are not intended for release from the U.S. Department of Energy as referenceable information.

If you have changes to our distribution list, please call Susan Klein at (505) 667-0916.

Sincerely,

Julie A. Canepa

JAC/SHK/shk

Attachment: a/s

Colin Heath, April 22, 1996, EES-13-04-96-1063

Cy w/att:

R.W. Andrews, M&O/INTERA, MS 32
W.E. Barnes, YMSCO, MS 523
H.A. Benton, M&O/B&W, MS 423
A.I. Berusch, DOE, Washington, DC
D.L. Bish, EES-1, MS D469
K.K. Bhattacharyya, M&O MK, MS 423
J.A. Blink, LLNL/LV, MS 423
B. Bodvarsson, LBL, Berkeley, CA
M. Brady, SNL, LV, NV, MS 465
S.J. Brocoum, YMSCO, MS 523
G.A. Bussod, EES-13, MS J521
J.A. Canepa, EES-13, MS J521
M.W. Chisholm, M&O/TRW, MS 12
W.J. Clarke, LLNL, MS 423
M.J. Clevenger, ESH-14, MS J521
R. Craig, USGS, LV, NV
R.L. Craun, YMSCO, MS 523
B.M. Crowe, EES-13/LV, MS J902
C. DiBella, NWTRB, Arlington, VA
W.R. Dixon, YMSCO, MS 523
J.R. Dyer, YMSCO, MS 523
N.Z. Elkins, EES-13/LV, MS J902
J.T. Fabryka-Martin, CST-7, MS J514
L.D. Foust, M&O/TRW, MS 423
A.V. Gil, YMSCO, LV, NV
L.R. Hayes, M&O/TRW, MS 423
J. Haynes, LATA, MS J521
S. Hanauer, OCRWM, Washington, DC
C.D. Harrington, EES-1, MS D462
L.E. Hersman, LS-2, MS M880
V.F. Iorii, YMSCO, MS 523
S.B. Jones, YMSCO, MS 523
H.N. Kalia, EES-13/LV, MS J902
S.H. Klein, EES-13, MS J521
S.S. Levy, EES-1, MS D462
B. Mukhopadhyay, PMO, LV, NV
S. T. Nelson, M&O/WCFS, MS 423
R. Patterson, YMSCO, MS 523
F.V. Perry, EES-13, MS J521
M. Peters, M&O/WCFS, MS 423
P.W. Reimus, EES-4, MS D443
B.A. Robinson, EES-5, MS F665
R.A. Rumsey, BUS-8, MS J521
S.F. Saterlie, M&O/TRW, LV, MS 423
W.D. Schutt, M&O/TRW, LV, MS 423
E.T. Smistad, YMSCO, MS 523
D. Stahl, M&O/B&W, MS 423
C.T. Statton, M&O/WCFS, MS 423
R.L. Strickler, M&O/TRW, Vienna, VA, MS 6
D.P Stucker, YMSCO, MS 523
C.D. Tait, CST-4, MS G739
A.L. Thompson, EES-13/LV, MS J902
I.R. Triay, CST-7, MS J514
G.A. Valentine, EES-5, MS F665
D.T. Vaniman, EES-1, MS D462
A.E. VanLuik, M&O/INTERA, MS 423
R.G. Vawter, M&O/TRW, MS 423
M.D. Voegele, SAIC, MS 423
K.A. West, EES-13, MS J521
N. White, NRC, LV, NV
D.R. Williams, YMSCO, MS 523
J.L. Younker, M&O/TRW, MS 423
G.A. Zyvoloski, EES-5, MS F665

RPC File (S. Martinez), MS M321
EES-13 File, MS J521

Los Alamos Monthly Management Analysis Report for March 1996

(1) Summary of (a) Los Alamos' technical accomplishments, (b) deliverables completed, and (c) major problems that may impact future performance.

(a) Technical Accomplishments

WBS 1.2.3.1 Site Investigation Coordination and Planning. Staff represented the Los Alamos Site Characterization Project Leader at weekly surface-based testing meetings and Civilian Radioactive Waste Management System Management & Operating Contractor work scope consolidation meetings.

WBS 1.2.3.2.1.1.1 Transport Pathways. ***Quantitative X-ray Diffraction Studies.*** Staff received samples from the SMF from SD-7, SD-9, and SD-12. Samples from these cores are needed to provide credible bounds on transport models and will be used to meet the criteria for milestone 4240.

Staff completed XRD analysis of the SD-12 samples. These data provide important detail on the locations of zeolitized horizons beneath the potential repository in this part of the exploration block. Although the highly zeolitized (>50% clinoptilolite) portion of the Calico Hills Formation in this part of Yucca Mountain is thin (60 ft), the entire overlying portion of this formation and the lowest parts of the Topopah Spring Tuff are partially zeolitized (up to 12%) over a much thicker interval (220 ft). This dispersed zeolite distribution throughout otherwise vitric tuffs will be very important in providing retardation of most radionuclides, particularly Np. In addition, the SD-12 XRD data show a significant interval of tridymite and cristobalite beneath the zeolitized Calico Hills Formation. The presence of these relatively unstable silica polymorphs is important when considering the magnitude of silica mobilization and permeability modification under the thermal influence of a repository.

The work to be accomplished for milestone 4240 will define the nature of the vitric-to-zeolitic transition beneath the potential repository and will provide the quantitative data on zeolite abundances needed to develop defensible models of radionuclide retardation.

