Yucca Mountain Site Characterization Project

Monthly Activity Report

December 1993

Attachment to LA-EES-13-03-94-003

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LOS ALAMOS NATIONAL LABORATORY

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Monthly Activity Report

December 1993

WBS 1.2.1 Systems Engineering

Objective

The objective of this task is to integrate systems with the Geologic Repository Program, to describe the Yucca Mountain Site Characterization Project Mined Geologic Disposal System, and to evaluate the performance of the natural, engineered barrier, and total systems for meeting regulatory standards.

Activities and Accomplishments

Staff continued to evaluate the geochemical effects of various thermal loads on the potential repository. They completed a paper on geochemical effects on the thermal loading systems and submitted it to S. Saterlie of the M&O, who is preparing a study on this subject. This paper, titled "Preliminary Evaluation of Geochemical Effects of Various Repository Loads," (Milestone 4046), appears in the Appendix to this report.

Staff also reviewed the section of this study in which they evaluated the thermal loads of 110, 83, 55, 36, and 24 MTU/acre with regard to 1) zeolite, clay, and volcanic glass dehydration; 2) crystallization of volcanic glass to zeolite-clay-silica mineral assemblages; and 3) recrystallization of clinoptilolite-silica mineral assemblages to analcime-quartz assemblages. The effects of these partially reversible and irreversible processes were estimated with respect to retardation, changes in hydraulic properties, and thermal buffering.

Planned Activities

Staff will continue to evaluate the geochemical effects of various thermal loads on the repository.

WBS 1.2.3.1.1 Site Investigation Coordination and Planning/Site Management

Objective

The objective of this task is to manage and coordinate site characterization activities.

Activities and Accomplishments

Los Alamos management and principal investigators hosted a meeting with R. Patterson and R. St. Clair to plan for the Saturated-Zone Hydrology presentations at the February 1994 DOE Technical Program Review.

Staff participated in a Geochemistry Integration Team teleconference on the February 1994 Technical Program Review, geochemistry white paper, and Model Validation Workshop.

B. Carlos and A. Mitchell represented the principal investigators at the December Sample Overview Committee meeting.

Staff attended the Migration '93 meeting in Charleston, South Carolina.

Staff supported completion of FY93 milestones.

Staff revised FY 94 milestones and criteria statements and incorporated this information into the Planning and Control System.

WBS 1.2.3.1.2/3 Site Investigation Coordination and Planning/ Test Management and Integration

Objective

The objective of this task is to manage and integrate Exploratory Studies Facility (ESF) and Los Alamos site characterization test activities and to provide coordination for Los Alamos surface-based test planning and package development.

Activities and Accomplishments

Surface-Based Testing. Staff represented the Test Coordination Office at weekly surface-based testing meetings and M&O work scope coordination meetings.

Continued the final transition phase of support activities pertaining to the use of tracers, fluids, and material at Yucca Mountain to the M&O.

ESF Testing. Staff provided day-shift field coordination and PI support for ESF north ramp starter tunnel tests. Planning on the Phase III ESF tests was continued including the M&O test-to-test, test-to-construction, and waste isolation evaluations. Staff continued to finalize planning packages for the radial borehole test.

Construction of the ESF starter tunnel alcove was almost complete. This activity is fully supported by geologic mapping, consolidated sampling, hydrochemistry, and construction monitoring test activities; no perched water was identified in the ESF.

Efforts were continued to finalize record packages that document the development of controlled documents that govern Phase II ESF field testing activities.

Planned Activities

Continue support of Los Alamos surface-based site characterization and ESF test coordination activities in response to Project programmatic requirements.

Problem Areas

None

WBS 1.2.3.2.1.1.1 Mineralogy, Petrology, and Rock Chemistry of Transport Pathways

Objective

The purpose of this activity is to define the important mineralogical and geochemical variables along fracture and rock-matrix transport pathways at Yucca Mountain, in support of performance assessment and to evaluate the impact of repository construction on natural waste-transport barriers.

Activities and Accomplishments

Staff collected XRD data for all samples from UE-25 UZ-16 drill core. Quantitative analysis of this data will be completed in early 1994. Results of these analyses will be published in 1994, including an assessment of trends in mineral occurrences and abundances that are important for the evaluation of sorption, past and future water-rock interactions, and thermal loading at the Yucca Mountain site.

Further work was done in revising Study Plan 8.3.1.3.2.1. These revisions will take into consideration the most current information on core and ESF sampling anticipated at, and adjacent to, the Yucca Mountain site.

Approximately 300 mg of pure stellerite (usually a fracture-lining zeolite) were obtained from UE-25 UZ-16 at a depth of 373 m. The separation of this mineral will allow further mineralogical and chemical studies of the environment of zeolite formation. Zeolites such as stellerite provide indications of past fracture transport and deposition; although small in volume and difficult to isolate, these minerals occupy critical surfaces in fractures that are likely to be important to transport in the unsaturated zone. In addition, several new occurrences of stellerite in bulk-rock samples were noted this month; there were no indications that the occurrences were associated with the presence of fractures. This marks the first time in several years that a new zeolite such as this has been identified in matrix samples.

A draft paper, "Inferences of Paleoenvironment from Petrographic, Chemical, and Stable Isotope Studies of Calcretes and Fracture Calcites," was prepared. This paper, intended for the 1994 IHLRWM meeting, combines joint studies of hydrogenic deposits by Los Alamos and USGS, Denver. The authors found that calcretes and calcites at Yucca Mountain, which appear to contribute the youngest deposits along unsaturated-zone fractures, have the potential for revealing both the timing and the location of discrete fracture-flow systems. In related studies, several soil samples from Trench 14C were examined using XRD, and the evaporite minerals gypsum, calcite, halite, and bassanite were identified.

G. Guthrie and R. Raymond collected numerous samples of aeolian dust in the vicinity of Yucca Mountain. Sampling sites included the summit and eastern and western flanks of Yucca Mountain (including near the ESF), the western flank of the Calico Hills (along Fortymile Wash), Red Cone, Black Cone, and additional sites along Highway 95. These samples will be used to assess the background compositions of aeolian dusts, and they will provide a baseline for evaluating any additional dusts that could be introduced to the environment by operations at Yucca Mountain.

G. Guthrie collected the data necessary for basic calibration of the transmission electron microscope (TEM). These calibrations include image magnifications, diffraction-pattern magnifications, and rotation corrections, and they are necessary for basic survey work on the TEM. The TEM can provide fine-scale structural and compositional information that is unobtainable by other traditional petrologic techniques, and this level of petrologic information can be essential to understanding problems related to processes recorded by fine-grained materials, such as fracture-filling minerals and aeolian dusts. Analysis of the calibration data is complete, and the letter report to satisfy Milestone 4007 was complete.

B. Carlos examined core from USW UZ-14 and USW NRG 7/7a at the SMF.

Activities and Accomplishments (cont.)

Comments from YMPO on the "Field Guide to Fracture-Lining Minerals at Yucca Mountain" were addressed, and color plates were being selected. Staff reviewed and compiled the data on fracture-lining minerals in "old" core and prepared figures and tables. X-ray diffraction data continue to be collected on fractures from old core for inclusion in this report. Microdiffractometer analysis of previously unidentified crystals in lithophysal cavities, often referred to as "cinnamon sticks," revealed them to be amphibole crystals with possible minor surface alteration.

Sample preparation and X-ray diffraction analysis continued on numerous samples used by the Geochemistry task in sorption experiments.

Planned Activities

Work planned for the coming months includes the following activities: (1) continue analysis of calcites to understand transport and precipitation mechanisms; (2) examine drill core from USW UZ-14 and USW UZ-7a as it becomes available at SMF; (3) complete analysis of XRD data on UE-25 UZ-16 drill core; (4) continue analysis of background dust mineralogy around Yucca Mountain, with possible additional sampling near drill sites; (5) continue characterization of trace minerals and continue microautoradiography experiments; (6) begin analysis of fracture coatings in UE 25 UZ-16 and USW UZ-14 core; (7) begin examination of fracture-coating samples from the starter tunnel; (8) prepare preliminary report on fracture-lining minerals in USW UZ-14 when that hole is completed.

Problem Areas

A delay in completion of UZ-14 will force a delay in production of the letter report on UZ-14 (Milestone 4005, due 31 March 1994). No additional samples have been obtained recently.

Milestone Progress

3255
30 September 1994
Trace Mineral Study

3370
31 August 1994
Los Alamos report on Fracture Mineralogy of UZ-16

3371
30 June 1994
Los Alamos report Summarizing Fracture Mineralogy from Old Core

3372
29 April 1994
Los Alamos report on Quantitative Mineralogy in UZ-16

3373
14 January 1994
Paper on Paleohydrological Implications of Calcite Chemistry

4005
31 March 1994
Letter report on Fracture Mineralogy of UZ-14

4006
31 March 1994
Letter report on Quantitative Analysis of Hydrous Minerals

4007
23 December 93
Letter report on Temperature Calibration for Hazardous Minerals at Yucca Mountain
Completed.

4008
29 October 93
Convene Short Course on Health Hazards Fibrous Minerals
Completed.

4031
31 August 1994
Letter report on Silica Leaching and Porosity

Publications

B. Carlos, S. Chipera, and D. Bish
Distribution of Fracture-Lining Zeolites at Yucca Mountain, Nevada
Proceedings paper, *Zeolite '93*
Approved by YMPO; addressing reviewers' comments.

B. Carlos
Field Guide to Fracture-lining Minerals
Addressing YMPO comments.

S. J. Chipera, D. L. Bish, and B. A. Carlos
Equilibrium Modeling of the Formation of Zeolites in Fractures at Yucca Mountain, Nevada
Proceedings paper, *Zeolite '93*
Approved by YMPO; addressing reviewers' comments.

G. D. Guthrie, D. L. Bish, and B. T. Mossman
Quantitative Analysis of Zeolite-Bearing Dusts Using the Rietveld Method
Journal article, *Science*
Submitted.

G. Guthrie, D. Bish, S. Chipera, and R. Raymond
Distribution of potentially hazardous phases in the subsurface at Yucca Mountain, Nevada
Los Alamos report
Addressing YMPO comments.

D. T. Vaniman, D. Bish, D. Broxton, B. Carlos, S. Chipera, and S. Levy
Mineralogy as a Factor in Radioactive Waste Transport Through Pyroclastic Rocks at Yucca Mountain, Nevada
Journal article, *Clay and Clay Minerals*
In revision.

D. T. Vaniman
Calcite Deposits in Drill Cores USW G-2 and USW GU-3/G-3 at Yucca Mountain, Nevada
Los Alamos report
In Los Alamos publication process.

D.T. Vaniman and D. L. Bish
The Importance of Zeolites in a Potential High-Level Waste Repository at Yucca Mountain, Nevada
Proceedings paper, *Zeolite '93*
Approved by YMPO; addressing reviewers' comments.

WBS 1.2.3.2.1.1.2 Mineralogical and Geochemical Alteration

Objective

The objective of this task is to characterize past and present natural alteration processes that have affected the potential geologic repository and to predict future effects of natural and repository-induced alteration.

Activities and Accomplishments

Mapping was begun on a large block of laminated calcrete from the north wall of Trench 14; the block was cut apart to prepare vertical and horizontal surfaces for hand-sample-scale and microscope-scale mapping. The laminae within the block can be classified into porous ooidal, root-fossil rich, dense/sheared, and opaline, as in previous maps of this scale from Trench 14. Thin-section analysis will be used to describe the initiation of ooid formation, as revealed in the young "ash" lamina preserved in this block. Results of these studies will be incorporated in a Los Alamos report on calcite-silica deposits in Trench 14 (Milestone 3376). This report is an important basis document for Milestone YMP/93-11-R ("Report on the Origin of Calcite-Silica Deposits at Trench 14 and Busted Butte and Methodologies used to Determine their Origin").

In a correction to last month's report, G. WoldeGabriel noted that his recent studies comparing ages of zeolites and feldspars from the same samples were being conducted with samples from Barstow, not Yucca Mountain, and the data obtained so far are K/Ar ages, not Ar/Ar ages.

Planned Activities

Staff will continue to prepare for the 14-18 February program review, and a scoping meeting will take place in January. Evaluation of the thermal model output for the potential waste repository supplied by the M&O will continue, with preparation of a formal memorandum. The materials used in the steam-atmosphere heating experiments will be characterized. K/Ar studies, and studies of alteration in the Paintbrush tuff and near-surface deposits will continue. W. Carey will continue working with the thermal analysis equipment to determine the precision and accuracy required for thermodynamic calculations.

Problem Areas

None

Milestone Progress

3022
30 September 1994
Letter report on Zeolite Synthesis

3150
30 April 1994
Final report on Bedrock

3223
30 September 1994
Letter report on Cristobalite Dissolution Kinetics

3376
31 March 1994
Los Alamos report on Mineralogy and Chemistry of Calcite-Silica

3377
30 September 1994
Report on Microscopic-Scale Chemical Transport in Zeolitic Alteration

3379
30 June 1994
Paper on Evaluating Use of K-Ar Dating on Zeolites

3380
30 September 1994
Paper on Effects of Saturation and Temperature on Ion Exchange

4010
30 September 1994
Letter report on Long-Term Heating of Zeolites and Glasses

4015
30 September 1994
Letter report on Zeolite System Model

Publications

D. L. Bish
Thermal Behavior of Natural Zeolites
Proceedings paper, Zeolites '93
Submitted to YMPO.

S. Levy and C. Naeser
Bedrock Breccias Along Fault Zones near Yucca Mountain, Nevada
Chapter in USGS Bulletin on Yucca Mountain studies
In USGS editorial review.

S. Levy and G. Valentine
Natural Alteration in the Cooling Topopah Spring Tuff, Yucca Mountain, Nevada, as an Analog to a Waste-Repository Hydrothermal Regime
Submitted to YMPO.

D. Vaniman, D. Bish, and S. Chipera
Dehydration and Rehydration of a Tuff Vitrophyre
Journal article, *Journal of Geophysical Research*
Approved by YMPO.

D. Vaniman, S. Chipera, and D. Bish
Pedogenesis of Siliceous Calcretes at Yucca Mountain, Nevada
Journal article, *Geoderma*
Accepted for publication.

WBS 1.2.3.2.1.2 Stability of Minerals and Glasses

Objective

The objective of this activity is to produce a model for past and future mineral alteration in Yucca Mountain. The model is intended to explain the natural mineral evolution resulting from the transformation of metastable mineral assemblages to more stable assemblages and the effects of a repository emplacement.

Activities and Accomplishments

The study plan for this activity was completed and sent to the TPO. This study plan incorporates preliminary experimental results obtained by A. Lasaga of Yale University and H. Barnes of Penn State University. It describes an experimental procedure for moving towards a conceptual model of mineral evolution at Yucca Mountain that incorporates information on the low-temperature kinetics of mineral reactions. The contracts to Penn State and Yale Universities to perform some of the work outlined in the study plan were being finalized, and they should be let in January. Contract work scopes and quality assurance guidelines were developed within the constraints of a very limited budget.

Planned Activities

Contracts to Penn State and Yale will be let and experimental work will begin. Los Alamos will perform QA audits and orientation at Penn State and Yale before quality-affecting work begins.

Problem Areas

None

WBS 1.2.3.2.5 Postclosure Tectonics

Objective

The objective of these volcanism studies is to determine the hazards of future volcanic activities with respect to siting a high-level radioactive waste repository at Yucca Mountain.

Activities and Accomplishments

Analysis of the geochemical data for the Lathrop Wells center shows that each of the four major eruptive episodes identified in field studies is geochemically distinct, and cannot be related to each other by fractionation of a single magma batch. Geochemical data also show systematic changes through time at Lathrop Wells with increases in La/Sm, Th/K, and Th and decrease in Ti. Differences in La/Sm and Th/K of different eruptive units indicate that a minimum of 6-8 separate magma batches were involved in the formation of the Lathrop Wells center.

Staff spent one day at Alkali Buttes, New Mexico, examining products of strombolian and hydrovolcanic eruptions as part of analog studies for effects studies.

Staff examined aerial photographs of Lathrop Wells and confirmed a time break between the formation of the main cone and the eruption of the major scoria-fall deposits. The basis of that time break is the erosional nonconformity separating the deposits. Further, this has lead to an increased understanding of the interpretation of cosmogenic ^{3}He age determinations. ^{3}He ages of the oldest volcanic units of the center are minimum ages because deposits near the main cone have been covered by as much as 2.5 meters of scoria-fall deposits.

Using non-Poissonian distribution models, staff completed revised calculations of the recurrence rate of volcanic events (E1) . The primary goal of this work has been to compare the results of non-Poisson models versus Poisson models (homogeneous vs. nonhomogeneous). The differences in the models are dependent on a beta factor that is sensitive to the time-distribution of volcanic events. The models are similar for beta factor of 1 and dissimilar when beta is not equal to one. For the Yucca Mountain calculations, the beta factor is dependent on the selected interval recurrence calculations. For calculations based on the past geologic record, beta factors are less than or equal to 1. This means that nonhomogeneous Poisson distribution models give recurrence rates that are less than or equal to homogeneous Poisson calculations. The difference in the distribution models is not significant in probability calculations.

Work in Progress. Revision of the "Volcanism Status Report" continued. Work during the month focused on revision of Chapters 2, 4, and 7. Completion of the report has been delayed until 11 February 1994 in order to include new stratigraphic data of the Lathrop Wells center, new geochemical interpretations, and for expansion of nonhomogeneous Poisson modeling of the recurrence rate of volcanic events and simulation modeling of the probability of magmatic disruption of the proposed repository.

Planned Activities

Continue work in all areas discussed above.

Problem Areas

None.

Milestone Progress

3075
30 November 1993
Preliminary Geologic Mapping of Pliocene Volcanic Centers of Crater Flat
Delayed to Spring 1994.

3238
30 September 1993
Frequency of the Occurrence of Quaternary Basalt in the Central Great Basin by Structural SET
Delayed; now part of Milestone 3422

3245
30 September 1994
Review of Geophysics Data for YM Region (M3)

3396
31 March 1994
Revised Geologic Map Lathrop Wells Volcanic Center

3398
30 September 1994
Structural Controls of Sites of Basaltic Volcanism

3422
11 February 1994
Volcanism Status Report
Revised date because of an unanticipated number of NRC comments.

3395
29 July 1994
Preliminary Geologic Map of Quaternary Volcanic Centers of Crater Flat

3397
30 September 1994
Report on Geochemistry of Lathrop Wells Eruptive Sequence

4016
30 September 1994
Letter report on Lithic Fragment Studies (M4)

4017
30 September 1994
Progress report on Geochronology Studies (M4)

4018
30 September 1994
Letter report on evolving patterns of Volcanic Fields in the southwest USA

4020
30 September 1994
Letter report on Magma System Dynamics

4033
30 September 1994
Letter report on Spatial Scales of Hydrothermal Processes

T055
30 September 1994
Revised Probability Calculations

Publications

B. M. Crowe et al.
Volcanism Status Report
First draft in technical review; resolving NRC comments.

B. M. Crowe et al.
Simulation Modeling of the Probability of Magmatic Disruption of the Potential Yucca Mountain Site
Conference paper, *Focus '93 proceedings*
Approved by YMPO.