Milestone 3664. Milestone 3664, "Electronic Submission of 3-D Mineralogy Data to Framework Model," was completed. Included in this data set are results from the analysis of USW NRG-6 that were previously unpublished. The report and data submittal do not include results from USW SD-7, 9, and 12, which will not be completed until June 1996. These later results will, however, be included in the Mineralogy of Transport Pathways Summary and Synthesis Report (see below).

In analyzing data for milestone 3664, staff found that the differences between calcite and zeolite distributions in the PTn may be related to either variations in UZ water compositions within the PTn or to differences in the transport of Ca^{2+} versus the flow and saturation required for zeolite formation. It is notable that the only significant formation of zeolites in the PTn in or near the exploration block is in UE-25 UZ#16; this may be an artifact caused by the lack of data from this interval in most other cores (e.g., UE-25a#1), but the high sample density within the PTn in NRG-6 suggests otherwise. With further analysis of PTn samples, it may be possible to map those portions of the block in which PTn saturation has been significant in the past (e.g., in the eastern imbricate fault zone).

In contrast to the patchy and restricted location of zeolite alteration in the lower part of the PTn, clays are almost ubiquitous throughout the PTn. Clay abundances vary considerably and appear to reflect the microhydrologic stratigraphy as well as the accessibility to glass in the PTn. If identified as a Project priority, it should be possible to address the past history of the PTn as a reactive barrier to downward- or lateral-flowing UZ waters at Yucca Mountain with further study of samples from USW SD-7, 9, and 12.

Silica Health Hazards in the ESF. On 7 March, D. Bish and D. Vaniman collected samples from the ESF under the guidance of N. Elkins in an effort to understand dust compositions and exposures. These samples were analyzed at Los Alamos by S. Chipera, D. Bish, and D. Vaniman using XRD methods, and the results were communicated immediately to Project participants. Chipera, Bish, and Vaniman compared the silica polymorph and feldspar mineralogy in the whole-rock samples with that in the dust collected from a wall placard in the ESF. Their results indicated that crystalline silica abundances in the dust are within the same range as in the bulk rock, as evidenced by the ratios of the crystalline silica polymorphs to feldspar (the dust contains additional minor phases probably introduced during the mining operations, such as material wearing from the conveyor belts, exhaust particles, etc.). These results suggest that the elevated crystalline silica concentrations observed on 21 and 22 February in the ESF and those observed in the thermal test alcove ***were not*** due to unusual wall-rock mineralogy. This task's studies of the host rock mineralogy indicate that the mineralogy is remarkably constant, particularly the ratio of total crystalline silica polymorphs to total feldspar (the major crystalline phases in the host rock). The primary difference observed in crystalline silica mineralogy of fracture samples was an increase in tridymite and a decrease in cristobalite relative to wall rock mineralogy. Thus, elevated airborne cristobalite and/or quartz concentrations ***cannot*** be attributed to fracture-coating minerals.

In addition, size fractionations were conducted on a dust smear removed from the ESF wall just behind the head of the TBM to determine if any mineral segregation occurs during the mining/grinding operation. The quantitative XRD results do not support the occurrence of any significant segregation/concentration of crystalline silica polymorphs in the finer fractions (although a slight increase in tridymite abundance may be possible). These results show that the fine rock material generated during the mining operation does not

deviate significantly in mineralogy from that of the bulk rock being mined. Thus, the Project should be able to predict fairly accurately the concentrations of the mineral constituents in the dust phase simply by knowing the concentrations in the rock being mined. Obviously, there are very large quantities of crystalline silica polymorphs being encountered by the TBM and potentially being released to the atmosphere.

Staff discussed the results cited above with M. Pochowski of the M&O. According to Pochowski, typical filter loadings are 750 micrograms total, with 18.4 micrograms quartz, 64.6 micrograms cristobalite, and no tridymite. The total loading can be determined very accurately (gravimetrically), whereas the individual mineral abundances are difficult to determine. The Min-Pet analyses of ESF samples and dusts suggest that these particular numbers are unusual in that the proportion of crystalline silica minerals is *very low*—about 11%—much lower than the average of about 40%. Based on our knowledge of the mineralogy of wall rocks and dusts in the ESF, these numbers appear to be suspect. Note, that the regulated number is the total weight of quartz, cristobalite, and tridymite—low numbers for these minerals could be providing the erroneous impression that dust levels are within regulations. The fact that tridymite is seldom, if ever, detected is probably because it is generally present below the labs' detection limits.

Staff prepared standard filter samples to assist in assessing the accuracy of contract analyses of filter samples. Several standards of known mineral abundances were being used in preparing standard filter samples. These standards contain known abundances of quartz and cristobalite with a known amount of feldspar. Since tridymite is not readily obtainable in pure form, a volcanic tuff sample containing tridymite and whose mineralogic composition is known will also be used as a dust standard. Filters received from ESF industrial hygiene personnel at the end of this month are being loaded with the known dusts. These filters can then be used as standards to be sent out to the contract labs, thereby providing a means of assessing the accuracy of their quantitative analyses.

Synthesis and Summary Report. Staff continued to analyze data and write input to the Mineralogy of Transport Pathways Summary and Synthesis Report. Progress was somewhat slowed this month because of time devoted to (1) preparing milestone 3664, (2) preparing and analyzing SD-12 and SD-9 samples to meet the 20 June completion date for milestone 4240, and (3) addressing problems of high-cristobalite contents in dust at the ESF, an effort that was unplanned.

Planning Activities. Staff formulated comments to the Contingency Plan level 3 milestones, in particular noting areas in which Min-Pet personnel should participate in FY97.

Project Support. Staff discussed aspects of both the Los Alamos and OCRWM quality programs with Tom Colandrea of Colandrea and Associates, Inc., to assist in Dan Dreyfus' assessment of progress and problems in QA implementation across the Project.

Staff participated in the 28 March mid-year review of the interface between Site Characterization and Performance Assessment; the status of the summary and synthesis report was also discussed at this meeting.

WBS 1.2.3.2.1.1.2 Alteration History. Staff concentrated on preparing "Mineralogy-Petrology Contribution to the Near-Field Environment Report" (milestone 3668). This milestone, which is being prepared under WBS 1.2.3.2.1.2, includes summaries of Alteration History studies pertinent to past and expected hydrothermal processes affecting the candidate host rock and surrounding units. Other Alteration History contributions include the results of paleohydrologic studies, with short summaries of recent isotopic studies in the Exploratory Studies Facility. Experimental and theoretical studies include the effects of dehydration and rehydration of clinoptilolite, smectite, and volcanic glass and thermodynamic and kinetic considerations of mineral transformations under repository conditions.

The material written for the near-field environment report will serve as first drafts for several sections of the Alteration History Summary and Synthesis Report. New draft sections added to the report this month include material on syngenetic alteration of the Topopah Spring Tuff, Quaternary paleohydrology, and K/Ar geochronologic studies of zeolitization.

WBS 1.2.3.2.1.2 Stability of Minerals and Glasses. Staff focused on completing milestone 3668, "Contribution to the Near-Field Environment Report." This report is divided into three sections: (1) a description of the host-rock mineralogy and the importance of host-rock minerals in the near field; (2) a description of paleohydrology and evidence of past mass transport in host rock tuffs as applied to potential near-field processes; and (3) an assessment of the stability of minerals and glasses under anticipated near-field conditions. The latter also includes a discussion of the impacts of potential mineral transformations on the evolution of porosity, permeability, and water chemistry. The bulk-rock mineralogy within the near-field environment (NFE) varies with depth and laterally across Yucca Mountain. Comparatively soluble silica phases, including cristobalite, tridymite, opal-CT, and volcanic glass are ubiquitous within the NFE. Limited data illustrate the possibility of up to 14% stellerite (a zeolite) within the host rock, and major amounts of clinoptilolite and mordenite are common directly underlying the host rock in the eastern portion of Yucca Mountain, in and below the lower vitrophyre of the Topopah Spring Tuff. Natural alteration in the lower vitrophyre exemplifies hydrothermal modification of rock porosity by the dissolution of volcanic glass and precipitation of smectite, zeolite, and silica. Laboratory data illustrate the many significant effects of long-term, relatively low-temperature excursions on the minerals in the NFE, including dissolution/precipitation of silica,

dehydration of zeolites and smectite with associated large volume decreases, dehydration of volcanic glass, transformation of clinoptilolite and mordenite to analcime, and transformation of α-cristobalite to the β phase at about 220°C with an associated volume increase. Unfortunately, available dissolution kinetic data for both analcime and clinoptilolite are not well constrained and reflect the incomplete status of kinetic data measurement for these minerals. Based on existing data, the dissolution of clinoptilolite appears to be slower than analcime, by a factor near 100.

The latter results are based on recent calculations of B. Carey, who continued to work on the synthesis of kinetic data. He has formulated a criterion for evaluating the significance of kinetic reactions in the thermohydrologic evolution of the mountain that is based upon the Damköhler number derived from dimensional analysis of the diffusion-advection-reaction equation. The Damköhler number relates the relative rate of reaction to fluid velocity or material diffusion. The analysis thus far indicates that diffusion is likely to have the least significance in controlling fluid composition and that reaction rates become significant where they are less than about 10^{-9} moles/m^2/s for fluid velocities greater than 10^{-5}. This recent analysis is discussed in detail in milestone 3668.

The milestone on kinetics of the smectite to illite reaction (4037) was revised and resubmitted. The revision included new data from Pennsylvania State University.

Planning Activities. Staff began extensive planning for FY97 activities to support the viability assessment.

Project Support. Staff formulated comments to the Contingency Plan level 3 milestones, in particular noting areas in which Min-Pet personnel should participate next FY. Staff also continued to address comments on the study plan.

WBS 1.2.3.2.5 Volcanism. ***Probability Studies.*** Bruce Crowe attended the Geophysics Integration workshop at Lawrence Berkeley National Laboratory. He presented (1) geophysical data with respect to the east boundary of the Crater Flat basin and (2) information on the status of ground magnetic and aeromagnetic data with respect to detection of basaltic intrusions.

Staff started processing digital topographic data to produce a base map for compiling revised geologic maps of Hidden Cone and Little Black Peak centers of the basalt of Sleeping Butte. They also started preparing final computer-based maps of spatial and structural models used in probabilistic volcanic hazard assessment.

Staff continued editing chapter 3, "Tectonic Framework," and chapter 7, "Probabilistic Volcanic Hazard Assessment and Probabilistic Volcanic Risk Assessment," of the volcanism synthesis report. Staff

received the draft report titled "Probabilistic Volcanic Hazard Analysis for Yucca Mountain, Nevada," (Expert Judgment Panel report) from Geomatrix, and data from this report will be incorporated into chapters 3 and 7 of the Volcanism synthesis report. Chapter 7 may require only a limited revision because the probability distributions in the Geomatrix report were so similar to probability distributions presented in the Volcanism status report (Crowe et al. 1995).

Geochemistry of Eruptive Sequences. A Los Alamos report titled "Geochemistry of the Lathrop Wells Volcanic Center"(Perry and Straub, 1996) was published. This report is a compilation of detailed geochemical data from the Lathrop Wells center that was gathered during the last few years of site characterization.