G. Valentine et al.
Effects of Magmatic Processes on the Potential Yucca Mountain Repository: Field and Computational Studies
Conference paper, *Focus '93 proceedings*
Approved by YMPO.

WBS 1.2.3.2.8.1 Rock-Varnish Dating Support for USGS Neotectonic Studies

Objective

This activity will provide rock-varnish dating support in various areas of surface site characterization activities including erosion, neotectonics, and paleoclimate.

Activities and Accomplishments

A paper titled "Preliminary Analysis of Erosionally Enhanced Scarps Associated With Faults in Crater Flat, Nevada" co-authored with John Whitney, USGS, was presented at the fall meeting of the American Geophysical Meeting in San Francisco.

Cosmogenic dating samples continue to be analyzed at the AMS Facility at the University of Arizona.

Staff made a presentation on analysis of erosionally enhanced scarps along the Windy Wash and Solitario Canyon faults in Crater Flat at the Tectonics Workshop sponsored by the USGS.

Planned Activities

No planned activities reported.

Problem Areas

None

Milestone Progress

4035
30 September 1994
Letter report on FY94 Fault-Scarp Studies

Publications

C.D. Harrington, J.W. Whitney/ A.J.T. Jull and G.S.Burr
Preliminary Analysis of Erosionally Enhanced Scarps Associated With Faults in Crater Flat, Nevada (Abstract)
EOS Transactions of the AGU, V. 74, p. 403
Published.

S. Reneau
Maganese Accumulation in Rock Varnish in a Desert Piedmont, Mojave Desert, California, and Application to Evaluating Varnish Development
Journal article, *Quaternary Research*
(V. 40, p. 309-317, November 1993)
Published.

WBS 1.2.3.3.1.2.2 Water-Movement Tracer Tests

Objective

The objective of the water-movement tracer tests is to obtain measurements of chlorine isotope distributions to help quantify the percolation of precipitation in the unsaturated zone.

Activities and Accomplishments

Staff continued a thorough reviews of notebooks and logbooks containing all chlorine-36 and halide analyses obtained to date in preparation for closing out these documents.

Los Alamos QA staff conducted an internal audit of Hydro Geo Chem's activities. No deficiencies were found.

Hydro Geo Chem began processing a suite of 12 water samples from the saturated zone for chloride and bromide analysis; these samples will be submitted to an outside analytical laboratory for chlorine-36 analysis next month.

The present three-year contract with Hydro Geo Chem ends on 31 December 1993. A committee reviewed all proposals in response to an RFP, and J. Fabryka-Martin was preparing a report summarizing the committee's findings.

Planned Activities

Revise existing DPs; prepare new DPs; process soil samples for Cl/Br and chlorine-36/Cl ratios; process cuttings samples from UZ-16, UZ-14 and neutron-access boreholes; participate in planning activities for sample collection from ESF; collect additional soil samples from Yucca Mountain area as opportunities arise.

Problem Areas

None

Milestone Progress

3417
30 September 1994
Progress report on Cl-36 Analysis

Publications

J. Fabryka-Martin
Distribution of Chlorine-36 in the Unsaturated Zone at Yucca Mountain: An Indicator of Fast Transport Paths
Conference paper, *Focus '93 Proceedings*
Addressing YMPO comments.

WBS 1.2.3.3.1.2.5 Diffusion Tests in the ESF

Objective

The objective of this task is to determine *in situ* the extent to which the nonsorbing tracers diffuse into the water-filled pores of the Topopah Spring welded unit.

Activities and Accomplishments

The task is deferred because of lack of funding.

WBS 1.2.3.3.1.3.1 Site Saturated Zone Ground-water Flow System (Reactive Tracer Testing)

Objective

Experiments will be conducted at the C-Well complex (holes UE-25c #1, UE-25c #2, and UE-25c #3) and other wells in the vicinity of Yucca Mountain using reactive tracers to characterize retardation and transport properties at a larger scale than currently used in laboratory experiments.

Activities and Accomplishments

Software QA. B. Robinson continued to serve as CCB Chair, and Z. Dash continued to serve as a member of the CCB.

The input sections of the code FEHM were reworked, verification runs were performed, and documentation prologs were written. This version of the code will now be placed in the configuration management system. The latest version of the user's manual was being updated to reflect the present status of the code

Colloid Transport. Additional transport experiments using microspheres and iodide were conducted carried out on each of the C-Wells fracture specimens. Repeatability was demonstrated by running identical tests as was done previously. Also, one of the fractures was assembled with flow induced perpendicular to the flow direction of the previous test. The average transit time in the fracture remained the same, but the dispersive characteristics differed as a function of flow direction. In the next phase of the study the aperture distribution will be measured, after which numerical modeling studies will be carried out to attempt to explain this behavior.

Planned Activities

Contribute to the SQA effort by serving as CCB Chair. Continue work on the FEHMN user's manual.

Continue modeling studies using FEHMN to support the design of the field tests.

Begin lithium column sorption experiments.

Begin aperture characterization measurements for the C-Wells fracture specimens.

Problem Areas

None

Milestone Progress

3247
30 September 1994
Characteristics of Reactive Tracers Polystyrene Micro (M3)

3249
3 January 1994
Column Sorption Experiments with Li (M3)

4029
30 September 1994
Letter report, *Input to Tpp/Jp*

T112
30 September 1994
Final Documentation for FEHM

Publications

B. A. Robinson
FRACNET—Fracture Network Model for Water Flow and Solute Transport
Los Alamos report
In preparation.

B. A. Robinson
SORBEQ—A One-Dimensional Model for Simulating Column Transport Experiments
Los Alamos report
Approved by YMPO; in Los Alamos publication process.

B. A. Robinson
A Strategy for Validating a Conceptual Model for Radionuclide Migration in the Saturated Zone Beneath Yucca Mountain (3201)
Journal article, *Radioactive Waste Management and the Nuclear Fuel Cycle - Special issue on the Yucca Mountain Project*
Approved by YMPO; accepted for publication.

P. Reimus
Transport of Synthetic Colloids through Single Saturated Fractures: A Literature Review
Los Alamos report
Approved by YMPO.

P. Reimus
Transport of Synthetic Colloids and a Nonsorbing Solute through a Saturated Natural Fracture
Conference abstract, ACS Symposium
Submitted to YMPO.

W. L. Polzer and E. H. Essington
The Use of Selectivity Coefficients to Estimate Modified Langmuir Isotherm Parameters as a Function of Experimental Conditions
Journal article, *Radioactive Waste Management and the Nuclear Fuel Cycle - Special issue on the Yucca Mountain Project*
Approved by YMPO; accepted for publication.

WBS 1.2.3.4.1.1 Ground-water Chemistry Model

Objective

The goal of this investigation is to provide conceptual and mathematical models of the ground-water chemistry at Yucca Mountain. These models will explain the present ground-water composition in relation to interactions of minerals and ground-water and will be used to predict ground-water compositions as a result of anticipated and unanticipated environments.

Activities and Accomplishments

Staff continued work on Milestone 3006 and 4014.

Planned Activities

No planned activities reported.

Problem Areas

None

Milestone Progress

3006
31 May 1994
pH and Eh Buffering at Yucca Mountain

4014
31 May 1994
Letter report on Most-active Ground-water Chemistry
(input to Milestone 3349 [Dynamic Transport])

4032
30 September 1994
Letter report on Most Critical Groundwater Parameters and Sorption Studies

Publications

None

WBS 1.2.3.4.1.2.1 Batch Sorption Studies

Objective

The objective of this task is to provide sorption coefficients for elements of interest to predict radionuclide movements from the repository to the accessible environment.

Activities and Accomplishments

Staff completed a set of experiments to study Np sorption (under atmospheric conditions) onto Fe-oxide minerals derived from Bandelier and Paintbrush tuffs. Samples were provided by S. Chipera of the Min-Pet task.

The solid phase was pretreated with J-13 water, separated using centrifugation, and equilibrated in a solution of Np and J-13 water. Following a three-day sorption period, the phases were again separated using centrifugation, and the amount of ^{237}Np in each phase was determined using liquid scintillation counting. (The liquid scintillation counting technique used is capable of discriminating alpha from beta activity; consequently no interference from the ^{237}Np daughter [^{233}Pa] is expected.) The results of these experiments may be seen in Table I.

Table I. Np Sorption onto Natural Oxide Minerals

Water type	J-13
Length of pre-Equilibration	2 days
pH of water after pre-equilibration	8.1 - 8.5
Length of sorption	3 days
pH of water after sorption	8.0 - 8.2
Tuff particle size	75 - 500 microns
Temperature	20°C

Kd (ml/g) with an initial Np Concentration of 7.9E-07 M

Tuff	Trial #1	Trial #2	Experimental average	Predicted based on % hematite
DEB 8/93-1B	5.4	5.4	5E+00	6E+01
DEB 8/93-2	33.1	32.3	3E+01	1E+02
OU-1085-3-6	31.3	29.5	3E+01	2E+02
OU-1085-3-7	13.6	10.9	1E+01	2E+01
OU-1106-2-21	64.2		6E+01	2E+02
USW G4-159.0/.4	41.1		4E+01	5E+02

Kd (ml/g) with an initial Np Concentration of 1.8E-05 M

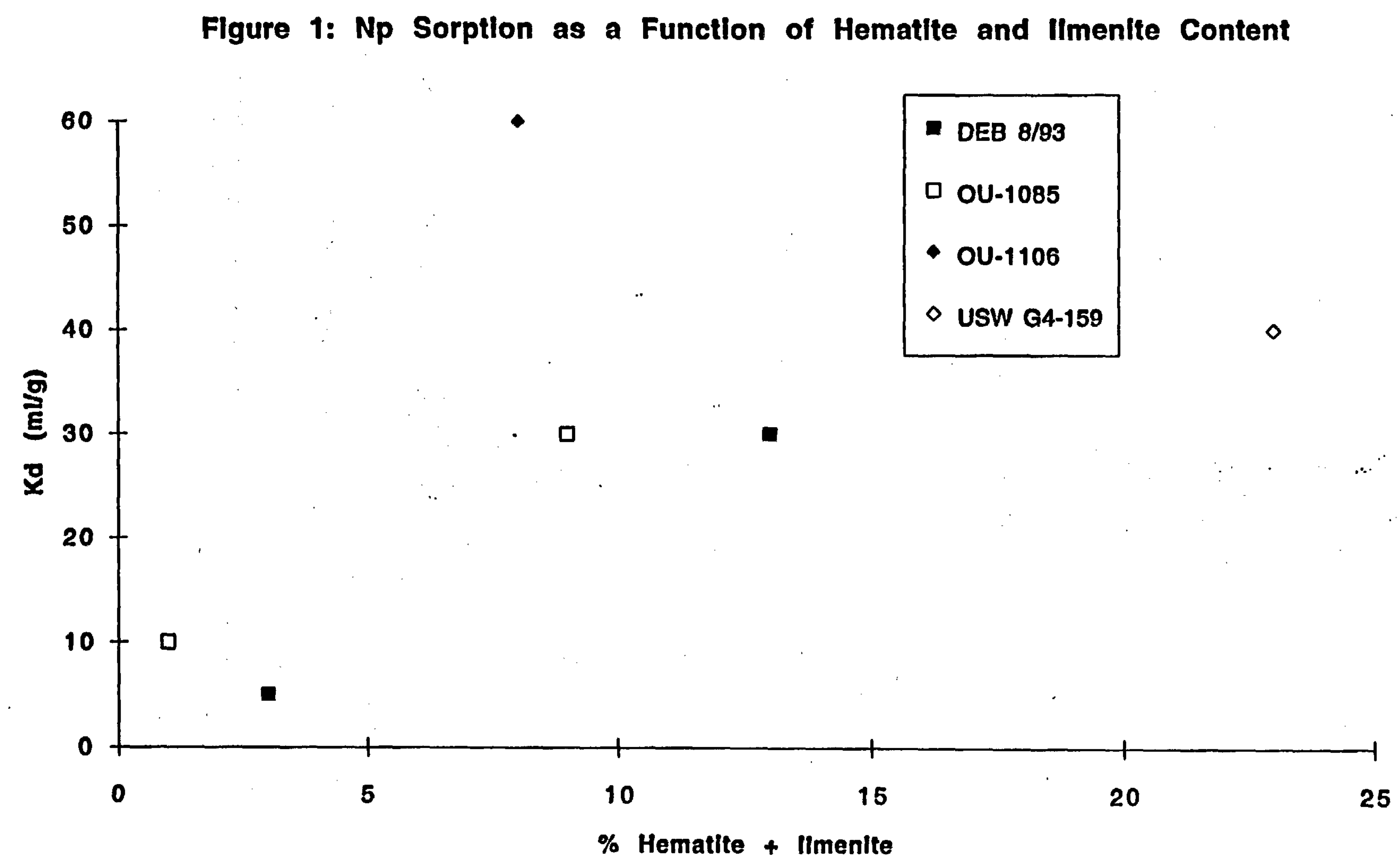
Tuff	Trial #1	Trial #2	Experimental average	Predicted based on % hematite
DEB 8/93-1	1.4	1.9	2E+00	1E+01

Table II was prepared from Chipera's data (see reference at end of this section); it tabulates the sorption data in Table I as a function of mineralogy. Using the Np sorption results for hematite in J-13 reported in the "Los Alamos October 1993 Monthly Activity Report," staff used the percentage of hematite in the samples to predict the sorption coefficient of the samples. These calculations assumed that the surface area of the pure hematite sample is the same as the surface area of the iron oxides in the tuff samples. Since Np sorption onto metal oxides is dominated by surface complexation, the discrepancies between the predicted sorption coefficients in Table I and the experimentally determined values in Table II could be caused by a lower surface area of the iron oxides in the tuff samples vs. the surface area of the pure hematite (which was 9 m^2/g) or by passivation of iron oxides in the tuff samples.

Table II. Np Sorption Coefficients as a Function of Mineralogy

Sample ID	Np K_d (ml/g)	% Magnetite + Maghemite	% Magnetite/ Maghemite	% Maghemite	% Hematite
DEB 8/93-1B	5	86	100	0	3
DEB 8/93-2	30	58	100	0	5
OU-1085-3-6	30	42	20	33.6	9
OU-1085-3-7	10	50	85-90	5-7.5	1
OU-1106-2-21	60	23	NA	NA	8
USW G4-159.0/.4	40	73	100	0	23

Sample ID	Np K_d (ml/g)	% Ilmenite	% Hematite + Ilmenite	% Magnetite + Maghemite + Hematite + Ilmenite	% Smectite
DEB 8/93-1B	5	0	3	89	0
DEB 8/93-2	30	8	13	71	0
OU-1085-3-6	30	0	9	51	9
OU-1085-3-7	10	0	1	51	11
OU-1106-2-21	60	0	8	31	0
USW G4-159.0/.4	40	0	23	96	0



Predecisional information—preliminary data—do not reference

Assuming a similar surface area of iron oxides in all tuff samples, three conclusions may be drawn from inspection of Table II.

1) Np sorption does not seem to be correlated with the total amount of magnetite, maghemite, hematite, and ilmenite in the tuff samples.

2) Smectite does not play a major role in the observed Np sorption. (This conclusion agrees with the experimentally determined sorption coefficient for Np sorption onto montmorillonite [30 ml/g] reported in the "Los Alamos October 1993 Monthly Activity Report.")

3) A plot of Np sorption vs. the amount of hematite (Fe_2O_3) and ilmenite ($FeTiO_3$) in the tuff samples shows a correlation between the amount of metal oxides in the tuff samples and the Np sorption.

Reference:
Chipera, S. J. "Letter Report: Trace Minerals for Sorption Studies," TWS-EES-1-09-93-007, September 24, 1993.

Planned Activities

Continue work in all areas discussed above.

Problem Areas

None

Milestone Progress

3218
30 September 1993
Effects of Water-Rock Ratios on Sorption Coefficients
Internal technical review completed, and comments are being addressed.

3338
30 September 1994
Interim report on Radionuclide Sorption/Whole Rock M3
Internal review completed.

3345
30 September 1993
Neptunium Sorption onto Feldspar
Internal technical review completed.

3346
30 September 1993
Sorption as a Function of Temperature
Internal technical review completed, and comments are being addressed.

3393
30 September 1994
Report on the Effects of Organic Coatings on Radionuclide Sorption

3394
30 September 1994
Report on Influence Sure Pre-reaction on Sorption Properties of Minerals

Publications

M. Kholer, B. D. Honeyman, and J. O. Leckie
Uranyl Interactions in the Goethite /Solution Interface Region: Formation of Binary and Ternary Surface Complexes
Journal article, *Geochemica*
(Milestone 3345)
In preparation.

M. Kholer, B. D. Honeyman, A. van Geen, and J. O. Leckie
Neptunium(V) Sorption on Hematite in Aqueous Suspension: Effects of Carbonate and EDTA
Journal article, *Geochemica*
In preparation.

WBS 1.2.3.4.1.2.3 Sorption Models

Objective

The objective of this task is to provide sorption models for elements of interest to predict radionuclide movements from the repository to the accessible environment.

Activities and Accomplishments

Staff received a sample of magnetite, which was separated from Yucca Mountain tuff by S. Chipera. They mounted some of the sample grains for AFM experiments and obtained several AFM images. All of the surfaces observed so far were very rough and covered with clusters of small (~40 nm diameter) particles. These surface roughness values are very high compared to the goethite surfaces examined in previous studies. No crystalline surfaces were found.

Planned Activities

We plan AFM characterization of several more grains of the magnetite sample, and we will try to break some of the grains to expose fresh surfaces. These will be examined for the presence of natural surface coatings, then their reaction with water will be observed and compared to those of freshly cleaved mineral surfaces.

Problem Areas

None.

Milestone Progress

3347
30 September 1993
AFM Analysis of Hematite and Goethite
In preparation.

3038
30 September 1994
Report on Sorption Models (M3)

Publications

M. Hawley and P. Rogers
Surface Reactions of Goethite Observed by AFM
Conference abstract, Materials Research Society meeting
Approved by YMPO.

WBS 1.2.3.4.1.2.2 Biological Sorption and Transport

Objective

The purpose of this research is to determine whether microbial activity can influence the movement of plutonium in tuff. Because fluids are used extensively in the exploration of locations for a nuclear repository, those micro-organisms capable of utilizing drilling fluids as growth substrates are of special interest.

Activities and Accomplishments

This work has been deferred because of lack of funds.

WBS 1.2.3.4.1.3 Radionuclide Retardation by Precipitation Processes

Objective

The objective of the solubility determination task is to determine the solubility and speciation of important waste elements under conditions characteristic of the repository and along flow paths from the repository into the accessible environment.

Activities and Accomplishments

Speciation. C. D. Tait and D. Clark presented posters at the Migration '93 conference in Charleston, SC. D. Hobart also attended the conference.

Modeling of Np(V) hydrolysis using the best- and worst-case scenarios was completed. The purification of Np stock solutions was completed, but no further work on oxygen-17 NMR was attempted this month.

Other modeling work continued; staff was in the process of obtaining a QA-approved version of EQ3/6.