Staff continued to explore statistically Lathrop Wells geochemical data as part of Volcanism synthesis studies. Geochemical data were transformed as geomean centered ratios to eliminate concerns of data closure. Multivariate statistical analyses (principal component analyses) were run on the data set and the observed effects of data closure on this data set were minor. Interpretations of the data are limited by a large number of processes (factors) affecting the data, uncertainty of unit assignments, effects of geochemical alteration of scoria units, and multicolinearity. Staff was re-running the data using elemental sets (which should clearly discriminate alternative processes affecting the data set and will compare results of analyses using only lava units with those including both lava and scoria units) to assess the effects of alteration.

A report titled "Assessment of Geochemical Variations at the Lathrop Wells Volcanic Center, Southwestern Nevada" (Perry et al.) was being prepared as part of Volcanism synthesis studies.

Field Geologic Studies. Staff conducted a field review session at the Lathrop Wells volcanic center and southern Crater Flat with the USGS to examine field relations bearing on information currently being assessed for inclusion in the Volcanism synthesis report. Topics reviewed included the stratigraphic identify of outcrops of Paintbrush Tuff near and beneath the Lathrop Wells volcanic center, the stratigraphic identity of lithic fragments in cone scoria, tectonic models of the Crater Flat basin, and Quaternary faulting affecting the 3.7 Ma basalt of southeast Crater Flat.

Eruptive Effects. Staff continued to compile field data on lithics from the San Francisco Volcanic Field. They also began writing up this material for inclusion in the Volcanism synthesis report.

Subsurface Effects. Staff began revising the Volcanism synthesis report chapter that describes structural controls on intrusion geometries at the Paiute Ridge analog center. The sections on alteration studies from Paiute Ridge and Grants Ridge were almost complete.

WBS 1.2.3.3.1.2.2 Water Movement Test. ***Chlorine-36 Studies.*** A milestone report titled "Summary report of chlorine-36 studies: systematic sampling of porewater for chlorine-36 in the Exploratory Studies Facility (ESF)" (Fabryka-Martin et al., 1996) was completed. The report summarizes chlorine-36 (^{36}Cl) activities of the past three months. As a basis for assessing ground-water travel times and for identifying potential fast paths for infiltrating water, the distribution of ^{36}Cl in the ESF tunnel was determined from analyses of samples collected at 52 locations between Stations 2 and 36. Rock samples were collected systematically every 200 m throughout the tunnel, as well as from diverse geologic features such as faults, fractures, and lithophysal cavities. All of the systematic samples as well as most of the feature-based samples contain ^{36}Cl levels consistent with travel times exceeding a few thousand years. Upper age limits range up to several hundred thousand years. Uncertainties about temporal variations in the atmospheric $^{36}Cl/Cl$ input ratio prevent calculation of more precise ground-water travel times at this time. Bomb-pulse ^{36}Cl occurs at a few distinct fractured and/or faulted zones, indicating that at least a small proportion of the water at these locations is less than 50 years old.

In this report, a flow and transport model using the FEHM code is used to simulate transport of ^{36}Cl into the ESF tunnel. Modeling results show that observed ^{36}Cl signals are consistent with existing site conceptual models and parameter estimates. Base-case parameters predict Pleistocene-aged water in the ESF, while parameter changes consistent with increased fracturing of the Paintbrush nonwelded unit (as might be associated with faults) lead to a prediction of a small component of bomb-pulse ^{36}Cl in ESF fractures. Thus, these modeling results show that the new ^{36}Cl data presented in this report do not require a major reevaluation of previous work.

WBS 1.2.3.3.1.3.1 Reactive Tracer Testing. ***Sodium Iodide Pilot Tracer Test.*** The sodium-iodide pilot tracer test begun at the C-holes on 13 February was still in progress. This test involved an injection of 5 kg of iodide into C#2 between packers 3 and 5 (Bullfrog and upper Tram formations) with 100 to 140 gpm production out of C#3 (also Bullfrog and upper Tram). Staff was interpreting the iodide test as the data became available for the purposes of planning a reactive tracer test using lithium bromide. The results to date indicate that it will not be possible to conduct a lithium bromide test between C#2 and C# because lithium concentrations would not exceed half the background concentration in the ground-water (60-70 ppb), even if 40 kg of lithium bromide were injected. However, the pilot test was conducted by injecting only 180 gallons of tracer solution into a packed-off interval exceeding 2000 gallons in volume, and there was no attempt to chase the tracer solution out of the borehole. The next test, involving injection of pentafluorobenzoic acid into C#2, will be conducted with a 5 gpm water chase for an extended period of time, and it is hoped that the chase will accomplish two things: (1) flush tracer out of the borehole more quickly, and (2) reduce tracer residence times in the formation by pushing tracer into more conductive pathways in the vicinity of the injection borehole. A second conservative tracer (a pyridone derivative) will be injected into C#1 during the next test, so staff will also have the opportunity to assess tracer response between C#1 and C#3 before conducting a reactive tracer test. It should be noted that predictions

based on the iodide pilot test between C#2 and C#3 cannot be used to predict tests conducted between C#1 and C#3. This information will be presented next month in a milestone report. No details of the analyses are provided in this monthly report because the test is not yet complete, and the iodide data have not yet been officially released.

Modeling to Support Tracer Test Interpretations. A Laplace transform transfer function model was developed to assist in the interpretation of tracer tests conducted at the C-holes. The model contains transfer functions for the injection pulse, the injection borehole, the formation, and the production borehole. These transfer functions are multiplied by each other to achieve a convolution in the time domain. The transfer function for the formation is a Laplace transform solution for transport in a dual-porosity medium with flow in fractures and diffusion into the porous matrix. Parameters in the model can be varied to obtain a best fit to a data set by minimizing the sum of squares of differences between the data and the model. The adjustable parameters include (1) the mean fluid residence time in the formation, (2) the dispersivity in the formation, (3) a time constant for how long tracer spends in the injection borehole, (4) the average fracture aperture (which controls the amount of matrix diffusion), and (5) the fraction of tracer participating in the test. Application of this model to "fit" the iodide breakthrough curve from the pilot tracer test has led to two preliminary conclusions:

- It is possible to fit the iodide data assuming any amount of matrix diffusion by adjusting the fraction of tracer assumed to participate in the test. This result suggests a need to use more than one tracer in a tracer test to better determine the formation parameters (mean residence time and dispersivity) and the amount of matrix diffusion occurring in the formation.

- It would greatly help in the interpretation of a tracer test to eliminate or minimize the uncertainty associated with how quickly tracer leaves the injection borehole by flushing tracer out of the borehole. This would decrease the number of adjustable parameters in the model, and it may also result in more tracer participating in the test.

In addition to the transfer function model, a 2-D finite-difference model was developed to conduct simulations of steady-state flow and tracer transport in a heterogeneous formation. When using this model, a hydraulic conductivity distribution for the formation is generated stochastically using a specified variance, covariance function, and correlation length(s). A flow field in the heterogeneous conductivity field resulting from pumping a single production well is then calculated and used for tracer transport calculations. An injection/ recirculation well can also be included in the calculations. Tracer transport is simulated using particle-tracking techniques. Some preliminary results from this model indicate that partial recirculation can reduce tracer travel times in a heterogeneous formation by over an order of magnitude if the injection borehole happens to be in a low conductivity zone where little flow occurs as a result of the production well. In this case, the recirculation serves to "push" tracer out of the low

conductivity zone and into conductive pathways where it can then quickly move to the production well. Thus, the model suggests that recirculation has the potential to dramatically reduce tracer travel times at the C-holes. However, it is also possible that recirculation may have little or no effect on travel times. Project scientists are hoping that recirculation enhances tracer recoveries enough between C#2 and C#3 that it is possible to conduct a lithium tracer test between these two holes.

Lithium Bromide Column Experiments . Staff continued to analyze lithium transport experiments conducted last year.

WBS 1.2.3.4.1.1 Ground-water Chemistry Model. Modeling of ground-water chemistry reactions in the soil zone on Yucca Mountain is ongoing.

WBS 1.2.3.4.1.2.1 Batch Sorption Studies. Staff completed section I of the sorption summary report. To date, they have completed sections I., III., and IV., A. of this report.

Outline for the sorption report:

I. Ground-water Chemistry (and its effects on sorption)

II. Mineralogy Variability (and its effects on sorption)

III. Sorption Data (determined by batch experiments)

- A. Sorption of Simple Cations
- B. Sorption of Simple Anions
- C. Sorption of Actinides

IV. Models that can explain the measured sorption data

- A. Ion Exchange
- B. Surface Complexation

V. Recommended sorption data for PA

WBS 1.2.3.4.1.2.2 Biological Sorption and Transport. Staff was preparing for the upcoming International High-Level Waste Management Meeting in Las Vegas. Four papers will be presented at the "Microbiological Research at Yucca Mountain" session. In addition, all the individuals who analyzed the ESF samples will have the opportunity for a first-time in-depth discussion of their results and further publication objectives. Larry Hersman will collect all data for submission to the Project.

Work continued on the summary and synthesis report, specifically describing chelated transport studies. Paul Reimus and Larry Hersman were rewriting a previously approved report titled "Desferrioxamine B-Enhanced Transport of Iron in Volcanic Tuff During Unsaturated Conditions" to include Reimus' modelling input.

WBS 1.2.3.4.1.3 Speciation/Solubility. Staff continued database collection and data analysis. Data analysis includes using the SIT formalism to check for outlying data points from different sources.

WBS 1.2.3.4.1.4.1 Transport. Staff completed the summary of the solid-rock column data under unsaturated conditions (see section I., C of the transport outline). They completed section I of the transport summary and synthesis report.

Transport Report Outline

I. Assessment of Validity of Kd under Advective Conditions
- A. Crushed Rock Columns
  - 1. Using Water from the J-13 Well
    - a. Vitric Tuff
    - b. Zeolitic Tuff
    - c. Devitrified Tuff
  - 2. Using Water from the UE-25 p# 1 Well
    - a. Vitric Tuff
    - b. Zeolitic Tuff
    - c. Devitrified Tuff
- B. Saturated Solid Rock Columns
  - 1. Using Water from the J-13 Well
  - 2. Using Water from the UE-25 p# 1 Well
- C. Unsaturated Solid Rock Columns
  - 1. Zeolitic Tuff
  - 2. Devitrified Tuff

II. Radionuclide Transport through Fractures
- A. Conservative Radionuclides (tritium and pertechnetate)
- B. Sorbing Radionuclides

III. Colloid-Facilitated Radionuclide Transport
- A. Colloid Stability in Natural Ground-waters
- B. Sorption of Radionuclides onto Colloids
- C. Elution of Colloids through Fractures
  - 1. Saturated Systems
  - 2. Unsaturated Systems

Radionuclide Transport through Fractures. Staff collected data describing the elution of tritiated water, pertechnetate, and neptunium through five natural fractures at Yucca Mountain. Initial findings indicate the following: (1) It appears that diffusion from the fracture into the matrix can take place even at relatively fast flow rates. (2) Np can be significantly retarded, even during a fracture-flow scenario.