Solubility. Staff at LBL continued the Np, Pu, and Am solubility experiments in 0.1 M $NaClO_4$. The solutions have been assayed twice since the last report. The pH 6 and pH 8.5 Np solutions have remained relatively constant. The pH 7 solution, however, has shown increases in Np concentration with the last three assays, which may indicate that steady state has not been achieved. The Pu solutions have remained relatively constant with the latest assays. The three solutions showed insignificant decreases in Pu concentration, and appear to have reached steady state. The Pu concentrations of the pH 6 and 7 solutions are nearly equal at $(8.71 \pm 0.46) \times 10^{-8}$ M and $(5.43 \pm 0.30) \times 10^{-8}$ M, respectively. The Pu concentration of the pH 8.5 solution is less than an order of magnitude higher at $(3.64 \pm 0.19) \times 10^{-7}$ M. As for the Am/Nd solutions; all three solutions showed virtually no change in concentration, although slight fluctuations were seen in all three Am/Nd solutions. Staff is continuing to monitor all solutions to ensure that steady-state conditions are reached.

Staff completed Eh measurements and oxidation state determinations for the three Pu solutions. The measured Eh potentials were (91 ± 15) mV for the pH 6 solution, (177 ± 15) mV for the pH 7 solution, and (108 ± 15) mV for the pH 8.5 solution. These data indicate that the solutions are slightly oxic. The results of the oxidation state determinations are given in Table I. Staff found Pu(V) and Pu(VI) to be the predominant oxidation states; however, a significant amount of Pu(IV) was present in the pH 7 and 8.5 solutions. They will re-measure the Eh and oxidation state distribution of each solution when the experiments are concluded.

Table I. Results of Plutonium Oxidation State Determinations in 0.1 M $NaClO_4$ at 25°C and pH's 6, 7, and 8.5.

Oxidation State Distribution	Initially Pu(IV) at pH 6	Initially Pu(IV) at pH 7	Initially Pu(IV) at pH 8.5
	(1.6±0.3)%	(1.3±0.3)%	(3.6±0.3)%
Pu(IV)	(3.9± 0.4)%	(14.3±1.2)%	(10.4±0.8)%
Pu(V)	(77.8+8.0)%	(42.1+8.9)%	(64.2 + 7.8)%
Pu(VI)	(16.7+1.8)%	(42.3+4.2)%	(21.8 + 2.4)%

Staff completed counting the filtrates from the pH 8.5 Am/Nd filtration study performed on 13 October 1993 (See TWS-LBL-10-93-01). To determine the necessary pre-filtration volume, staff plotted the Am/Nd concentration as a function of filtered volume. They also determined that a pre-filtration volume of 2000 ml is adequate to condition the 4.1 nm filters used for phase separation of this solution. They have continued to closely monitor the pH of each solution. For three months the pH 8.5 solutions were continually deviating from their target pH values. However, since approximately day 90, the pH 8.5 solutions appear to have stabilized near their target pH, and have only required adjustment 3 to 4 times in the last 30 to 40 days. The pH 6 and 7 solution continue to be stable at their target pH, requiring minimal pH adjustment.

The record package for Milestone Report 3010, "Measured Solubilities and Speciation of Np, Pu, and Am in a Typical Groundwater (J-13) from the Yucca Mountain Region" was submitted. Staff continued to submit historical records to the RPC.

At Los Alamos, W. Efurd continued to collect equipment for use in solubility experiments.

Planned Activities

Continue all work discussed above.

Problem Areas

None

Milestone Progress

3344
30 September 1993
Report on Comparison of Solubilities of Np, Am, and Pu Between J-13 and UE-25p #1 Waters
Completed.

3350
30 September 1993
PAS Analysis of Pu(IV) Carbonate Systems
Completed.

3351
30 September 1993
Carbon-13 and Oxygen-17 Binding Constant Studies of Uranyl and Neptunyl Carbonate Complexes in Near-neutral Solution
Completed.

3411
30 September 1994
Report on Solubility of Np, Pu, Am in Neutral Solutions

3412
30 September 1994
Report on Solubility Comparison of Np, Pu, Am from Undersaturation

3413
30 September 1994
Report on Np Speciation by NMR and Optical Spectroscopy

4025
30 September 1994
Letter report on Thermochemical Data on Actinides

Milestone Progress (cont.)

4026
30 September 1994
Letter report on Status of Pu(IV) Colloid

Publications

D. L. Clark, D. E. Hobart, P. D. Palmer, J. C. Sullivan, and B. E. Stout
Carbon-13 NMR Characterization of Plutonyl(VI) Aqueous Carbonate Complexes
Journal article, *Inorganic Chemistry*
Submitted.

D. L. Clark, C. D. Tait, D. E. Morris, D. E. Hobart, S. A. Ekberg, and P. D. Palmer
Actinide(IV) and Actinide(VI) Carbonate Speciation Studies by NMR and PAS Spectroscopies
Los Alamos report
Submitted to YMPO.

D. L. Clark, J. G. Watkin, D. E. Morris, and J. M. Berg
Molecular Models for Actinide Speciation
Los Alamos report
Submitted to YMPO.

D. L. Clark et al.
Carbon-13 NMR Kinetics and Ligand Exchange Dynamics of Actinyl(VI) Carbonate Complexes in Aqueous Solution
Conference abstract, *Fourth International Conference on Chemical and Migration Behavior (Migration '93)*
Published.

D. L. Clark and P. Palmer
Oxygen-17 and Carbon-13 NMR Studies of Uranyl and Neptunyl Carbonate Complexes in Near-neutral Solution
Conference abstract, *Fourth International Conference on Chemical and Migration Behavior (Migration '93)*
Published.

D.L. Clark, P.D. Palmer, T.W. Newton, and W. D. Zwick
^{17}O and ^{13}C NMR Binding Constant Studies of Uranyl Carbonate Complexes in Near-neutral Aqueous Solution
Journal article, *Inorganic Chemistry*.
In preparation.

C. D. Tait, D. E. Morris, J. M. Berg and W. H. Woodruff
Evaluation of Alternative Detection Schemes in Photoacoustic Spectroscopy
Journal article, *Reviews of Scientific Instrumentation*
Approved by YMPO.

C. D. Tait, S. A. Ekberg, P. D. Palmer, and D. E. Morris
Plutonium (IV) Carbonate Speciation Changes
Journal article, *Inorganic Chemistry*
In internal review.

C. D. Tait et al.
Speciation of Neptunium(V) Carbonate as a Function of Temperature Using Absorption Spectroscopies
Conference abstract, *Fourth International Conference on Chemical and Migration Behavior (Migration '93)*
Published.

WBS 1.2.3.4.1.4 Radionuclide Retardation by Dispersive, Diffusive, and Advective Processes

Objective

The objectives of this task are to determine the rate of radionuclide movement along the potential flow paths to the accessible environment and to examine the effect of diffusion, adsorption, dispersion, anion exclusion, sorption kinetics, and colloid movements in the flow geometries and hydrologic conditions expected to exist along the flow path to the accessible environment in the scenarios used for performance assessment.

Activities and Accomplishments

Staff obtained results of single-particle-counting analysis, which was used to assess particle loading as a function of particle size distribution in J-13 water, from C. Degueldre. (A schematic diagram of the apparatus used may be seen the November 1993 Los Alamos Monthly Activity Report.) The apparatus is designed so that water is filtered through three serial filters of different sizes; water samples, obtained before and after each filtration, were placed in either borosilicate glass or Teflon containers. The results of these experiments may be seen in Table I.

Table I. Particles (greater than 100 nm in diameter) per ml in J-13 Well Water

	Borosilicate Glass Container	Borosilicate Glass Container; Water Acidified to pH 4	Teflon Container
Unfiltered Water	9.3×10^5	1.5×10^6	3.0×10^5
Unfiltered Water	1.3×10^6	1.3×10^6	1.3×10^5
Water Filtered through 0.4 μm filter	1.1×10^6	1.9×10^6	1.9×10^5
Water Filtered through 0.05 μm filter	2.5×10^5	3.5×10^5	1.2×10^5
Water Filtered through a hollow fiber filter	2.1×10^6	2.3×10^6	1.3×10^6

Upon inspection of Table I, one may draw the following conclusions:

1) Removing the subsurface water does not appear to cause precipitation of calcium carbonate or other solids, which could have changed the density of colloids measured in the J-13 water (as indicated by the agreement between the acidified and unacidified water samples).

2) Glass appears to be the preferred container for collecting water samples; the decrease in quantity of colloids in the samples placed in Teflon containers was probably caused by particle adsorption to the walls of these containers.

3) Collecting water directly from the well, without further filtration, appears to be the best collection method. It appears that filters can add particles to the collected water.

4) Most importantly, the concentration of particles in J-13 water is apparently on the order of 10^6 particles per ml. At this low particle loading level, an extremely high level of sorption of radionuclides to the colloids must take place before the colloids could carry a significant quantity of radionuclides from the repository to the accessible environment.

Planned Activities

Work in all the above mentioned areas will continue.

Problem Areas

None

Milestone Progress

3041
30 September 1994
Report on Kinetics of Sorption on Crushed Tuff Colloids

3349
30 September 1993
Summary report on Np Transport through Yucca Mountain Tuffs
In internal technical review.

3383
30 September 1994
Progress report on Colloid-facilitated Radionuclide Transport

3414
30 September 1994
Effect of Fracture Coatings on Radionuclides Transport

3415
30 September 1994
Report on Validation of Batch Sorptions Kds for Radionuclide Transport in Porous Media

4032
30 September 1994
Letter report, *Most Critical Groundwater Parameters Sorption Studies*

4034
30 September 1994
Letter report on Diffusion of Non-Conservative Tracers/Tuff

Publications

J. Conca
Measurement of Unsaturated Hydraulic Conductivity in Yucca Mountain Tuff (3044)
Conference paper, *Focus '93 Site Characterization and Validation*
Approved by YMPO; in press as a Los Alamos report.

A. Meijer
Far-Field Transport of Carbon Dioxide: Retardation Mechanisms and Possible Validation Experiments
Conference paper, *Focus '93 Site Characterization and Validation*
Approved by YMPO; submitted to the American Nuclear Society for publication.

WBS 1.2.3.4.1.5.1 Retardation Sensitivity Analysis

Objective

The objectives of this task are to construct a geochemical/geophysical model of Yucca Mountain and to use this model to examine the physical and chemical controls on radionuclide transport along flow paths to the assessable environment.

Activities and Accomplishments

Integrated Transport. Work on neptunium simulations continued. Staff began work on a mountain-scale unstructured representation of Yucca Mountain. When completed, this model will allow task members to collaborate and exchange information more easily with USGS and LBL.

Staff met with K. Turner of the Colorado School of Mines regarding generating three-dimensional grids from database information. Turner, who collaborates with the USGS on regional flow models at Yucca Mountain, referred this staff to representatives of Stratamodel Inc. of Houston, Texas, a company that sells visualization software that could interact with their grid-generation codes.

Code Optimization. Staff is still working out minor difficulties in conjunction with the code TOUGH2, which was recently installed in the configuration management system.

Planned Activities

Continue transport simulations with flow fields obtained from the simulations described above. Update the Kd information with the latest results from the Sorption task.

Problem Areas

Staff continued working on GZSOLVE equation solver application. Reconfiguration of GZSOLVE equation was taking more effort than anticipated.

Milestone Progress

3355
30 September 1993
Site-Scale Simulations of Flow and Transport at Yucca Mountain
Expected 30 November 1993; video completed, text in preparation.

3416
30 September 1994
Report on 3D Integrated Transport at Yucca Mountain

4028
31 March 1994
Certification of Multi-use Matrix Solver GZOLVE
Delayed because of redesign requested by the M&O.

Publications

K. Birdsell, K. Eggert, and B. Travis
Three-Dimensional Simulations of Radionuclide Transport at Yucca Mountain
Journal article, *Radioactive Waste Management and the Nuclear Fuel Cycle - Special issue on the Yucca Mountain Project*
Approved by YMPO; accepted for publication.

WBS 1.2.3.4.1.5.2 Demonstration of Applicability of Laboratory Data

Objective

The purpose of this study is to design and conduct experiments to evaluate the applicability of laboratory data and to test models used in the radionuclide transport program to determine far-field radionuclide transport. Both intermediate- and field-scale experiments and natural analogs will be assessed for their potential to provide the required data.

Activities and Accomplishments

A meeting was held at LBL on 1 December with personnel from the Los Alamos Test Coordination Office on the status of the ESF and testing in the Calico Hills.

Planned Activities

Staff continued to develop a study plan outline.

Problem Areas

None

Milestones

3419
30 September 1994
Report on Criteria for Yucca Mountain Field Test (M3)

WBS 1.2.5.2.2 Site Characterization Program

Objective

The purpose of this task is to coordinate the regulatory Project requirements within the Los Alamos programmatic structure. The focus of this coordination effort is on the integration of the technical work within the regulatory framework.

Management and Integration

Los Alamos staff continued to revise the *Volcanism Status Report.*

Study Plans

Water Movement Test, R1 (8.3.1.2.2.2). Review comments on Rev. 1 of the Study Plan were received from the YMPO in May 1992; they were addressed and returned to YMPO in December 1992. This study plan was approved on 10 February 1993 by the DOE. It was submitted to the NRC for a Phase I review and accepted on 8 April 1993.

Diffusion Test in the Exploratory Studies Facility, R0 (8.3.1.2.2.5). In April 1992, this study plan was accepted by DOE. In June 1992 it was submitted to the NRC for review. It was accepted by the NRC on 19 January 1993. Sent to the State of Nevada for comments on 1 November 1993.

Testing of the C-Hole Sites With Reactive Tracers, R0 (8.3.1.2.3.1.7). In February 1990, DOE/HQ issued the study plan (8.3.1.2.3.1) as a controlled document; it was then sent to the NRC for comments. The Los Alamos study plan (8.3.1.2.3.1.7) was approved. Staff reviewed NRC comments on the USGS study plan related to the first six C-wells activities and notified the DOE that they agreed with all NRC comments.

Ground Water Chemistry Modeling, R0 (8.3.1.3.1.1). This study plan was returned in May 1992 from YMPO review; comments are now being addressed. Comments addressed by author and sent to YMPO for review on 8 November 1993.

Mineralogy, Petrology, and Chemistry of Transport Pathways, R0 (8.3.1.3.2.1). In January 1992, we submitted revised NRC comments to T. Bjerstedt. In August 1992, YMPO requested that we word process the changes to be incorporated in the revision. That revision is in progress and staff is also responding to review comments from the State of Nevada received in January 1993.

History of Mineralogy and Geochemical Alteration at Yucca Mountain, R0 (8.3.1.3.2.2). The YMPO approved the study plan on 18 December 1991 and submitted it to the NRC on 31 January 1992. No further action has been required.

Natural Analog Hydrothermal System in Tuff (8.3.1.3.3.1). This is an out-year activity.

Kinetics and Thermodynamics of Mineral Evolution and Conceptual Model of Mineral Evolution, R0 (8.3.1.3.3.2; 8.3.1.3.3.3). The study plan was in preparation.

Sorption Studies and Sorption Modeling, R0 (8.3.1.3.4.1; 8.3.1.3.4.3). A new draft of the study plan combining studies 8.3.1.3.4.1 and 8.3.1.3.4.3 was submitted to YMPO for review in October 1992. Review comments were returned to Los Alamos in February 1993; these comments are being incorporated in the study plan. Comments addressed by author and sent to YMPO on 22 October 1993.

Biological Sorption and Transport, R0 (8.3.1.3.4.2). A revision addressing the Exploratory Shaft Design was submitted in September 1992. The study plan was approved by YMPO on 25 November 1992 and accepted by the NRC on 25 March 1993.

Study Plans (cont.)

Dissolved Species Concentration Limits, and Colloid Formation and Stability, R0 (8.3.1.3.5.1; 8.3.1.3.5.2). All YMPO comments on the study plan were resolved by the principal investigator in September 1992. Rev. 0 was submitted to YMPO for comment resolution, verification, and approval on 9 October 1992. In preparation for forwarding to the NRC, the study plan was sent to YMPO on 28 July 1993 with all review comments addressed. All comments were verified on 6 August 1993. The study plan was approved by YMPO on 9 September 1993 and accepted by the NRC on 17 September 1993.

Dynamic Transport Column Experiments, R0 (8.3.1.3.6.1). All YMPO comments on the study plan were resolved by the principal investigator in September 1992. This study plan was revised, incorporating YMPO and DOE review comments. It was returned to YMPO in March 1993 for technical review. YMPO comments were completed in June 1993. These comments are now being addressed.

Diffusion, R0 (8.3.1.3.6.2). All YMPO comments on the study plan were resolved by the principal investigator in September 1992. The study plan was revised in response to YMPO comments and returned to YMPO in April 1993. Verification of comment resolution was completed on 28 June 1993. A separate list of technical procedures was sent to YMPO on 13 July 1993 in preparation for forwarding the study plan to the NRC. This study plan was approved by the YMPO on 6 August 1993, and submitted to the NRC on 12 August 1993 for Phase I review.

Retardation Sensitivity Analysis, R0 (8.3.1.3.7.1). This study plan was approved by the DOE and sent to the NRC for review in July 1992. It was accepted by the NRC on 19 January 1993.

Demonstration of the Applicability of Laboratory Data to Repository Transport Calculations, R0 (8.3.1.3.7.2). This study plan is deferred because no funds were allocated.

Gaseous Radionuclide Transport Calculations and Measurements, (8.3.1.3.8.1). This study plan is deferred because no funds were allocated.

Probability of Magmatic Disruption of the Repository, R0 (8.3.1.8.1.1). A detailed technical review was completed in July 1992 by the NRC. In August 1992, a one-day video conference was held with the NRC to discuss their technical review comments. In response to those comments, this study plan was revised and submitted to YMPO for review in February 1993. It was accepted and sent to the NRC on 31 March 1993 for review.

Physical Processes of Magmatism and the Effects on the Repository, R0 (8.3.1.8.1.2). A draft study plan was submitted to DOE for review in October 1992. The review comments were returned in January 1993 for comment resolution. Those comments have now been addressed, and revisions were completed on 2 June 1993. All comments were verified on 30 August 1993. The study plan was approved by YMPO on 21 September 1993. Study Plan was submitted to NRC on 4 October 1993 for review.

Characterization of Volcanic Features, R0 (8.3.1.8.5.1). This study plan was accepted by NRC on 4 September 1990. A minor revision was added in March 1993, which does not require a review by YMPO and the DOE.

WBS 1.2.5.3.5 Technical Database Input

Objective

The objective of this task is to coordinate input of technical data to the Project Technical Database (TDB) and the Automatic Technical Data Tracking System (ATDT).

Activities and Accomplishments

Continued checking on TDIFs that will be revised so that the acquired and developed data can be distinguished. Discussed these TDIFs with R. Lewis on 7 December.