Neptunium retardation in fractures could be due to both diffusion into the matrix and sorption onto the minerals lining the fracture walls. (3) Contrary to previous assumptions about the role of fractures in radionuclide retardation, preliminary results from this experiment indicate that fracture flow does not necessarily result in a fast pathway for actinide migration through fractures.

Staff received twenty naturally fractured core samples from the USGS core library in Mercury, Nevada. The cores were chosen for transport, hydrodynamics, matrix diffusion, and sorption studies of naturally fractured rocks. (The cores were determined to be natural because of the presence of secondary mineral coatings.) Many of the cores can be reassembled, producing a fractured core of up to 2-4 feet in length. The samples were chosen from NTS UE12N#15, UE20C, and UE18T bore holes. Cores UE12N#15 and UE18T are 2 1/2 inch diameter cores similar to the columns we have all ready used for our experiments, whereas core UE20C is a 4-inch-diameter core.

Staff also summarized the results of the tuff-wafer experiments (see section II. A. in the diffusion outline) and sections IA and IB #2 of the diffusion report (describing diffusion studies using rock beakers). To date, they completed sections I and II. A. of the diffusion report.

Diffusion Report Outline

I. Diffusion of Conservative Radionuclides through Saturated Tuff
- A. Tritiated Water
  - 1. Diffusion Cells
  - 2. Rock Beakers
- B. Pertechnetate
  - 1. Diffusion Cells
  - 2. Rock Beakers

II. Diffusion of Sorbing Radionuclides through Saturated Tuff
- A. Tuff Wafers
- B. Diffusion Cells
- C. Rock Beakers

III. Diffusion of Radionuclides through Unsaturated Tuff

WBS 1.2.3.4.1.5.1 Retardation Sensitivity Analysis. ***Site-Scale Transport Modeling.*** Evaluation of recent ESF samples for Cl-36 (^{36}Cl). A flow and transport model using the FEHM code was used to simulate transport of ^{36}Cl into the ESF tunnel. These modeling results show that observed ^{36}Cl signals are consistent with existing site conceptual models and parameter estimates. Base-case parameters (material properties and infiltration rates) predict Pleistocene-aged water (i.e., older than 10 ky) in the ESF, while parameter estimates consistent with increased fracturing of the PTn unit (as might be associated with fault zones) lead to predictions of a small component of bomb-pulse ^{36}Cl in the ESF fractures. These modeling

results show that the new ^{36}Cl data from the ESF (Fabryka-Martin et al., 1996) do not require a major reevaluation of previous work.

The ESF ^{36}Cl data cited above show $^{36}Cl/Cl$ ratios for systematic and feature-based samples up to station 35 in the ESF. The systematic samples were collected every 200 meters in the stretch of the ESF. The feature-based samples were collected only in distinct faults or fractures. Of these samples, no bomb pulse ^{36}Cl was found in the systematic samples. At five locations, bomb-pulse ^{36}Cl was found in the feature-based samples. Each of these five distinct locations is associated with extensions and/or projections of mapped surface structural features, such as Bow Ridge Fault, Drill Hole Wash Fault, western limit of Imbricate Fault Zone, and Sundance Fault.

Using a representative stratigraphic column at station 35 (a station at which bomb-pulse ^{36}Cl was found) extracted from the 3-D site-scale stratigraphic model of Robinson et al. ("An Unsaturated Zone Flow and Transport of Yucca Mountain," [milestone 3468, 1995]), simulations were performed to model the transport of ^{36}Cl, first assuming no faulting and then assuming structural modification of the PTn fractures due to faulting. With base-case properties, transport of bomb-pulse ^{36}Cl through the entire PTn could not be simulated. Modification of PTn properties based on the assumption that in a fault zone, fracture densities and apertures may increase as well as the net infiltration rate, yielded simulations which predict bomb-pulse ^{36}Cl arrivals at the ESF due to the ability of the modified PTn to sustain fracture flow.

Also included in this analysis is the incorporation of a time varying ^{36}Cl source function at ground surface over the last one-million years. Simulations using this function demonstrate that the $^{36}Cl/Cl$ ratios measured in the ESF, which are higher than current $^{36}Cl/Cl$ ratios in rainwater but not obviously bomb-pulse, indicate samples of Pleistocene water, a time period in which the $^{36}Cl/Cl$ ratio was about twice as high as it is now. This consideration is important so that $^{36}Cl/Cl$ ratios somewhat above present-day background are not misinterpreted as bomb-pulse.

Radionuclide Migration Calculations. Calculations of the transport of Pu and U in the unsaturated zone were initiated. For the sorption values currently expected for these radionuclides, migration velocities are extremely slow for Pu. Staff was analyzing the available batch and column sorption data for plutonium to assess the validity of the sorption K_d values used. U travels somewhat more rapidly, but it still poses no threat of breaking through to the water table in one-million years at 0.1 mm/y uniform infiltration rate. Higher infiltration rates will be considered in future calculations.

Other. Staff met with DOE representatives to discuss planning issues and progress on deliverables due this FY.

WBS 1.2.3.9.7 ESF Test Coordination. Staff provided multiple-shift field coordination and PI support for ESF north ramp and alcove tests. Planning for the Thermal Test Program was continued.

Geologic Mapping and Consolidated sampling activities were underway using the mapping gantry.

Staff continued to assemble Field Document Records Center files for activities conducted in the north ramp. This effort includes the maintenance of an administrative data base that identifies sample locations and their corresponding photo identifiers.

Staff generated test management progress reports to ensure test requirements were met and issues identified. ESF TCO staff continued to support both the Field Change Control Board and the Baseline Change Control Board (level III) on a weekly basis.

WBS 1.2.5.4.9 Development and Verification of Flow and Transport Codes. Staff continued testing of the multiple node module of FEHM for fault and fracture modeling.

Grid Generation. Notable among the many grids generated during this reporting period were refined site-scale saturated-zone models and 3-D cannister-scale models. The site-scale models were higher resolution models of several units; the grids contained about 100k and 300k nodes. Staff was working in collaboration with John Czarnecki and Claudia Faunt of the USGS to reduce the number on grid points. The cannister scale 3-D grid was developed for and in collaboration with Brian Dunlap of the M&O.

Repository fluxes for liquid and vapor were being transferred to David Sevougian of the M&O. To date the following has been transferred: 2-D fluxes for several repository locations, two different flow rates, and both fracture and matrix values. The transfer of 3-D fluxes was being processed.

WBS 1.2.5.3.5 Technical Database Input. The following ATDT records packages were sent to the Los Alamos Records Processing Center (RPC):

- "Geochemical Data for Basalts of the Yucca Mountain Region," DTN LAFP831851AQ95.001.
- "Ar Isotopic Ratios for Basalt Samples from the Yucca Mountain Region," DTN LAFP831851AQ95.002.
- "Age Calculations for Basalts of the Yucca Mountain Region," DTN LAFP831851DQ.95.003.

The following TDB record package was sent to the Los Alamos RPC:

- "Thermodynamic Analysis of Calorimetric Measurement of the Enthalpy of Hydration of Clinoptilolite."

WBS 1.2.6.1.1 Exploratory Studies Facility (ESF) Management, Planning and Technical Assessments. Staff attended weekly design and construction meetings. Staff participated in discussions with DOE and the design team to merge future design activities into the existing 2C design package. Staff provided design input to support field changes related to the thermal test alcove construction. Staff developed weekly and monthly administrative management reports for testing activities and facilitated job package record development. Staff provided field test coordination and administrative support for ESF north ramp main and alcove construction.

WBS 1.2.6.1.2/3 Quality Assurance and Safety Analysis. Staff attended weekly design and construction meetings and routinely observed ESF field testing activities. Staff reviewed test planning records and test-related field change requests for compliance with QA and safety concerns.

WBS 1.2.6.1.6 Exploratory Studies Facility (ESF) Test Management. Staff attended weekly design and construction meetings. Staff supported development of weekly and monthly administrative management reports for testing activities; staff facilitated job package record development. Staff provided field test coordination and administrative support for ESF north ramp main and alcoves construction.

WBS 1.2.6.8.4 Integrated Data and Control System (IDCS). The design team was notified that the IDCS has been placed on indefinite hold because of budgetary constraints. The IDCS data acquisition equipment received in FY 1995 continued to be configured and deployed as temporary portable data acquisition stations. The ESF TCO completed the Draft Field Work Plan (FWP) document titled "ESF Data Collection Systems" to direct the QA configuration, deployment, calibration, and operation of the data acquisition systems in the ESF. This FWP will direct the data collection of the ESF testing organizations in FY 1996 and 1997.

WBS 1.2.11.2/.3/.5 Quality Assurance. ***Program Development.*** Staff continued to place QPs & QP forms, as well as DPs on line. They continued to be involved in planning activities, trying to identify where cuts can best be absorbed and functions still remain viable and determining how to streamline processes without severely impacting technical work.

Procedure Revisions. QPs-06.1 & 06.2 were distributed for formal review. QPs-02.12, 04.6, 18.2, & 08.3 were identified as needing editorial changes and can be placed on-line when QP-06.1 & 06.2 are approved. All other procedures were being reviewed for process improvement and consolidation. P. Gillespie continued to evaluate QARD changes with respect to the RTN matrix. Updating the RTN matrix has been a major undertaking in FY96. Staff prepared to discuss the possibility of allowing Los Alamos to establish their own database.

M&TE. The Los Alamos standards and calibration group (ESH-9) is now conducting calibration activities for Los Alamos YMP researchers.

Audits and Surveys. The audit schedule was being prepared. RTN activities were taking up survey time.

DR-YMQAD-95-D-015 was issued by the YMSCO. This deficiency concerns one of our vendors (SIMCO), and is currently open. DR-YMQAD-96-D-033, a YMSCO- issued DR, was assigned to the TCO office for a field work package. Discussions were being conducted as to why this DR should not have been issued against Los Alamos continued.

Quality Engineering. B. Gundlach continued to work with investigators on FEHMN certification issues. He is also re-engineered the draft homepage on which we hope to make QA documents available on line.

(b) Deliverables Completed

Milestone 3664, "Electronic Submission of 3-D Mineralogy Data to Framework Model" Included in this data set are results from the analysis of USW NRG-6 that were previously unpublished.

Milestone 3783, "Summary report of chlorine-36 studies: systematic sampling of porewater for chlorine-36 in the ESF"

(c) Problem Areas

WBS 1.2.3.2.1.1.1 Mineralogy of Transport Pathways. Progress in meeting planned milestones is being impacted by requests to assist in analysis for silica-mineral health-hazard issues in the ESF. Requests for help on this issue continue to be made and the extent of impact on FY96 milestones is not yet known.

Min-Pet personnel continued to evaluate the samples held in the Los Alamos sample storage facility because sufficient funds are not available to continue to support the facility. Samples needed for future programmatic work will be stored in individual PI's offices or laboratories. Samples that are no longer needed will be shipped back to the SMF, and the Los Alamos sample-storage facility will be vacated.