The following data entries were reviewed:

- Radionuclide Migration Laboratory Studies for Validation of Batch Sorption Studies Data, DTN LA000000000005.001 and LA000000000005.002;
- Laboratory Studies of Radionuclides Migration in Tuff, DTN LA000000000006.001 and LA000000000006.002;
- Diffusion of Nonabsorbing Tracers in Yucca Mountain Tuff, DTN LA000000000007.001 and LA000000000007.002
- Actinide Behavior on Crushed Rock Columns, DTN LA000000000008.001 and LA000000000008.002;
- Radionuclide Migration as a Function of Mineralogy, DTN LA000000000009.001 and LA000000000009.002;
- The Elutions of Radionuclides through Columns of Crushed Rock from the Nevada Test Site, DTN LA000000000010.001 and LA000000000010.002; and
- Diffusion of Sorbing and Non-sorbing Radionuclides, DTN LA000000000034.001 and LA000000000034.002.

Staff continued to work with the PI to compile technical data for submittal on Chemistry of Diagenetically Altered Tuffs at a Potential Nuclear Waste Repository, Yucca Mountain, Nye County, Nevada, DTN LA000000000071.001 and LA000000000071.002.

Staff continued reviewing the lists of Los Alamos publications and technical reports with accession numbers that do not appear to be listed in the ATDT to determine if they should be listed. (This is in response to a YMP Project Office letter, Assessment of Technical Data Backlog, dated September 17, 1993.)

Staff attended an overview presentation and the Quarterly Technical Database Coordinators meeting in Las Vegas, Nevada, on 7-8 December.

Staff began work on a new TDIF for data from Inferences of Paleoenvironment from Petrographic Chemical and Stable-Isotope Studies of Calcretes and Fracture Calcites, DTN LA000000000075.001.

Planned Activities

Continue to determine what technical data needs to be logged into ATDT for current work on zeolites, saturated fluid flow, and other ongoing work of various PIs and what work needs to be submitted to the TDB.

Complete an estimate of the backlog of data that may need to be entered into ATDT and the cost and time required to do this.

Prepare a matrix indicating the planned deliverable submittals for FY94 based on the data entered into PACS in December 1998.

Estimate the resource requirements for this task for FY95.

Transfer the responsibilities of this task to another staff member in January 1994.

Problem Areas

None

WBS 1.2.5.4.6 Development and Validation of Flow and Transport Models

Objective

Model testing is necessary to assess performance at Yucca Mountain. This task will conduct an experiment in a caisson facility to provide a baseline of confidence in models for transport.

Activities and Accomplishments

Below-freezing temperatures damaged the plumbing in the caisson during the nine-day Los Alamos winter closing, and repairs will be started after the first of the year.

Planned Activities

Staff anticipates that tracers will be injected in late January or early February 1994.

Problem Areas

None

Milestone Progress

3418
30 September 1994
Final report on Caisson Experiment (M3)

Publications

None

WBS 1.2.5.4.7 Supporting Calculations for Postclosure Performance Analyses

Objective

This task will provide documentation and results of calculations used in analyses of postclosure performance that supports design of repository, seals, and waste package and perform calculations of postclosure performance needed to support activities carried out under other performance assessment WBS elements.

Activities and Accomplishments

No significant activities took place this month.

Planned Activities

No planned activities reported.

Problem Areas

None

Milestone Progress

3359
30 September 1993; Submitted to TPO 12 October 1993
Annual report—Support to Performance Assessment
Completed.

3420
30 September 1994
Update of FEHM Theory & Users Manual: Upgrade Documentation

3423
30 September 1994
Verification Document for FEHM

4004
30 September 1993
Letter report on Thermal Repository Calculations
Completed.

Publications

None

WBS 1.2.6.1./2-3/6 Exploratory Studies Facility

Objective

These Exploratory Studies Facility (ESF) tasks address the issues and information needs associated with the ES-based characterization of Yucca Mountain to determine the suitability of permanently isolating high-level nuclear waste from the biosphere in a geologic repository.

Activities and Accomplishments

Construction. Staff attended the weekly design and construction meetings. They provided design input to support field changes related to the starter tunnel alcove construction, and participated in writing of Title II design packages. Staff developed weekly and monthly administrative management reports for testing activities and facilitated job package (JP) record development. Staff provided field test coordination and administrative support for ESF north portal construction.

Staff supported field activities at the Fran Ridge site for the Lawrence Livermore National Laboratory (LLNL) large-block test. Site preparation for drilling activities were completed, and the isolation saw cutting was underway. The test planning package for the activity was ready for technical and project review and the test construction JP was being finalized.

Quality Assurance and Safety Analysis. Staff attended the weekly design and construction meetings and routinely observed ESF field testing activities. Staff reviewed design input to support field changes related to north portal construction and developing Title II design packages. Staff reviewed test planning records and test related FCR for compliance with QA and safety concerns.

Staff observed construction activities conducted in support of LLNL large-block test and testing activities conducted in the north ramp facility.

Test Management. Staff attended the weekly design and construction meetings. They supported the development of weekly and monthly administrative management reports for testing activities and facilitated JP record development. Staff provided field test coordination and administrative support for ESF north portal construction.

Staff prepared planning documents for the test construction portion of the LLNL large-block test. The program is being implemented under the control of a series of JP records and a test planning record to be completed before test activities are initiated. The site preparation portion of the work at Fran Ridge was proceeding as planned.

Planned Activities

Construction. Staff will support finalizing of Title II design packages for the north portal surface facility and north ramp excavations. They will continue field test coordination of the Fran Ridge Engineered Barrier test activity and the Construction Monitoring test activities being conducted in the north portal starter tunnel and alcove.

Quality Assurance and Safety Analysis. Staff will support finalizing of Title Activities II Design Packages for the north portal surface facility and north ramp. They will continue field test observations of the Fran Ridge Engineered Barrier test activity and the ESF test activity being conducted in north ramp facility (starter tunnel and alcove).

Test Management. Staff will support finalizing of Title II design packages for the north portal surface facility and starter tunnel alcove. Staff will continue planning document development and field test coordination of the Fran Ridge Engineered Barrier test activity and the ESF tests with construction activities.

Publications

N. Elkins
Planning and Implementation of Underground Testing in the ESF
Conference paper, *Rock Mechanics Conference*
Approved by YMPO.

Problem Areas

None

WBS 1.2.6.8.4 Integrated Data System

Objective

The integrated data system (IDS) supports the Exploratory Studies Facility (ESF) test program by providing a central facility to automatically measure and control aspects of the ESF tests. The primary purposes of the IDS are to assist the principal investigators (PI's) in acquiring high-quality test data in a uniform, controlled fashion and to transfer those data to the PI's organizations for data management and analysis.

Activities and Accomplishments

IDS design and development oversight continues. Staff provided clarification of design requirements and maintains a 1 May 1994 delivery milestone for data acquisition system (DAS) stations if so budgeted.

Continued role of integration and review of data flow requirements that are implemented and controlled by test planning records and Project procedures. Initiated and supported the review of field record submissions and facilitated data transfers to the constructor and test organizations.

Planned Activities

Continue to provide overview for YMPO of the design and development of the IDS by CRWMS M&O. Continue to meeting with principal investigators to develop and discuss the IDS support needs, IDS design requirements, current IDS design status, and data flow considerations.

Publications

H. Kalia
Acquisition of Test Data from the Exploratory Studies Facility for the Yucca Mountain Site Characterization Project
Conference paper, *Second International Symposium on Mine Mechanization and Automation*
Approved by YMPO.

Problem Areas

None

WBS 1.2.9.1.2 Technical Project Office Management

Objective

The objective of this task is to manage the Los Alamos Yucca Mountain Project Site Characterization Program.

Activities and Accomplishments

The TPO participated in the International Programs YMP Advisory Group meeting on 1 December in Denver, CO.

The TPO completed a general article on Los Alamos YMP research; it will be included in the Los Alamos publication, *Research Highlights.*

The TPO served on the organizing committee for the Migration '93, the Fourth International Conference on the Chemistry and Migration Behavior of Actinides and Fission Products in the Geosphere, held in Charleston, SC. She chaired the session titled "Database Evaluation and Management" and presented an overview paper on Los Alamos work titled "The Yucca Mountain Site Characterization Project: Site-Specific Research and Development on the Chemistry and Migration of Actinides."

WBS 1.2.9.2.2 Project Control

Objective

The objective of this task is to support management's efforts in planning, scheduling, and controlling the technical work. This task will develop, implement, and maintain computerized cost, schedule, and technical milestone databases and develop strategies to meet management information requirements.

Activities and Accomplishments

Staff attend a meeting in Las Vegas to discuss carry-over issues.

PACS status was submitted on 11 December.

Planned Activities

Staff will make minor modifications in FY 1994 Project planning.
Staff will submit January status report.

Staff will attend a course titled "Contracting for Project Managers" sponsored by George Washington University.

Problem Areas

None

WBS 1.2.11.2/.3/.5 Quality Assurance Program Development, Verification, and Engineering

Objective

The Quality Assurance (QA) Program supports Los Alamos Yucca Mountain Site Characterization Project participants and ensures that their efforts provide data and evidence admissible for the repository-licensing process.

Program Development (WBS 1.2.11.2)

Staff continued to focus on revising documents to satisfy the new Quality Assurance Requirements and Description (QARD). Of the forty-two affected documents, all were complete or in final preparation. Staff will begin to distribute the new procedures by mid January. One issue, that of accession numbers, was discussed at great length. The Los Alamos process was redefined, and the records procedure was modified accordingly. YMPO has promised to look into what is driving the need for accession numbers.

Travel. S. Bolivar and J. Day attended the YMPO Quality Assurance Managers meeting in Las Vegas. J. Day, T. Rudell, and J. Walterscheid also attended the Technical Database Working Group meeting in Las Vegas.

Procedure Revisions. Eighteen procedures were completed. Twelve other procedures were in final preparation. Two procedures still must be entered into the RTN.

Training. Staff continued to finalize the records management and orientation classes. The training coordinator made final entries into the training database. S. Bolivar completed a Negotiation and Conflict Management course.

Audits & Surveys Performed (WBS 1.2.11.3)

The final report for internal audit AR-93-12 (Los Alamos Chemical Science and Technology [CST] Division) was issued. There were two deficiency reports issued; one was for not having a personnel qualification form verified, and the other was for failure to work to a controlled procedure. Fifteen deficiencies were fixed during the audit; most of them related to lack of attention to detail. Audit report LANL-AR-93-11 (Los Alamos CST-HydroGeoChem) was in preparation. Survey report SR-93-04 (Los Alamos office in Las Vegas - to verify notebook entry problems not being repeated) was completed, and no deficiencies were identified. Survey report SR-93-03 (annual evaluation of Mettler) was in preparation. Survey plan SR-93-06 was approved. This survey is to verify that RTN entries were completed correctly and will run through 15 January. The incomplete audit and survey reports were in draft form and will be completed in early January.

Verifications. Staff reduced the number of open internal deficiency reports (DRs) to less than twenty, which was a self-assessment goal. There are currently eighteen open DRs, with four awaiting verification. Two DRs were issued in December. YMPO closed corrective action report CAR-91-041. This is the first time in several years that we haven't had an open CAR.

Quality Engineering (WBS 1.2.11.5)

Software. The software procedures and software quality assurance guide were completed. The quarterly software status report has been distributed.

Planned Activities

Final preparation of slides and view graphs for the classes on records (QP-17.6) and orientation will continue. The majority of staff's efforts will continue to be focused on completing procedure revisions. The INC-HydroGeoChem audit report survey report SR-93-003 will be completed. Survey SR-93-06 will terminate on 15 January.

Problem Areas

None

Publications

S. Bolivar
Los Alamos report, *The Los Alamos National Laboratory YMP Quality Program, A Status Report for January 1, 1992 to December 31, 1992.*
Submitted to YMPO.

WBS 1.2.12.2 1.2.12.5 1.2.13 Local Records Center Operations/Records Management and Document Control

Objective

The objective of this task is to satisfy the records management requirements of the YMP and NQA-1.

Activities and Accomplishments

Forty-seven records and/or record packages were received by the RPC; five of these were rejected and returned to their originators for corrections. Ninety-five records and/or record packages were submitted to the CRF, and none of these was rejected. No records were resubmitted to the CRF.

Planned Activities

No planned activities reported.

Problem Areas

None

WBS 1.2.15.2 Administrative Support

Objective

The objective of this task is to provide administrative support for the Los Alamos YMP and the YMPO.

Activities and Accomplishments

S. Klein, Los Alamos editor, reviewed and edited six technical information products (TIPs) and forwarded them to YMPO. She also prepared weekly reports and monthly highlights for December and transmitted them to the M&O and YMPO.

The editor completed the October Monthly Activity Report.

The editor updated the FY 1993 TIP database and distributed it to Los Alamos YMP management.

The editor reviewed FY94 deliverables with Los Alamos Project Control staff.

Planned Activities

Continue work in all areas discussed above.

Problem Areas

None

WBS 1.2.15.3 Training

Objective

The objective of this task is to fulfill the training requirements of the Yucca Mountain Project and maintain appropriate training records.

Activities and Accomplishments

Staff worked on the training database with R. Morley and M. Pope.

Staff completed the three training procedures.

Staff worked on personnel verifications.

Planned Activities

No planned activities reported.

Problem Areas

None

Appendix

Los Alamos
NATIONAL LABORATORY

Chemical Science and Technology
Responsible Chemistry for America

CST-8, Isotope Sciences, MS J514
Los Alamos, New Mexico 87545
(505) 667-4845, FAX 665-4955

Robert A. Levich
Project Director, DOE/AECL SA2
Department of Energy
Yucca Mountain Site Characterization Project Office
P.O. Box 986608
Las Vegas, NV 89193-8608

Subject: Report for quarters ending 12/31/93of Cigar Lake-analogue study - actinide and fission product geochemistry task of DOE/AECL subsidiary agreement number 2.

Current status and accomplishments: This report includes results of an integrated effort of Los Alamos National Laboratory personnel David Curtis, Paul Dixon, June Fabryka-Martin, and Don Rokop, Carol Bruton and Henry Shaw at Lawrence Livermore National Laboratory, and Jan Cramer and his colleagues of AECL Research.

Radionuclide retention in spent fuel analogues - uranium minerals

-A manuscript titled Radionuclide Release from Natural Analogues of Spent Fuel was submitted for publication in the proceedings of the Migration-93 meeting.

-A poster presentation titled Radionuclide Release from Natural Analogues of Spent Fuel was presented at the Migration-93 meeting on December 11, 1993.

-We continue to work on the determination of ^{99}Tc, ^{129}I, ^{239}Pu and U abundances in samples from Cigar Lake core 220 to understand processes of radionuclide release from their uranium minerals.

-June Fabryka-Martin sent Jack Cornett additional samples of urnaium ore for ^{129}I and ^{36}Cl analysis. These were Cigar Lake samples CS235L, W83A, W83C, Koongarra samples G-4674 and G-2698, and samples from Key Lake, Oklo, and Pocos de Caldas deposits.

-Jan Cramer sent aliquots of the Cigar Lake core 220 samples to Dr. Rod Ewing at the University of New Mexico. Dr. Ewing is an authority on uranium mineralology and has written extensively on the value of studies of uranium minerals as analogues to spent fuel. Dr. Ewing and his students will study the minerology and petrology of the samples. The work is not funded by the subsidiary agreement and the results are not an identified milestone in the project objectives

Radionuclides in water from the Cigar Lake Deposit

-Twelve water samples from Cigar Lake were received in Los Alamos. The Los Alamos staff are evaluating a strategy for measuring radionuclide abundances in these large volumes of water.

6th Natural Analogue Working Group Meeting

-The organizing committee for the meeting met on December 12th in Charleston, SC. In attendence were David Curtis, Paul Hooker, Linda Kovach, and Henning von Maravic. Preliminary arrangements were made regarding the meeting format, the agenda and the the attendees and speakers.

FEB -2 '9?

Status of Milestones and Problems

-The manuscript for the Migration-93 meeting represents partial completion of milestone 15.

-The delivery of water samples to LANL and ore samples to University of New Mexico represents partial completion of milestone 12.

Yours truly

David B. Curtis
Project Manager

DC:cr

Cy:
Jan Cramer, AECL Whiteshell Laboratory
Carol Bruton, Lawrence Livermore Laboratory
Henry Shaw, Lawrence Radiation Laboratory
Julie Canepa, LANL YMP Project Office
Paul Dixon, LANL, INC-6
June Fabryka-Martin, LANL, INC-9
Don Rokop, INC-6

Milestone 4007

CALIBRATION OF THE PHILIPS CM-30 TRANSMISSION ELECTRON MICROSCOPE

G. D. Guthrie, Jr.
EES-1, Los Alamos National Laboratory

The transmission electron microscope (TEM) uses an electron beam to illuminate a thin specimen. That part of the beam passing through the specimen may focused to produce either an enlarged image of the specimen or a diffraction pattern of the specimen (which can be used to identify crystalline phases). Enlargements possible with the TEM range from scales showing micrometer-sized features to scales showing features nearly as small as individual atoms (*e.g.*, ~0.2 nanometers). These imaging capabilities make the TEM extremely useful for studying many petrologic problems involving fine-grained materials (*e.g.*, fracture-filling materials) and mineral reactions (*e.g.*, alteration), because many of the important details of these processes are too small to be studied by conventional petrologic techniques (*e.g.*, optical microscopy, scanning electron microscopy, and electron probe microanalysis). TEM also allows the study of the microstructures of minerals, which are important determinants of a mineral's properties (*e.g.*, cation-exchange characteristics), and TEM can provide information about a mineral's surface that is complementary to information provided by surface techniques such as atomic-force and scanning-tunneling microscopies. Finally, many TEMs are equipped with analytical instrumentation that allow chemical compositions to be determined on volumes over a million times smaller than the volumes analyzed by electron probes; hence, TEM can provide compositional details on individual crystals of fine-grained materials. (This letter report, however, does not address any of the analytical aspects of the TEM.)

The effective exploitation of the TEM requires the calibration of several aspects, including the image and diffraction-pattern magnifications. This letter report documents these calibrations for a Philips CM-30 TEM (LANL PN#832950) at the Los Alamos National Laboratory. Image and diffraction-pattern magnifications were calibrated for this instrument during November and December, 1993. These calibrations are reported below, and they are compared with calibrations determined in October, 1989, by another scientist at Los Alamos (K. Sickafus, personal communication) in an attempt to evaluate the long-term variability of these parameters. This variability is used as an estimate of the maximum error expected for the calibrations over the course of 1–2 years. Future calibrations will be used to refine this estimate.

The experimental conditions under which the images for calibration were obtained were chosen to mimic those anticipated for future TEM analyses. These include an accelerating voltage of 300 keV ($\lambda = 0.0197$ Å); a properly saturated filament; a properly stigmated and focused primary condenser lens; a centered condenser aperture; centered selected-area apertures (when used); properly stigmated and focused diffraction and objective lenses; a generally aligned TEM; and a specimen at eucentric height. These conditions should be met during future investigations to ensure that the calibrations apply.

The samples used for calibration purposes were as follows:

1. A diffraction-grating replica (Ted Pella, Inc., P.O. Box 492477, Redding CA 96049; catalog #606, Grating Replica, Parallel) with parallel line gratings spaced at 2160 lines/mm or 463.0 nm/line. This specimen is a physical standard, because the value quoted for the spacing of the lines is determined by the diffraction of light. This specimen is commonly used to calibrate TEM magnifications up to ~170000×.