WBS 1.2.3.3.1.3.1 Reactive Tracer Testing. Potential problems or issues that may adversely affect performance during future reporting periods include: (1) the pending layoff of drilling crews to support C-holes activities, which could cause serious delays if there is a need to pull equipment out of the holes after the layoff occurs, and (2) the possibility that partial recirculation will not improve the recovery of conservative tracer between C#2 and C#3 plus the possibility of low tracer recoveries between C#1 and C#3, the combination of which would make it very unlikely that a successful reactive tracer test could be conducted using lithium as tracer. To hedge against the possibility that lithium cannot be used as a reactive tracer, staff was compiling a list of additional potential reactive tracers for a permit application.

(2) Personnel Changes

WBS 1.2.3.4.1.5.1 Retardation Sensitivity Analysis. Jake Turin, a Los Alamos hydrogeochemist, has begun contributing to the ^{36}Cl modeling effort, in addition to working on the C-Wells reactive tracer task.

(3) Unusual Costs and Possible Financial Performance Problems

NA

(4) Programmatic Issues That may Impact the Overall CRWMS M&O Effort

WBS 1.2.3.2.1.1.1 Mineralogy of Transport Pathways. The question how to prioritize staff effort—for either completion of planned milestones (see below) or for addressing the immediate concerns over silica-mineral health hazards in the ESF—will need to be resolved soon.

WBS 1.2.5.4.9 Development and Verification of Flow and Transport Codes.
A meeting was held with M&O on 29 March in Los Alamos. This meeting was intended for planning PA work scope for FY 96, but no work scope discussions took place. Considerable discussion was held regarding the results of FY95 Los Alamos deliverables.

(5) Worked Planned

WBS 1.2.3.2.1.1.1 Mineralogy of Transport Pathways. Work planned for the coming months includes the following: (1) continue to provide input to mineralogic models for site transport evaluations and (2) support the project in preparation of synthesis and summary reports.

WBS 1.2.3.2.1.1.2 Alteration History. Staff will continue writing the Alteration History portion of the Mineralogy of Transport Pathways Summary and Synthesis report, in support of a site investment analysis. Sections on mineral dehydration and rehydration will be prepared for inclusion in the report. The work in support of the FY96 Thermal Loading Study Report will continue through April and will also be included in the Alteration History Summary and Synthesis Report.

WBS 1.2.3.2.1.2.2 Stability of Minerals and Glasses. Summary and synthesis report writing will continue, and study plan comments will continue to be addressed.

WBS 1.2.3.2.5 Volcanism. Synthesis of Volcanism activities will continue.

WBS 1.2.3.3.1.2.2 Water Movement Test. Staff will obtain final ^{36}Cl results for samples submitted for analysis since December 1995. Staff will process critical ESF samples for chlorine-36. Staff will continue acquisition of halide data for boreholes to replace old data discarded as unreliable. Staff will continue acquisition of halide data for chlorine-36 samples already submitted for isotope analysis. Staff will participate in planning activities for sample collection from ESF and boreholes Prepare for DOE audit scheduled for June 1996.

WBS 1.2.3.3.1.3.1 Reactive Tracer Testing. Staff will continue to work on milestone 3249, which describes the results of the LiBr column studies. This report will discuss the ability to predict the transport behavior of lithium by assuming an equilibrium adsorption isotherm based on the results of earlier batch sorption experiments.

Staff will conduct a reactive tracer test (using lithium bromide and polystyrene microspheres as tracers) immediately after the next round of conservative tracer tests involving injection into both C#1 and C#2 are completed. The first reactive tracer test will be conducted by injecting into whichever hole shows the highest recovery of conservative tracer.

WBS 1.2.3.4.1.2.1 Batch Sorption Studies. Staff will complete section IV., B of the sorption report.

WBS 1.2.3.4.1.1 Ground-Water Chemistry Model. Staff will continue development of quantitative models for soil-zone chemical processes. Staff will continue to refine conceptual models for processes that could control ground-water chemistry at Yucca Mountain. Staff will continue implementation of laboratory experiments designed to evaluate controls on ground water compositions in the unsaturated and saturated zones at Yucca Mountain.

WBS 1.2.3.4.1.2.2 Biological Sorption and Transport. Staff will continue summary and synthesis report. Staff will continue to prepare for IHLWM meeting.

WBS 1.2.3.4.1.3. Solubility/Speciation. Staff will continue work described above.

WBS 1.2.3.4.1.5.1 Retardation Sensitivity Analysis. Staff will continue code development on reduced-degree-of-freedom methods and transport model improvements, including the incorporation of a longitudinal and transverse dispersion model option. Staff will continue simulations on the impact of repository waste heat on far-field radionuclide transport for Tc, Np, Pu, Se, and Np. Staff will continue grid development for saturated-zone transport calculations.

WBS 1.2.5.4.9 Development and Verification of Flow and Transport Codes. Continue work described above.

WBS 1.2.11.2/.3/.5 Quality Assurance Program Development, Verification, and Engineering. Staff will continue to establish a surveillance schedule. Staff will continue discussions with the M&O to allow each AO to implement their own RTN Matrix using Microsoft Access software as the preferred database. Staff will continue efforts on the QA homepage as we continue to examine options for putting forms and QA procedures on line in an effort to address electronic document control. Staff will be placing two prototypical QPs on the homepage; these will be followed by four additional QPs. Staff will provide the laboratory lead with monthly status reports on Software QA activities and 1994 and 1995 QA-related statistics.