2. A perforated film of crystalline gold (Ted Pella, Inc., P.O. Box 492477, Redding CA 96049; catalog #621, Multi-Purpose Test Specimen on 3.05 mm Grid) as described by Scholz and Heydenreich (1984). The film is oriented so that the [001] zone axis can be aligned parallel to the electron beam. The [001] zone axis of gold will contain <100>*, which have constant magnitudes ($d_{100} = 4.0786$ Å). Hence, this film is a physical standard and can be used to calibrate the camera length for the diffraction patterns.

Furthermore, lattice images of this specimen can be used to calibrate image magnifications under high-resolution (*i.e.*, lattice-imaging) conditions. In this report, the specimen was not used for calibration of high-resolution imaging. Diffraction patterns are typically obtained along with high-resolution images, so measurements made on lattice fringes in future studies can use periodicities recorded on the diffraction patterns as complementary checks on magnifications.

Magnification calibrations were made using calibration specimen #1. Fringe spacing was determined by measuring the periodicities of the fringes on the film, using the sharp boundary between bright and dark portions of fringes. This procedure eliminates many of the uncertainties associated with determining the exact centers of fringes. Measurements were made using either (1) a 4× ocular fitted with a scale marked every 0.1 mm (this was used for lower-magnification images) or (2) a ruler with a scale marked every 1.0 mm. Whenever possible, the distance between multiple fringes was measured, and a normalized value was used as the periodicity of an individual fringe. Magnifications (M) were calculated by the equation:

$$M = \frac{D\ \text{mm}}{463.0\ \text{nm}} \times \frac{1 \times 10^6\ \text{nm}}{1\ \text{mm}} \qquad (1)$$

where D is the periodicity as measured in millimeters on the film. Values for the calibrated magnifications on the negatives are given in Table 1. The changes in the magnifications from October, 1989, to December, 1993, may relate in part to either: (1) errors inherent in measurements made by two different operators (G. Guthrie for the 1993 measurements and K. Sickafus for the 1989 measurements); (2) variations in the magnification constants over time; or (3) variations in magnification constants due to differences in operating conditions (*e.g.*, lens strength or stigmation). Future calibrations will allow the evaluations of the potential drift of the magnification constants. However, all current magnifications are within ±3% of the 1989 magnifications. An error of ±5% is standard for magnification constants, particularly at higher magnifications (*e.g.*, see Spence, 1988, p. 269). Hence, an error of ±5% will be used for the magnification constants in Table 1.

Table 1. Calibration of Image Magnifications

Reported Magnification screen (negative)	Calibrated Magnification on Negative: Current†	Calibrated Magnification on Negative: Previous (K. Sickafus, 10/89)	% Change¥
4900× (5600×)	5850×	5790×	1.0
6500× (7400×)	7560×	7620×	−0.8
9100× (10500×)	10580×	10500×	0.8
12000× (13500×)	13600×	13800×	−1.4
15000× (17000×)	17300×	17500×	−1.1
19000× (21000×)	21200×	21600×	−1.9
27000× (31000×)	30200×	30900×	−2.3
35000× (42000×)	41600×	42700×	−2.6
46000× (52000×)	51200×	51300×	−0.2
61000× (69000×)	67000×	68600×	−2.3
78000× (89000×)	86000×	88200×	−2.5
110000× (120000×)	117000×	118000×	−0.8
140000× (160000×)	153000×	155000×	−1.3

† The values listed as under "Current" represent the absolute values determined from Eq. 1 rounded to the appropriate significant figures based on estimates of *maximum* errors associated with the measurement process and the sharpness of the fringes measured.

¥ % change is defined as {100 × [(current − previous) ÷ previous]}.

Table 2. Calibration of Diffraction-Pattern Magnifications

Reported Camera Length (mm)	Calibrated Camera Length on Negative (mm)		% Change¥	Camera Constant
screen L (negative L)	Current L	Previous L (K. Sickafus, 10/89)		
440 (500)	509	506	0.6	10.03
620 (700)	628	635	−1.1	12.37
840 (950)	851	862	−1.3	16.76
1050 (1200)	1090	1100	−0.9	21.5
1450 (1650)	1500	1512	−0.8	29.6
1950 (2200)	2010	2020	−0.5	39.6
2550 (2900)	2640	2650	−0.4	52.0
3200 (3610)	3300	3300	0.0	65.0
4400 (5000)	4610	4580	0.7	90.8
5610 (6300)	5850	5830	0.3	115.2

¥ % change is defined as {100 × [(current − previous) ÷ previous]}.

Camera lengths (L) were determined using calibration specimen #2. The lengths of r^*_{100} (D_{r^*}) were determined by measuring the distance between as many reflections as possible and normalizing. For example, if the distance between two adjacent reflections were measured, then D_{r^*} would be half the value (since the fundamental observed spacing corresponds to r^*_{200}). The measured value is related to the corresponding *d*-spacing (d_{100} = 4.0786 Å) and wavelength of electrons (λ = 0.0197 Å) by the relationship:

$$D_{r^*}d = L\lambda \tag{2}$$

(for a discussion of this, see Spence, 1988, p. 281). Values for the calibrated camera lengths on the negatives are given in Table 2. All of the current calibrated camera lengths are within ±2% of the values determined in 1989. An accuracy of 1–2% is typical for electron diffraction pattern measurements unless an internal standard is used (*e.g.*, see Hirsch et al., 1977, p. 125).

A camera constant (K) can be defined as:

$$K = L\lambda \tag{3}$$

This camera constant is more practically useful, in that

$$d = K/D_{r^*} \tag{4}$$

Camera constants are also listed in Table 2.

This TEM will be operated as a user-to-calibrate instrument, and calibrations will be done biannually while the instrument is used for YMP R&D projects. Prior to any quality-affecting work, the calibrations will be done according to any applicable quality programs.

References

Hirsch, P., Howie, A., Nicholson, R. B., Pashley, D. W. and Whelan, M. J. (1977) *Electron Microscopy of Thin Crystals*. Robert E. Krieger Publishing Company, Malabar, Florida, p. 124.

Scholz, R. and Heydenreich, J. (1984) A crystalline test specimen for checking the performance of high-resolution electron microscopes. *Ultramicroscopy*, 13:407–414.

Spence, J. C. H. (1988) *Experimental High-Resolution Electron Microscopy*. Oxford University Press, Oxford, p. 269 & 281.

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WBS 1.2.6.1.1, 1.2.3.1
"QA N/A"

memorandum

TWS-EES-13-LV-01-94-18

January 3, 1993
702/794-7095
M/S 527

TO: J. R. Dyer, DOE/YMPO
W. B. Simecka, DOE/YMPO

FROM: R. D. Oliver, LANL

SUBJECT: EXPLORATORY STUDIES FACILITY TESTING ACTIVITIES - DECEMBER 1993 - MONTHLY PROGRESS REPORT

GENERAL EXPLORATORY STUDIES FACILITY (ESF) ACTIVITIES

TEST PROGRAM: EXECUTIVE SUMMARY

Major activities in December included the evaluation of Test Alcove #1 for tunnel support and depth in relation to the shear zone. The depth of Test Alcove #1 was determined to be short of the necessary length required to start drilling for the Radial Borehole Test. The determining factor on the depth of the test alcove has been break-through on a shear zone expected from approximately 10 meters to 20 meters (30 feet to 60 feet). As the Alcove has proceeded in construction, concerns have surfaced from the Civilian Radioactive Waste Management System Management & Operating (CRWMS M&O) Contractor about adequate tunnel support. After review with all parties concerned, including the design team, constructor, and principle investigator, augmentation of the present tunnel support system with fibercrete was approved. Before the final rounds are set to expose the working face for the drilling of Radial Borehole Test boreholes, it will be necessary that the field change request establishing the acceptable use of steel sets and lagging be approved. The provision for steel sets will assure adequate tunnel support without the use of fibercrete.

The Test Coordination Office (TCO) has been actively involved in the Design Review process for Design Package 2B. Package 2B includes: electrical system for the portal and tunnel, conveyor system for tailings, the mapping gantry for the Tunnel Boring Machine (TBM), TBM and conventional mining for the main test level, compressed air and water systems for construction support, and the communication system to include emergency notification. The TCO reviews the design package to assure that testing requirements have been fully considered, such as common facility interference with proposed test activities and adequate support utilities to accommodate various testing situations.

Included as Attachment 1 is a drawing of the NORTH RAMP AND EXISTING/PROPOSED TEST LOCATIONS - NEW ALIGNMENT, which illustrates possible test locations as they relate to the proposed ramp alignment. The *Geologic Mapping* test activities for December included U.S. Bureau of Reclamation (USBR) completing geologic mapping to the face of the test alcove. Attachment 2 illustrates the configuration of the TBM Mapping Gantry with clearances and elevations. Five samples were collected for the *Consolidated Sampling* test activity (illustrated in Attachment 3) during December and no *Perched Water* was identified. The *Construction Monitoring* test activity consisted of monitoring for peak particle velocity during blasting activities by the Sandia Field Team and completion of the Rock Mass Classification Indices for the test alcove. The location of the alcove face in relation to the shear zone is also illustrated in Attachment 3. No additional field *Hydrochemistry Test* activities were conducted. Activities at the Fran Ridge Site for the Engineered Barrier-Large Block Experiment included drilling the remaining fourteen of seventeen vertical test holes and logging of those holes by Lawrence Livermore National Laboratory. The site layout of the Large Block and associated support facilities is illustrated at Attachment 4.

ENVIRONMENTAL, SAFETY, AND HEALTH (ES&H) ACTIVITIES

Approximately 32.1 kiloliter (8,480 gallons) of water with lithium-bromide tracer was reported used during this period by the constructor. The total construction water used to date is approximately 1,670 kiloliter (441,221 gallons). The TCO submitted environmental information to Department Of Energy for an operations permit involving road crossings for a phone line to Fran Ridge.

Safety related activities centered around the use of a neutron logging source for the Large Block Experiment at Fran Ridge and preparation for Laser Induced Breakdown Spectroscopy (LIBS) activities in Test Alcove #1 in conjunction with the drilling of the hydrochemistry test boreholes. Training for participants in general safety and health procedures continues to be focused on working environment and hazard communications.

INTEGRATED DATA SYSTEM

Efforts during December were concentrated on the identification of data format requirements from the principal investigators and developing an alternative Integrated Data System (IDS) support plan for FY 1994. Work on identifying and planning for the Data Acquisition Stations (DAS) needs of the principal investigators and communication of these needs to the IDS Design CRWMS M&O continues.

TEST PROGRAM: ADMINISTRATIVE SCHEDULE AND SUMMARY TABLE

Table I identifies the field activities in progress at the ESF. The Administrative Schedule (Attachment 5) is based on information provided by the ESF Design Team and is consistent with the TBM advance as illustrated by the "ESF TUNNEL BORING MACHINE ADVANCE TIME LINE ILLUSTRATION" (Attachment 6).

TABLE I
ESF Testing Field Activity
North Ramp Starter Tunnel

SCP PROGRAM NAME	SCP STUDY NAME	SCP STUDY PLAN NUMBER	TEST NAME (SCP ACTIVITY)	WBS ELEMENT	TCO TEST EVENT NAME	TPP #	JP #
Rock Characteristic Program	Characterization of Structural Features in the Site Area	8.3.1.4.2.2	Geologic Mapping of the ESF	1.2.3.2.2.1.2	Geologic Mapping - Starter Tunnel	TPP 92-10	JP 92-20A
Geohydrology Program	Characterization of YM Percolation in the Unsaturated-Zone ESF Investigation	8.3.1.2.2.4	Perched Water Testing in the ESF	1.2.3.3.1.2.4	Perched Water - Starter Tunnel (Contingency)	TPP 92-11	JP 92-20B
			Hydrochemistry Tests in the ESF	1.2.3.3.1.2.4	Hydrochemistry Testing	TPP 92-12	JP 92-20E
			Radial Borehole Tests in the ESF	1.2.3.3.1.2.4	Radial Borehole Testing	TPP 92-13	JP 92-20F
Thermal and Mechanical Rock Properties Program	In Situ Design Verification	8.3.1.15.1.8	Evaluation of Mining Methods Monitoring of Ground Support Systems	1.2.4.2.1.1.4	Construction Monitoring in the ESF	TPP T-93-2	JP 92-20D
Geochemistry Program	Water Movement Tests, Rev. 0 Water Movement Tests, Rev. 1	8.3.1.2.2.2	Chloride and Chlorine-36 Measurements of Percolation at YM	1.2.3.3.1.2.2	Consolidated Sampling in the ESF	TPP 92-14	JP 92-20C
	History of Mineralogic and Geochemical Alteration of YM	8.3.1.3.2.2	History of Mineralogic and Geochemical Alteration of YM	1.2.3.2.1.1.2			
	Mineralogy, Petrology, and Chemistry of Transport Pathways	8.3.1.3.2.1	Mineral Distribution Between Host Rock and Accessible Environment	1.2.3.2.1.1.1			
	Mineralogy, Petrology, and Chemistry of Transport Pathways	8.3.1.3.2.1	Fracture Mineralogy Studies	1.2.3.2.1.1.1			
Repository Horizon Rock-Water Interaction Large Block Experiment	Engineered Barrier System Field Tests	SIP-NF-2 Rev. 0	Repository Horizon Rock Water Interaction - Large Block Experiment	1.2.2.2.4	Engineered Barrier-Fran Ridge Large Block Experiment	NA	JP 93-10

SITE CONSTRUCTION

Job Package (JP) 92-20 ESF North Portal Pad and Facilities

The Starter Tunnel depth is about 60 meters (197 feet) with an alcove on the right rib which is about meters (75 feet) deep. Construction of the ESF Test Alcove #1 reached CS 0+27.4 (90 feet). Because of the ground conditions in the test alcove, it was agreed between the constructor, testing, and the U.S. Geological Survey (Principle Investigator) that the alcove could be fibercreted to its current depth, springline to springline.

Reynolds Electrical and Engineering Company, Inc., (REECo) has completed the grouting and pull-testing of permanent rockbolts and has applied shotcrete to selected areas of the box cut. They have actively supported the Sandia National Laboratories (SNL) Field Team with the installation of construction monitoring equipment.

TEST PROGRAM: FIELD ACTIVITIES

Each of the following appendices contains a description of the progress in milestones and deliverables, a summary of field activities, a brief description of the manner of data flow, and a cost/schedule summary. When pertinent, additional graphic information is provided to illustrate progress or concerns.

Appendix I - Geologic Mapping of the ESF (JP 92-20A)
Appendix II - Perched Water Testing in the ESF (JP 92-20B)
Appendix III - Consolidated Sampling in the ESF (JP 92-20C)
Appendix IV - Construction Monitoring in the ESF (JP 92-20D)
Appendix V - Engineered Barrier-Fran Ridge Large Block Site Experiment (JP 93-10)
Appendix VI - Hydrochemistry (JP 92-20E)

ISSUES: None

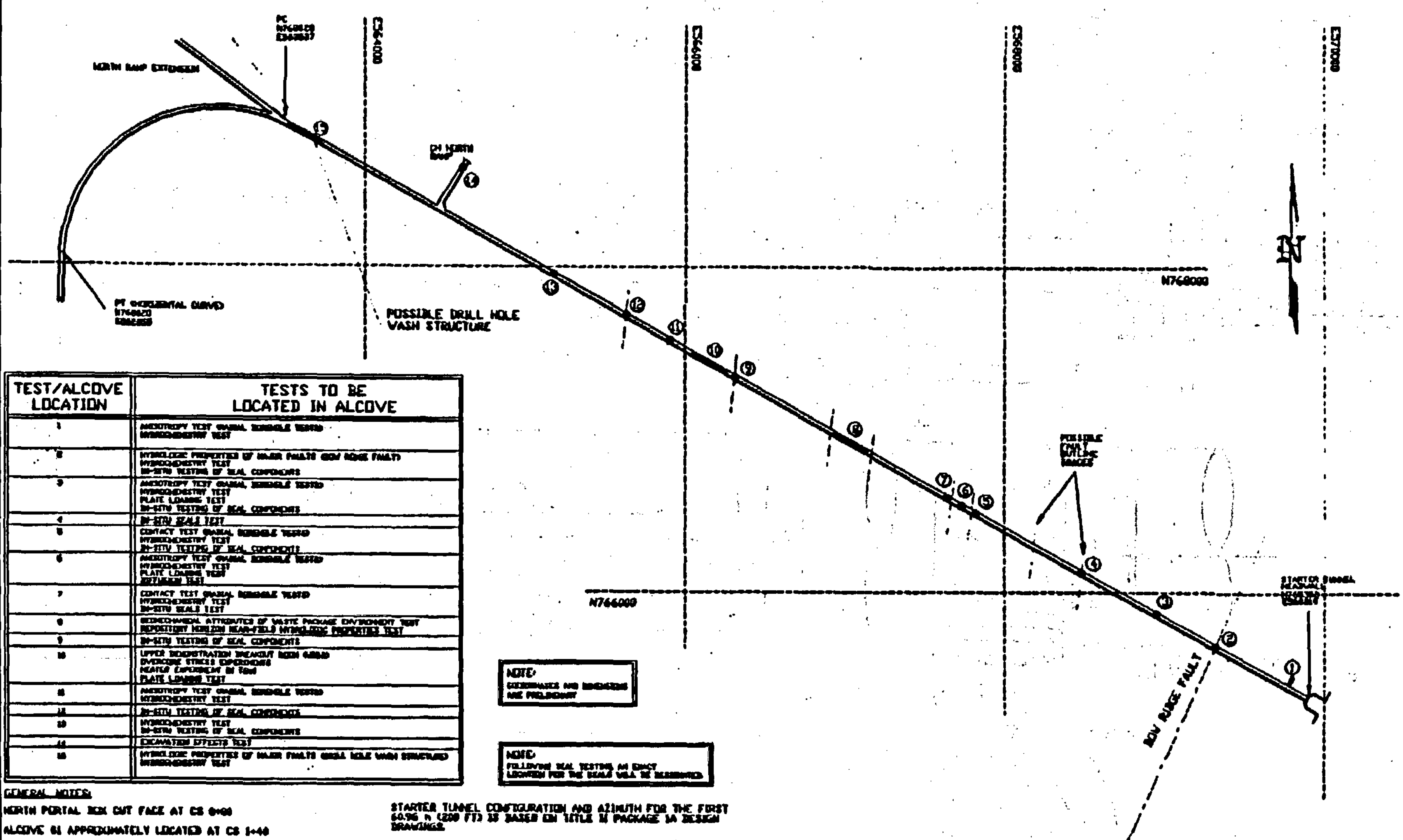
Attachments "Limited Value Material"

RDO:dm08

Cy:
R. A. Crawley, DOE/YMPO, MS 523
W. J. Boyle, DOE/YMPO, MS 523
V. F. Iorii, DOE/YMPO, MS 523
E. H. Petrie, DOE/YMPO, MS 523
K. J. Skipper, DOE/YMPO, MS 523
M. W. Smith, DOE/YMPO, MS 523
D. P. Stucker, DOE/YMPO, MS 523
R. S. Waters, DOE/YMP, MS 523

Cy con't:
R. J. White, DOE/YMPO, MS 523
D. R. Williams, DOE/YMPO, MS 523
W. A. Girdley, DOE/FOC, MS 717
W. A. Wilson, DOE/FOC, MS 717
W. C. Kopatich, RSN, MS 403
E. L. Wright, RSN, MS 403
B. R. Gardella, REECo, MS 408
R. C. McDonald, CRWMS M&O, MS 423
R. W. Craig, USGS/LV, MS 509
D. L. Edwards, USGS/LV, MS 509
L. R. Hayes, USGS, Denver, CO
M. D. Voegele, SAIC, MS 517
D. S. Kessel, SNL/LV, MS 509
L. E. Shephard, SNL, Dept. 6302, Albuquerque, NM
J. A. Blink, LLNL/LV, MS 527
W. L. Clarke, LLNL, Livermore, CA
J. A. Canepa, LANL, EES-13, MS J521
D. M. Boak, LANL, EES-13/LV, MS 527
N. Z. Elkins, LANL, EES-13/LV, MS 527
E. F. Homuth, LANL, EES-13/LV, MS 527
K. L. Kinter, LANL, EES-13/LV, MS 527
A. J. Mitchell, LANL, EES-13/LV, MS 527
D. M. Rashid, LANL, EES-13/LV, MS 527
D. J. Weaver, LANL, EES-13/LV, MS 527
J. H. Berry, LANL/FOC, MS 735
R. G. Kovach, LANL/FOC, MS 735
EES-13/LV, LANL, MS 527

TWS-EES-13-LV-01-94-18
Attachment 1
1 Page



TEST/ALCOVE LOCATION	TESTS TO BE LOCATED IN ALCOVE
1	ANISOTROPY TEST (RADIAL BOREHOLE TESTS) HYDROCHEMISTRY TEST
2	HYDROLOGIC PROPERTIES OF MAJOR FAULTS (BOW RIDGE FAULT) HYDROCHEMISTRY TEST IN-SITU TESTING OF SEAL COMPONENTS
3	ANISOTROPY TEST (RADIAL BOREHOLE TESTS) HYDROCHEMISTRY TEST PLATE LOADING TEST IN-SITU TESTING OF SEAL COMPONENTS
4	IN-SITU SEALS TEST
5	CONTACT TEST (RADIAL BOREHOLE TESTS) HYDROCHEMISTRY TEST IN-SITU TESTING OF SEAL COMPONENTS
6	ANISOTROPY TEST (RADIAL BOREHOLE TESTS) HYDROCHEMISTRY TEST PLATE LOADING TEST DIFFUSION TEST
7	CONTACT TEST (RADIAL BOREHOLE TESTS) HYDROCHEMISTRY TEST IN-SITU SEALS TEST
8	GEOMECHANICAL ATTRIBUTES OF WASTE PACKAGE ENVIRONMENT TEST REPOSITORY HORIZON NEAR-FIELD HYDROLOGIC PROPERTIES TEST
9	IN-SITU TESTING OF SEAL COMPONENTS
10	UPPER DEMONSTRATION BREAKOUT ROOM (UDBR) OVERCORE STRESS EXPERIMENTS HEATER EXPERIMENT IN TSw1 PLATE LOADING TEST
11	ANISOTROPY TEST (RADIAL BOREHOLE TESTS) HYDROCHEMISTRY TEST
12	IN-SITU TESTING OF SEAL COMPONENTS
13	HYDROCHEMISTRY TEST IN-SITU TESTING OF SEAL COMPONENTS
14	EXCAVATION EFFECTS TEST
15	HYDROLOGIC PROPERTIES OF MAJOR FAULTS (DRILL HOLE WASH STRUCTURE) HYDROCHEMISTRY TEST

NOTE:
COORDINATES AND DIMENSIONS ARE PRELIMINARY

NOTE:
FOLLOWING SEAL TESTING AN EXACT LOCATION FOR THE SEALS WILL BE DETERMINED

GENERAL NOTES:

NORTH PORTAL BOX CUT FACE AT CS 0+00

ALCOVE 01 APPROXIMATELY LOCATED AT CS 1+40

TWO THOUSAND FEET GRID. COORDINATES ARE BASED ON THE NEVADA STATE COORDINATE SYSTEM CENTRAL ZONE.

DIMENSIONS AND ELEVATIONS ARE SHOWN IN METERS. METERS ARE ROUNDED TO ONE DECIMAL PLACE. WHERE DISCREPANCIES BETWEEN ELEVATIONS AND GRADIENTS OCCUR DUE TO ROUNDING, ELEVATIONS WILL GOVERN.

THE BASIS FOR THE TEST ALCOVE LOCATIONS IS THE ESF DR YMP/CC-0012. REV 3/31-91.

THE GEOLOGICAL, STRUCTURAL FEATURES ARE BASED ON THE SAIC PRELIMINARY CROSS SECTION CC-CC, DATE 3/5-91.

ACTUAL TEST ALCOVES WILL BE LOCATED IN THE FIELD AS GEOLOGY IS REVEALED BY EXCAVATION. ALCOVE LOCATIONS SHOWN ARE APPROXIMATIONS.

AN AREA OF LENGTH TO BE DETERMINED BEHIND AN ADVANCING TBM WILL HAVE THE UTILITIES LOCATED IN A MANNER TO PERMIT OPTIMIZED MAPPING OF THE RAMP PERIMETER.

SEE CALCULATION ST-SA-001 FOR MAJOR COORDINATES AND VERTICAL CURVE DATA.

STARTER TUNNEL CONFIGURATION AND AZIMUTH FOR THE FIRST 60.96 m (200 FT) IS BASED ON TITLE II PACKAGE 1A DESIGN DRAWINGS.

EXISTING DRILLHOLE LOCATIONS ARE BASED ON FIELD SURVEYS. PROPOSED DRILLHOLE LOCATIONS ARE BASED ON INFORMATION CONTAINED IN THE WORK PROGRAMS.

FAULT TRACE LOCATIONS, EXCEPT FOR THE BOW RIDGE FAULT, ARE APPROXIMATIONS BASED ON AT-DEPTH PROJECTIONS OF INFORMATION FROM USGS OPEN FILE REPORT 84-494, PRELIMINARY GEOLOGIC MAP AND SECTIONS, BY SCOTT AND BONK. THE BOW RIDGE FAULT TRACE IS AN AT-DEPTH PROJECTION BASED ON PRELIMINARY FIELD WORK FROM ON-GOING ROCK AND SOIL INVESTIGATIONS.

LEGEND:

FAULT ZONE
RAMP CONFIGURATION
REFERENCE GRID
TEST LOCATION (CERTAIN)
TEST LOCATION (DEFERRED)
TEST LOCATION (IN REVIEW FOR DEFERRAL)

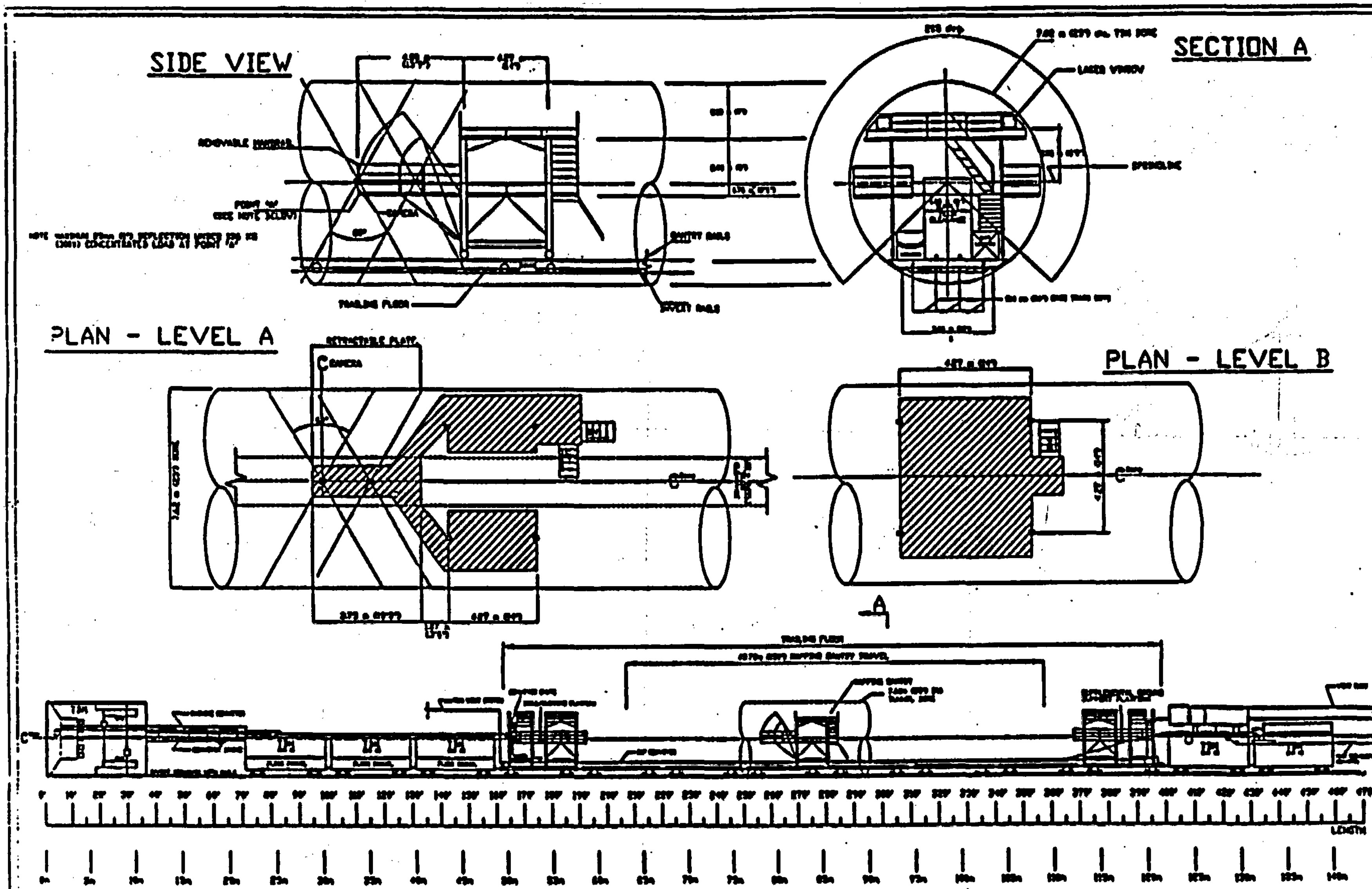
GRAPHIC SCALE
121.92 (400) 0 121.92 (400) 243.84 m (800 FT)

LOS ALAMOS NATIONAL LABORATORY
TEST COORDINATION OFFICE - YUCCA MOUNTAIN PROJECT

PROJECT: NORTH RAMP AND EXISTING/PROPOSED TEST LOCATION ILLUSTRATION - NEW ALLIGNMENT

CAD FILE: NORTHRMP.DWG	AUTOCAD R12	A	SCALE NOTED	REVISION A1
DRN. BY: B.J. WEAVER	APPROVED BY: ON FILE N.Z. ELKINS/R.B. OLIVER		DATE DRN 1/3/94	
NOTES: ADMINISTRATIVE/ILLUSTRATIVE USE ONLY			PLOT DATE: 1/4/94	

TWS-EES-13-LV-01-94-18
Attachment 2
1 Page



TBM CONFIGURATION

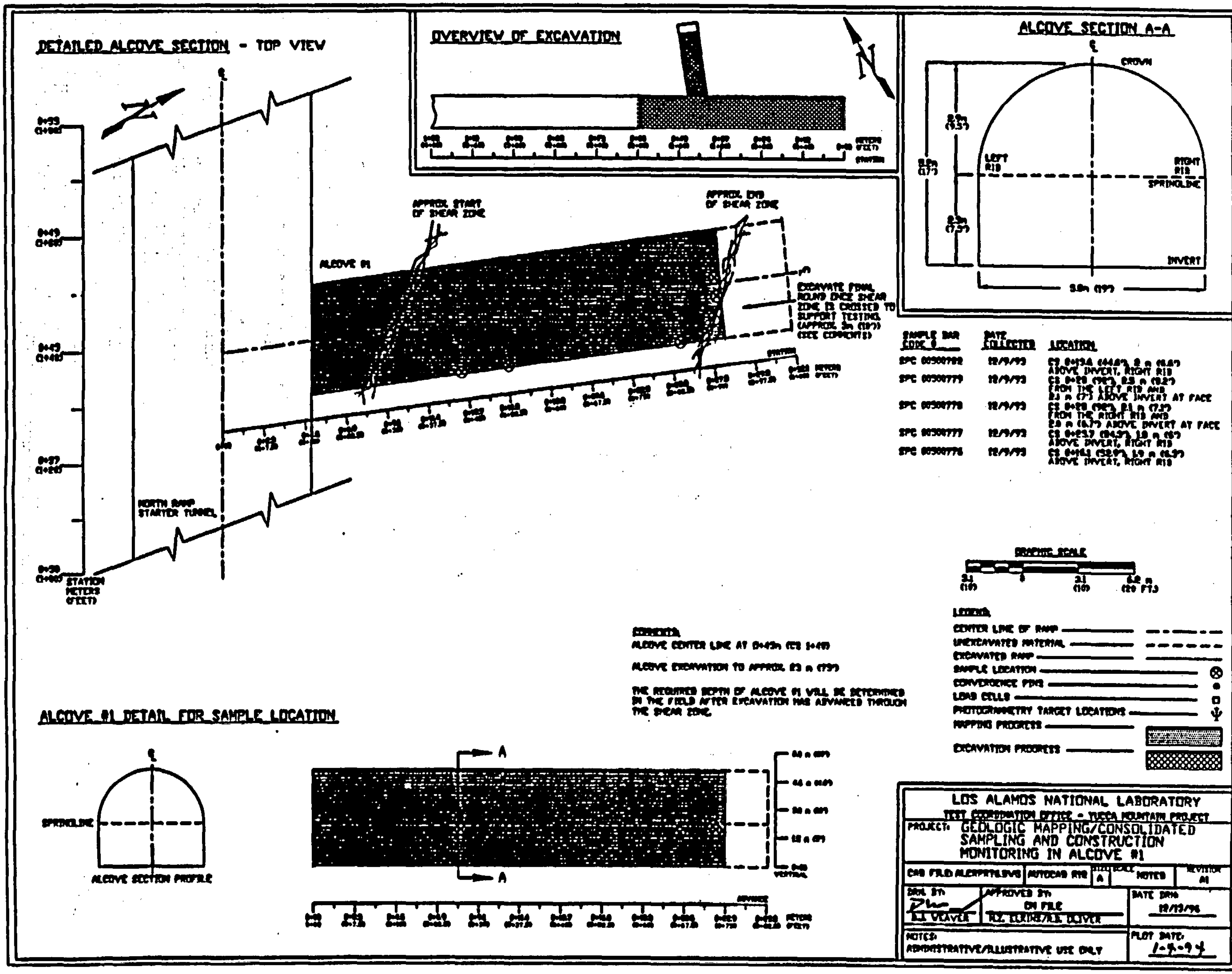
CAR #	FUNCTION/CONTENTS
1	TRANSFORMERS, SPARE CUTTER RACK,
2	LUNCH ROOM, TOILET, FIRST AID ROOM
3	SHOP AREA
4	CABLE STORAGE, VENTLINE CARTRIDGE, CONVEYOR TAILPIECE,
5	ROCK BOLT, AND MISCELLANEOUS STORAGE

ESTIMATED TOTAL LENGTH = ~460'

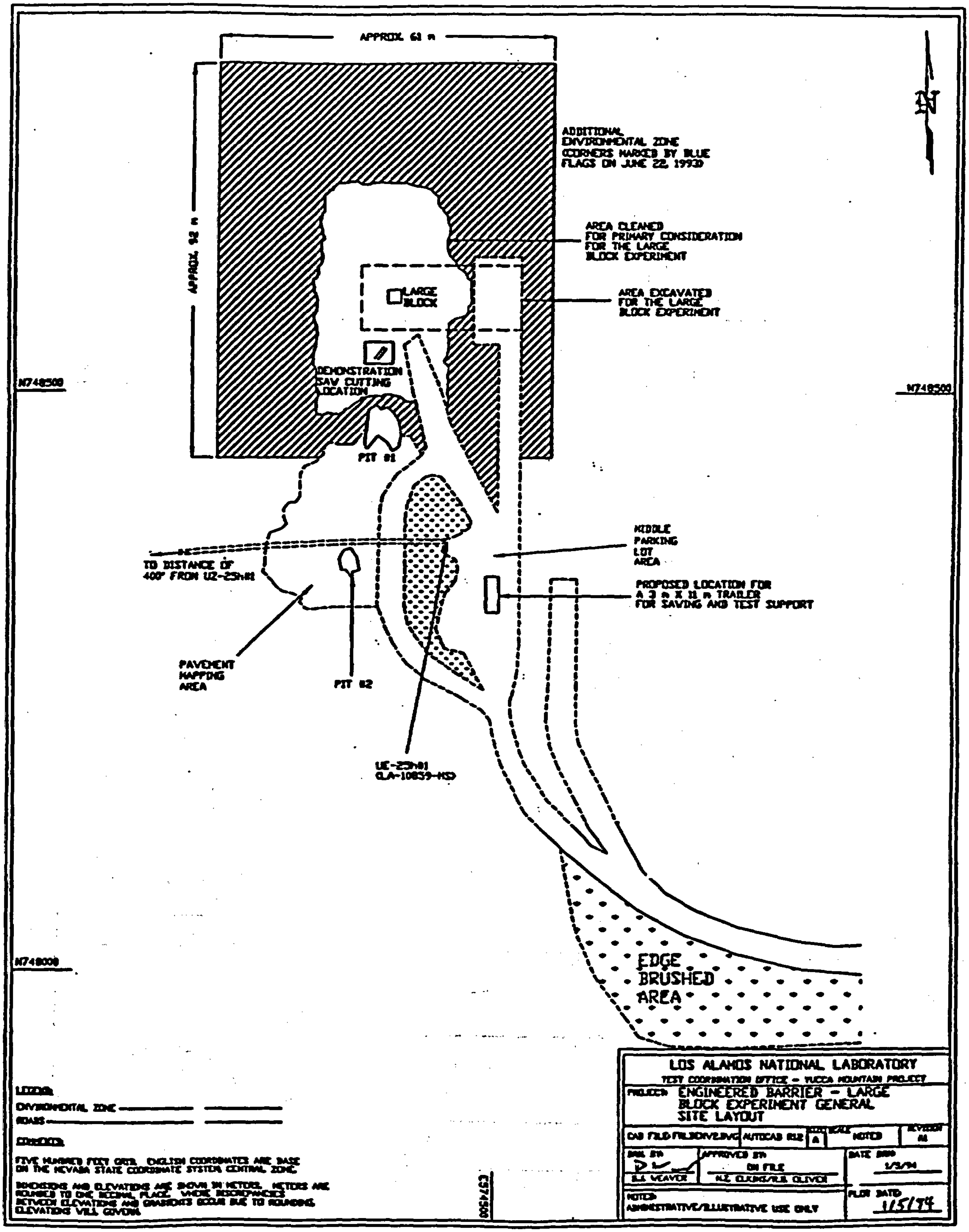
COMMENTS
DATA FOR ILLUSTRATION TAKEN FROM CIVILIAN RADIOACTIVE WASTE MANAGEMENT SYSTEM MANAGEMENT & OPERATING CONTRACTOR SKETCH TITLED "GEOLOGIC MAPPING GANTRY AND ROLLING SUPPORT", FIGURE # 11711-A

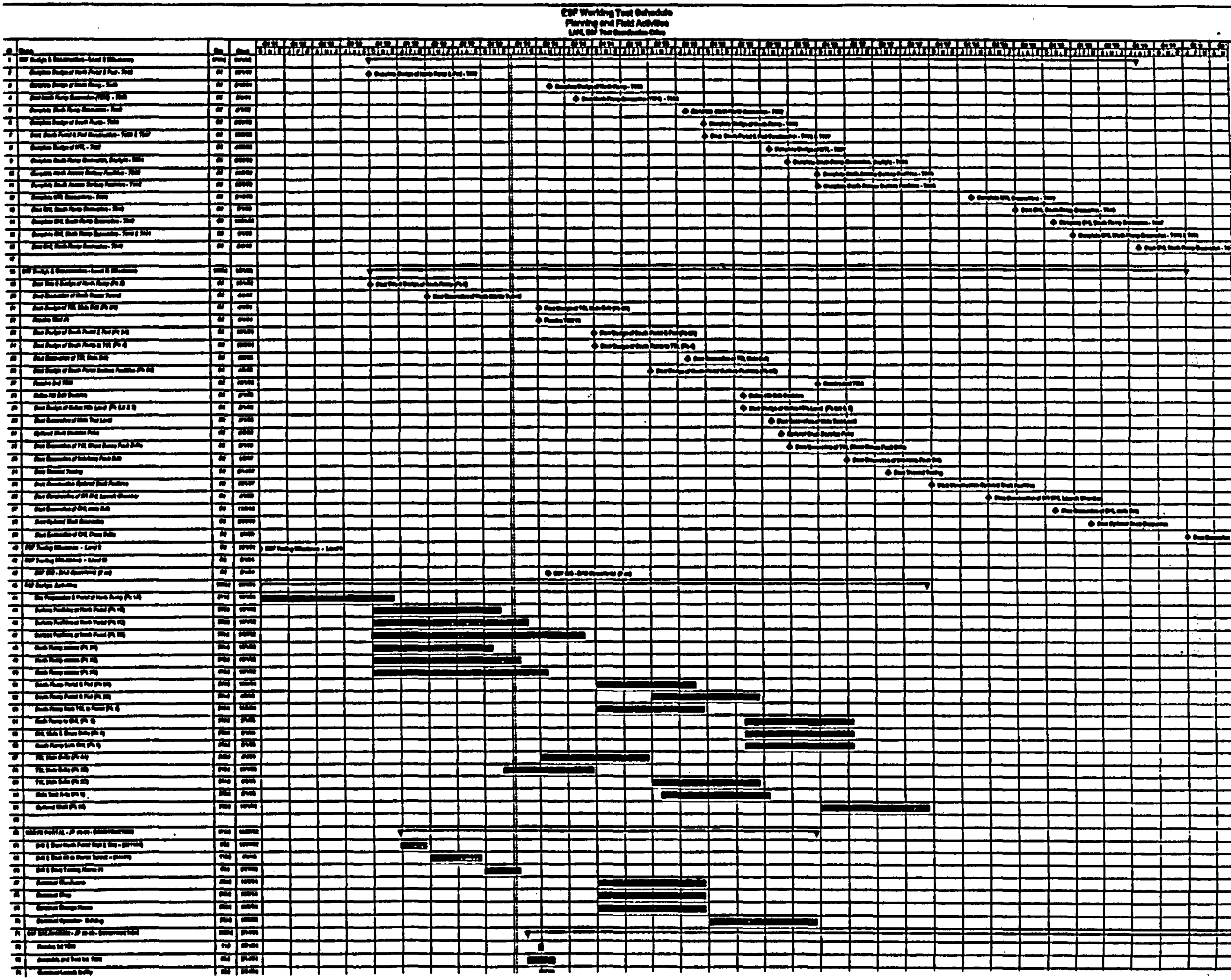
LOS ALAMOS NATIONAL LABORATORY
TEST COORDINATION OFFICE - YUCCA MOUNTAIN PROJECT
PROJECT: GEOLOGIC MAPPING GANTRY AND ROLLING SUPPORT

CAD FILE: GANTRY.DWG | AUTOCAD R12 | SIZE A | SCALE NOTED
DRN. BY: D.J. WEAVER | APPROVED BY: ON FILE | DATE DRN: 10/29/93
NOTES: ADMINISTRATIVE/ILLUSTRATIVE USE ONLY | PLOT DATE: 1-5-94

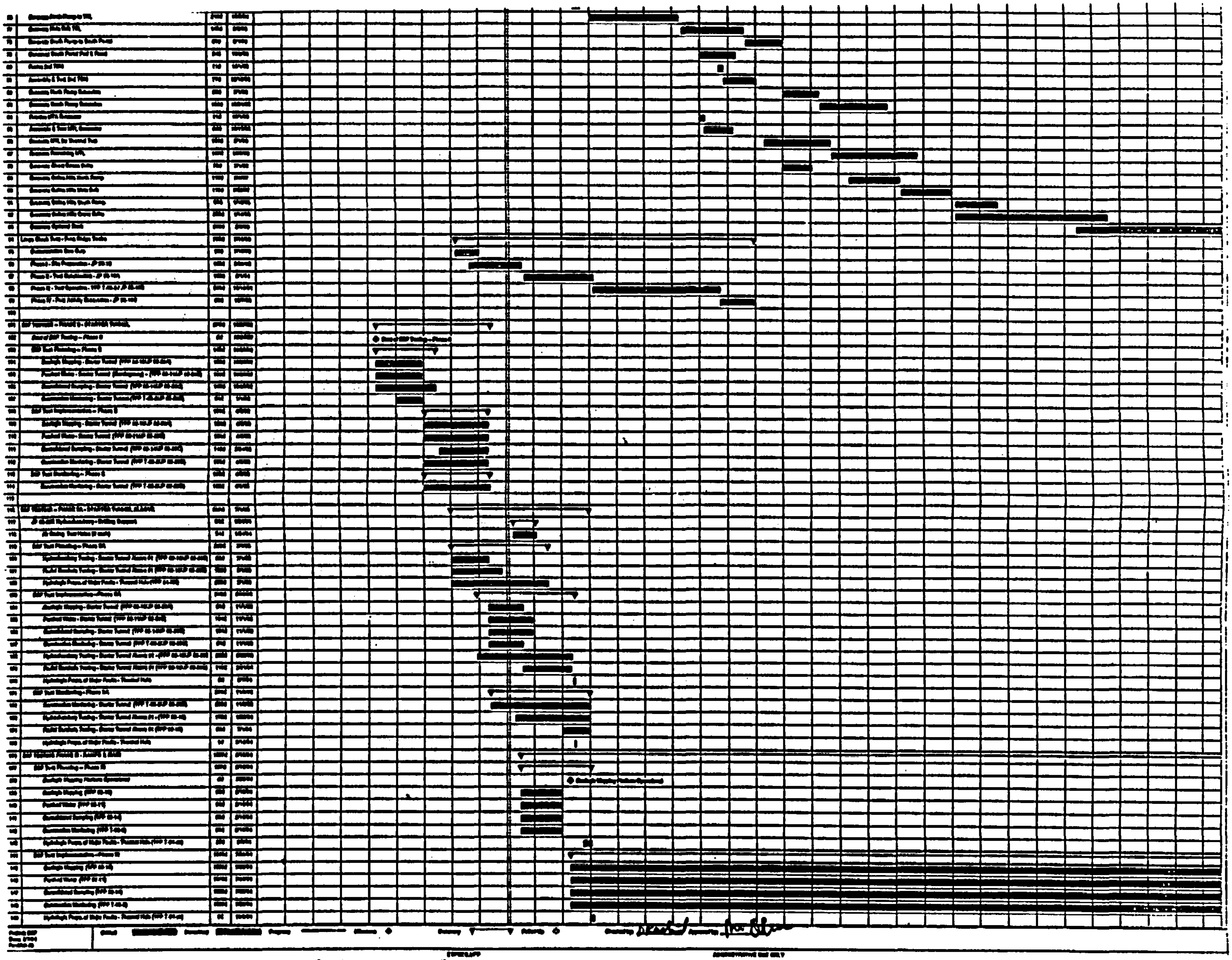


TWS-EES-13-LV-01-94-18
Attachment 3
1 Page


APPROX. 61 m
APPROX. 92 m
ADDITIONAL ENVIRONMENTAL ZONE (CORNERS MARKED BY BLUE FLAGS ON JUNE 22, 1993)
AREA CLEANED FOR PRIMARY CONSIDERATION FOR THE LARGE BLOCK EXPERIMENT
LARGE BLOCK
AREA EXCAVATED FOR THE LARGE BLOCK EXPERIMENT
DEMONSTRATION SAW CUTTING LOCATION
N748500
N748500
PIT #1
MIDDLE PARKING LOT AREA
TO DISTANCE OF 400' FROM UZ-25n#1
PROPOSED LOCATION FOR A 3 m X 11 m TRAILER FOR SAWING AND TEST SUPPORT
PAVEMENT MAPPING AREA
PIT #2
UE-25h#1 (LA-10859-MS)
N748000
EDGE BRUSHED AREA
E574500
LOS ALAMOS NATIONAL LABORATORY
TEST COORDINATION OFFICE - YUCCA MOUNTAIN PROJECT
ENGINEERED BARRIER - LARGE BLOCK EXPERIMENT GENERAL SITE LAYOUT
AUTOCAD
A
NOTED
ON FILE
ADMINISTRATIVE/ILLUSTRATIVE USE ONLY
1/5/94

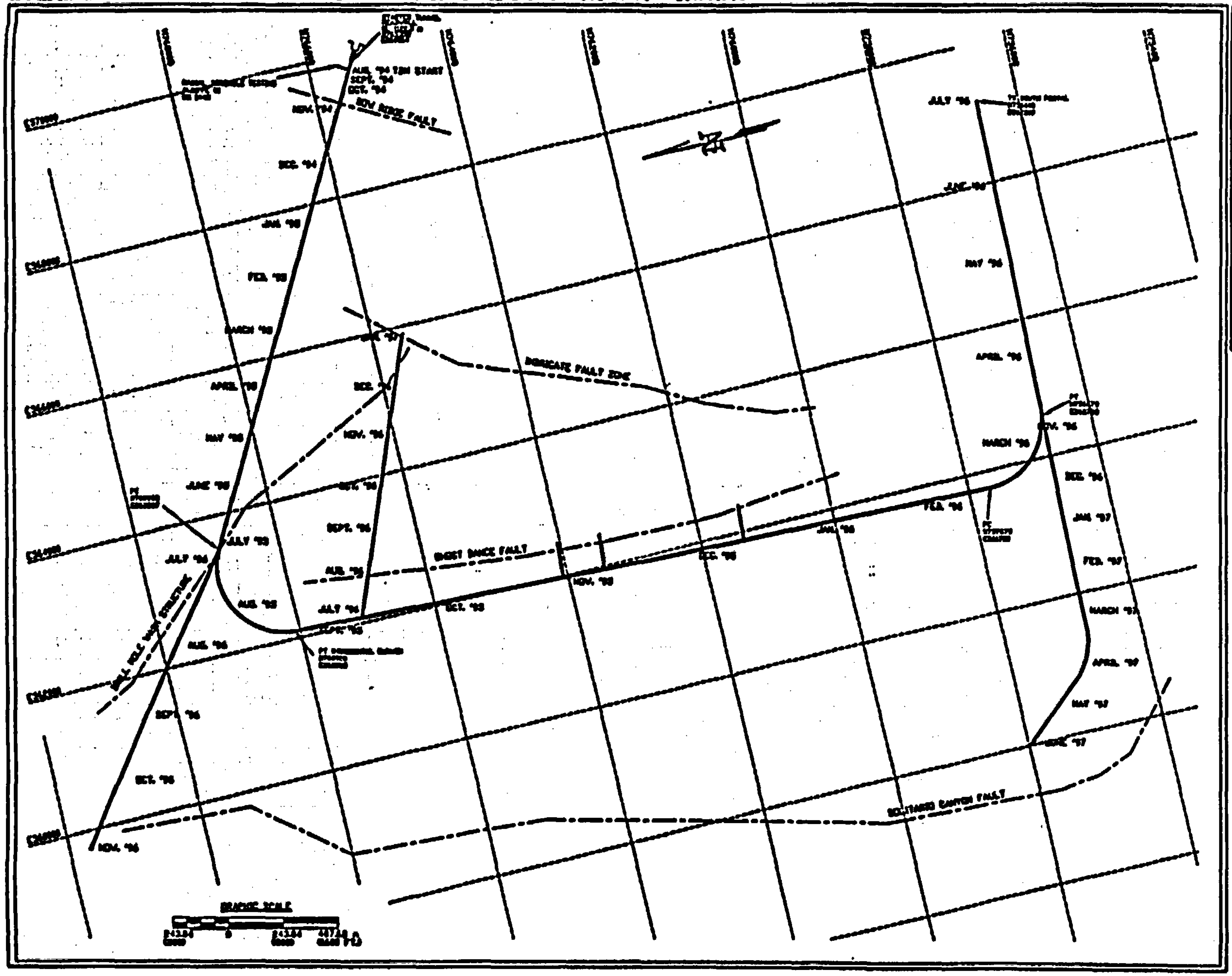


TWS-EES-13-LV-01-94-18
Attachment 5
1 Page



FOR SIMPLICITY, THE CORE TEST AREA HAS NOT BEEN ILLUSTRATED

EXCAVATE MTA - THERMAL TEST	MAY/01/96 - DEC/09/96
EXCAVATE REMAINING MTA	DEC/09/96 - FEB/10/98
EXCAVATE GHOST DANCE DRIFTS	JUL/01/96 - OCT/08/96



LOS ALAMOS NATIONAL LABORATORY

ESF TUNNEL BORING MACHINE

ADVANCE TIME LINE ILLUSTRATION

TWS-EES-13-LV-01-94-18

Attachment 6

1 Page

GEOLOGIC MAPPING OF THE ESF

PROGRESS - MILESTONES AND DELIVERABLES

The geologic mapping data collection activity started with starter tunnel construction.

SUMMARY OF FIELD ACTIVITIES

A meeting to inspect the text alcove on December 2, 1993 involved individuals from the U.S. Department of Energy/Yucca Mountain Site Characterization Project Office, U.S. Bureau of Reclamation, (USBR) U.S. Geological Survey, Civilian Radioactive Waste Management System Management & Operating Contractor, Nuclear Regulatory Commission, and Los Alamos National laboratory. The representative from the USBR stated that the alcove was still in the *"shear zone"* and that mining should continue, with two more 2.4 meters (8 feet) blasts. The USBR completed geologic mapping to the face of the test alcove which is located at CS 0+27.4 (90 feet). The geological mapping and site characterization was completed on December 10, 1993, with the entire test alcove released to construction for shotcreting from springline to springline.

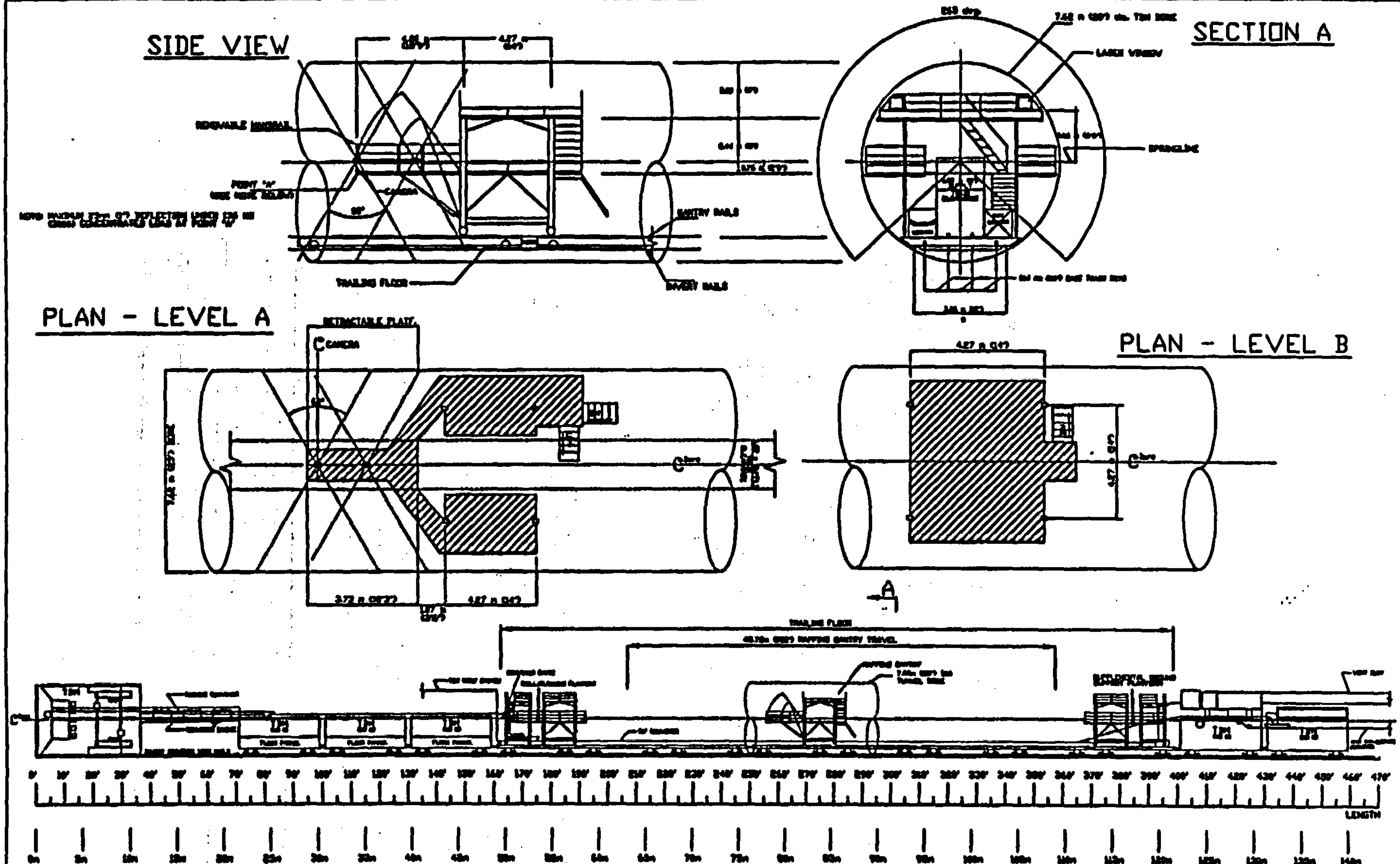
DATA FLOW INFORMATION

Analysis of geologic mapping field data by investigating organizations is progressing and preliminary information for the starter tunnel has been shared with the constructor, facility design teams and construction management.

COST AND SCHEDULE SUMMARY

The costs and progress estimates on this activity are within the scope set by JP 92-20A. No detailed cost schedule is included in this monthly report. Illustrations are provided to show progress and Test status.

SCP PROGRAM NAME	SCP STUDY NAME	SCP STUDY PLAN NUMBER	TEST NAME (SCP ACTIVITY)	TPP #	JP #
Rock Characteristic Program	Characterization of Structural Features in the Site Area	8.3.1.4.2.2	Geologic Mapping of the ESF	TPP 92-10	JP 92-20A



TBM CONFIGURATION

CAR #	FUNCTION/CONTENTS
1	TRANSFORMERS, SPARE CUTTER RACK,
2	LUNCH ROOM, TOILET, FIRST AID ROOM
3	SHOP AREA
4	CABLE STORAGE, VENTLINE CARTRIDGE, CONVEYOR TAILPIECE,
5	ROCK BOLT, AND MISCELLANEOUS STORAGE

ESTIMATED TOTAL LENGTH = ~460'

COMMENTS

DATA FOR ILLUSTRATION TAKEN FROM CIVILIAN RADIOACTIVE WASTE MANAGEMENT SYSTEM MANAGEMENT & OPERATING CONTRACTOR SKETCH TITLED "GEOLOGIC MAPPING GANTRY AND ROLLING SUPPORT" FIGURE # 10511-A

LOS ALAMOS NATIONAL LABORATORY
TEST COORDINATION OFFICE - YUCCA MOUNTAIN PROJECT

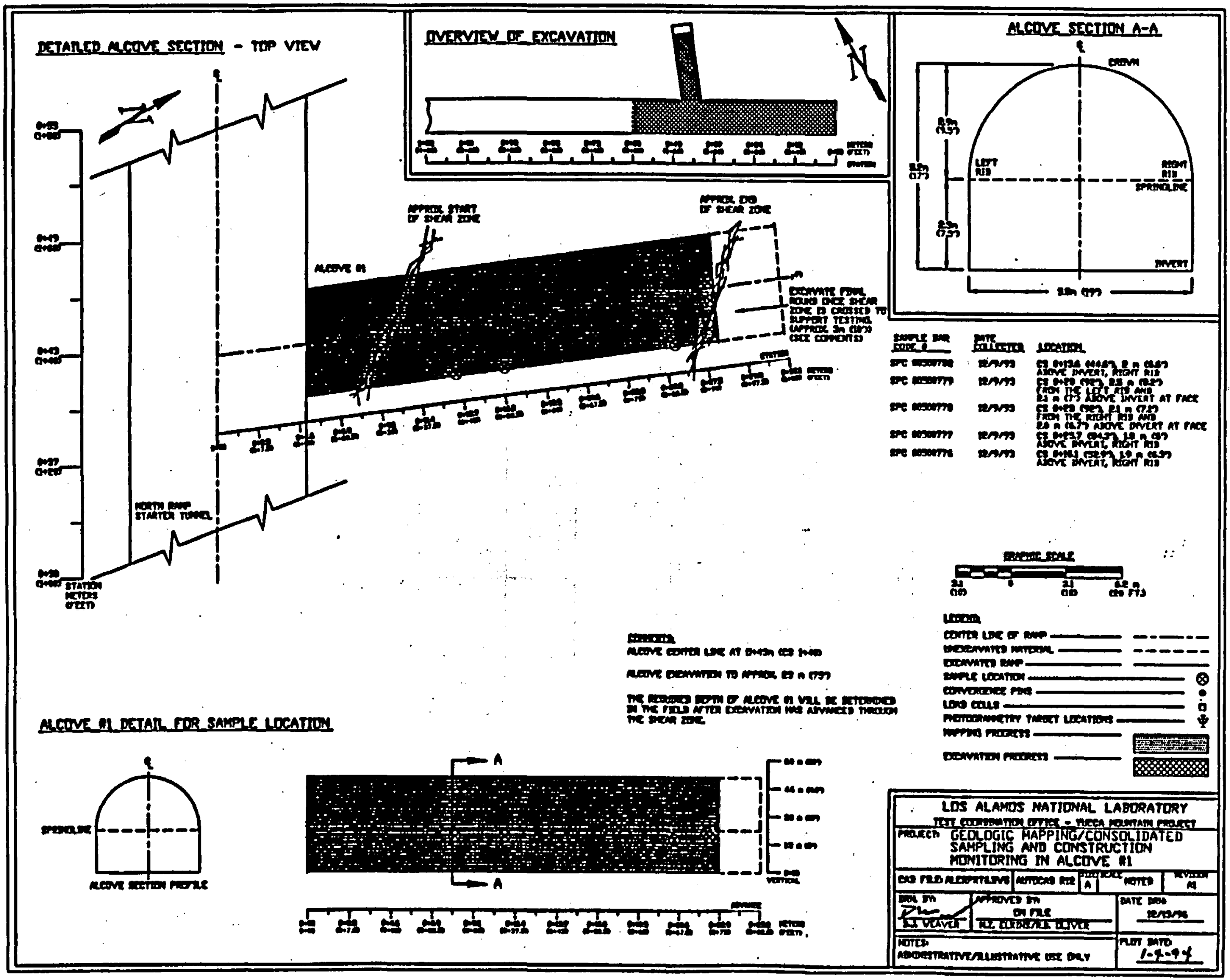
PROJECT: GEOLOGIC MAPPING GANTRY AND ROLLING SUPPORT

CAD FILE: GANTRY.DWG	AUTOCAD R12	SIZE A	SCALE	NOTES	REVISION A1

DWG. BY: B.J. WEAVER	APPROVED BY: ON FILE H.Z. ELKINS/R.D. OLIVER	DATE DRN: 10/22/93

NOTES: ADMINISTRATIVE/ILLUSTRATIVE USE ONLY

PLOT DATE: 1-5-94



DETAILED ALCOVE SECTION - TOP VIEW
OVERVIEW OF EXCAVATION
ALCOVE SECTION A-A
CROWN
LEFT RIB
RIGHT RIB
SPRINGLINE
INVERT
APPROX. START OF SHEAR ZONE
APPROX. END OF SHEAR ZONE
ALCOVE #1
NORTH RAMP STARTER TUNNEL
STATION METERS (FEET)
SAMPLE BAR CODE #
DATE COLLECTED
LOCATION
ABOVE INVERT, RIGHT RIB
FROM THE LEFT RIB AND
ABOVE INVERT AT FACE
FROM THE RIGHT RIB AND
ABOVE INVERT AT FACE
ABOVE INVERT, RIGHT RIB
ABOVE INVERT, RIGHT RIB
GRAPHIC SCALE
LEGEND
CENTER LINE OF RAMP
UNEXCAVATED MATERIAL
EXCAVATED RAMP
SAMPLE LOCATION
CONVERGENCE PINS
LOAD CELLS
PHOTOGRAMMETRY TARGET LOCATIONS
MAPPING PROGRESS
EXCAVATION PROGRESS
COMMENTS:
ALCOVE #1 DETAIL FOR SAMPLE LOCATION
SPRINGLINE
ALCOVE SECTION PROFILE
LOS ALAMOS NATIONAL LABORATORY
TEST COORDINATION OFFICE - YUCCA MOUNTAIN PROJECT
PROJECT: GEOLOGIC MAPPING/CONSOLIDATED SAMPLING AND CONSTRUCTION MONITORING IN ALCOVE #1
A
NOTED
APPROVED BY
ON FILE
DATE DRN
NOTES:
ADMINISTRATIVE/ILLUSTRATIVE USE ONLY
PLOT DATE

PERCHED WATER TESTING IN THE ESF

PROGRESS - MILESTONES AND DELIVERABLES

The ESF perched water data collection contingency activity was started with starter tunnel construction.

SUMMARY OF FIELD ACTIVITIES

No water or samples were collected during the period. Equipment to collect samples, if identified, is on station.

DATA FLOW INFORMATION

Perched water sample data and observations will be recorded in a scientific notebook if encountered.

COST AND SCHEDULE SUMMARY

The costs and progress estimates on this activity are within the scope set by JP 92-20B. No detailed cost and scheduling information is provided for the monthly report.

SCP PROGRAM NAME	SCP STUDY NAME	SCP STUDY PLAN NUMBER	TEST NAME (SCP ACTIVITY)	TPP #	JP #
Geohydrology Program	Characterization of YM Percolation in the Unsaturated-Zone ESF Investigation	8.3.1.2.2.4	Perched Water Testing in the ESF	TPP 92-11	JP 92-20B

CONSOLIDATED SAMPLING IN THE ESF

PROGRESS - MILESTONES AND DELIVERABLES

The consolidated sampling data collection and observation activity began when the starter tunnel construction exposed suitable rock. The Test Planning Package (TPP) and Job Package (JP) for consolidated sampling were revised during October.

SUMMARY OF FIELD ACTIVITIES

Samples were taken on December 9, 1993, the distribution of samples for the tests being conducted in the test alcove are as follows:

Bar Code	Location	For
SPC 00500782	CS 0+13.6, (44.6 feet), 2 meters (6.6 feet) above invert right rib	S. Levy
SPC 00500779	At the face CS 0+28, (92 feet) 2.5 meters (8.2 feet) from left rib S. and 2.1 meters (7 feet) above invert	S. Levy
SPC 00500778	At the face CS 0+28, (92 feet) 2.1 meters (7.1) from right rib and 2.0 meters (6.7 feet) above invert	S. Levy
SPC 00500777	CS 0+25.7, (84.3 feet), 1.8 meters (6 feet) above invert, right rib	S. Levy
SPC 00500776	CS 0+16.1, (52.9 feet), 1.9 meters (6.3 feet) above invert, right rib.	S. Levy

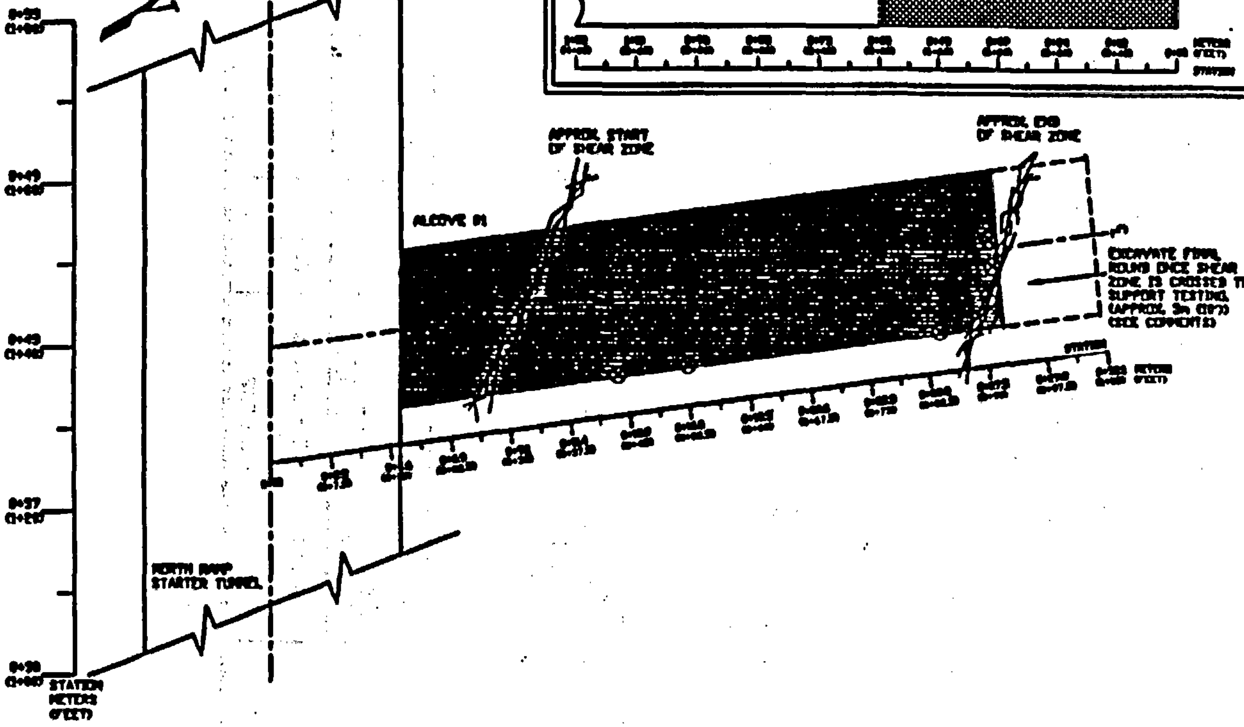
DATA FLOW INFORMATION

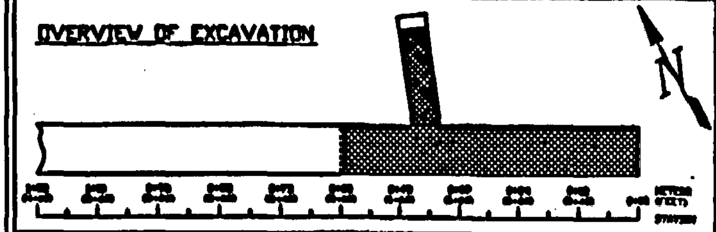
Consolidated sampling data and sample collection activities are controlled by the JP Document and Records Center files; scientific notebooks, and by AP-6.26Q, sample collection report records and bar codes. Test-related photo and survey mission data is being submitted to the JP record file and the PIs.

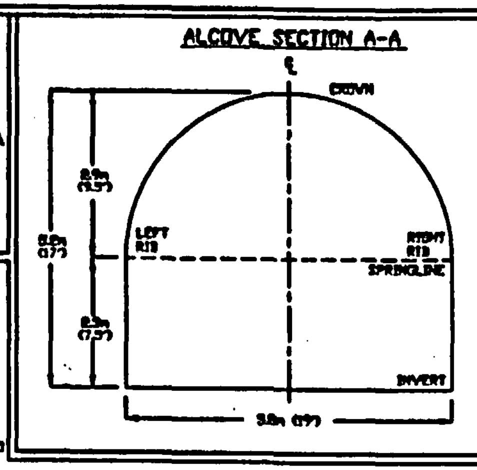
COST & SCHEDULE SUMMARY

The costs and progress estimates on this activity are within the scope set by JP 92-20C. No detailed cost schedule is included in this monthly report. Illustrations are provided to show progress and Test status.

SCP PROGRAM NAME	SCP STUDY NAME	SCP STUDY PLAN NUMBER	TEST NAME (SCP ACTIVITY)	TPP #	JP #
Geohydrology Program & Geochemistry Program	Water Movement Tests, Rev. 0 Water Movement Tests, Rev. 1 Characterization of the Percolation in the Unsaturated-Zone Surface-Based Study History of Mineralogic and Geochemical Alteration of YM	8.3.1.2.2.2 8.3.1.2.2.3 8.3.1.3.2.2	Consolidated Sampling in the ESF	TPP 92-14	JP 92-20C







SAMPLE BAR CODE #	DATE COLLECTED	LOCATION
SPC 00500782	12/9/93	CS 0+13.6 (44.6'), 2 m (6.6') ABOVE INVERT, RIGHT RIB
SPC 00500779	12/9/93	CS 0+28 (92'), 2.5 m (8.2') FROM THE LEFT RIB AND 2.1 m (7') ABOVE INVERT AT FACE
SPC 00500778	12/9/93	CS 0+28 (92'), 2.1 m (7.3') FROM THE RIGHT RIB AND 2.0 m (6.7') ABOVE INVERT AT FACE
SPC 00500777	12/9/93	CS 0+23.7 (84.3'), 1.8 m (6') ABOVE INVERT, RIGHT RIB
SPC 00500776	12/9/93	CS 0+16.1 (52.9'), 1.9 m (6.3') ABOVE INVERT, RIGHT RIB

GRAPHIC SCALE

COMMENTS:

ALCOVE CENTER LINE AT 0+43m (CS 1+40)

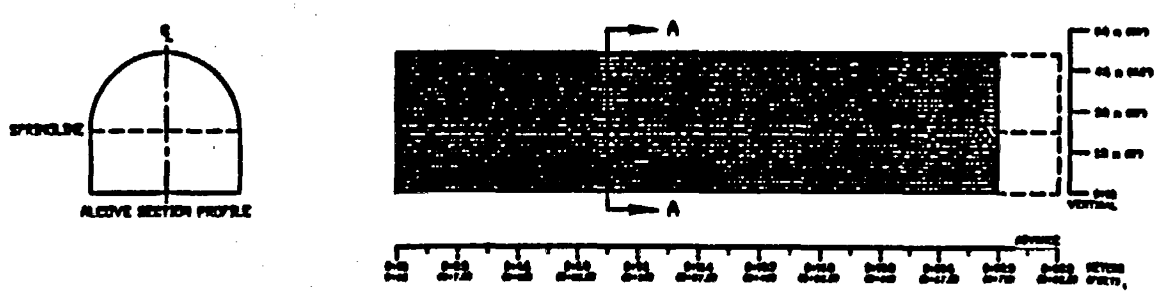
ALCOVE EXCAVATION TO APPROX. 23 m (75')

THE REQUIRED DEPTH OF ALCOVE #1 WILL BE DETERMINED IN THE FIELD AFTER EXCAVATION HAS ADVANCED THROUGH THE SHEAR ZONE.

LEGEND:

- CENTER LINE OF RAMP
- UNEXCAVATED MATERIAL
- EXCAVATED RAMP
- SAMPLE LOCATION
- CONVERGENCE PINS
- LOAD CELLS
- PHOTOGRAMMETRY TARGET LOCATIONS
- MAPPING PROGRESS
- EXCAVATION PROGRESS

ALCOVE #1 DETAIL FOR SAMPLE LOCATION



LOS ALAMOS NATIONAL LABORATORY
TEST COORDINATION OFFICE - YUCCA MOUNTAIN PROJECT

PROJECT: GEOLOGIC MAPPING/CONSOLIDATED SAMPLING AND CONSTRUCTION MONITORING IN ALCOVE #1

CAD FILE: ALCRPRTS.DVG	AUTOCAD R12	A	SCALE: NOTED	REVISION: A1
DRN. BY: D.J. VEAVER	APPROVED BY: ON FILE R.Z. CLEDES/R.B. OLIVER		DATE DRN: 12/13/93	
NOTES: ADMINISTRATIVE/ILLUSTRATIVE USE ONLY			PLOT DATE: 1-5-94	

CONSTRUCTION MONITORING IN THE ESF

PROGRESS - MILESTONES AND DELIVERABLES

The construction monitoring data collection and observation activity began with starter tunnel construction.

SUMMARY OF FIELD ACTIVITIES

The SNL Field Team has continued monitoring the blasting activity and the Peak Particle Velocity (PPV) for the test alcove. The SNL Field Team completed the Rock Mass Classification Indices for the test alcove. A review of the Construction Monitoring Work Plan for the Test Alcove was conducted with representation from the DOE/Field Test Coordinator, Test Coordination Office, Construction Manager, Construction Department Manager, and Principal Investigator. The SNL Field Team completed installation of the two Multi Point Borehole Extensometer (MPBX) gauges located horizontally and vertically at CS 0+56.3 (185 feet) and vertical MPBX gauge located at CS 0+42.7 (140 feet). In addition, the Field Team gathered data from load cells and convergence pins that had previously been installed.

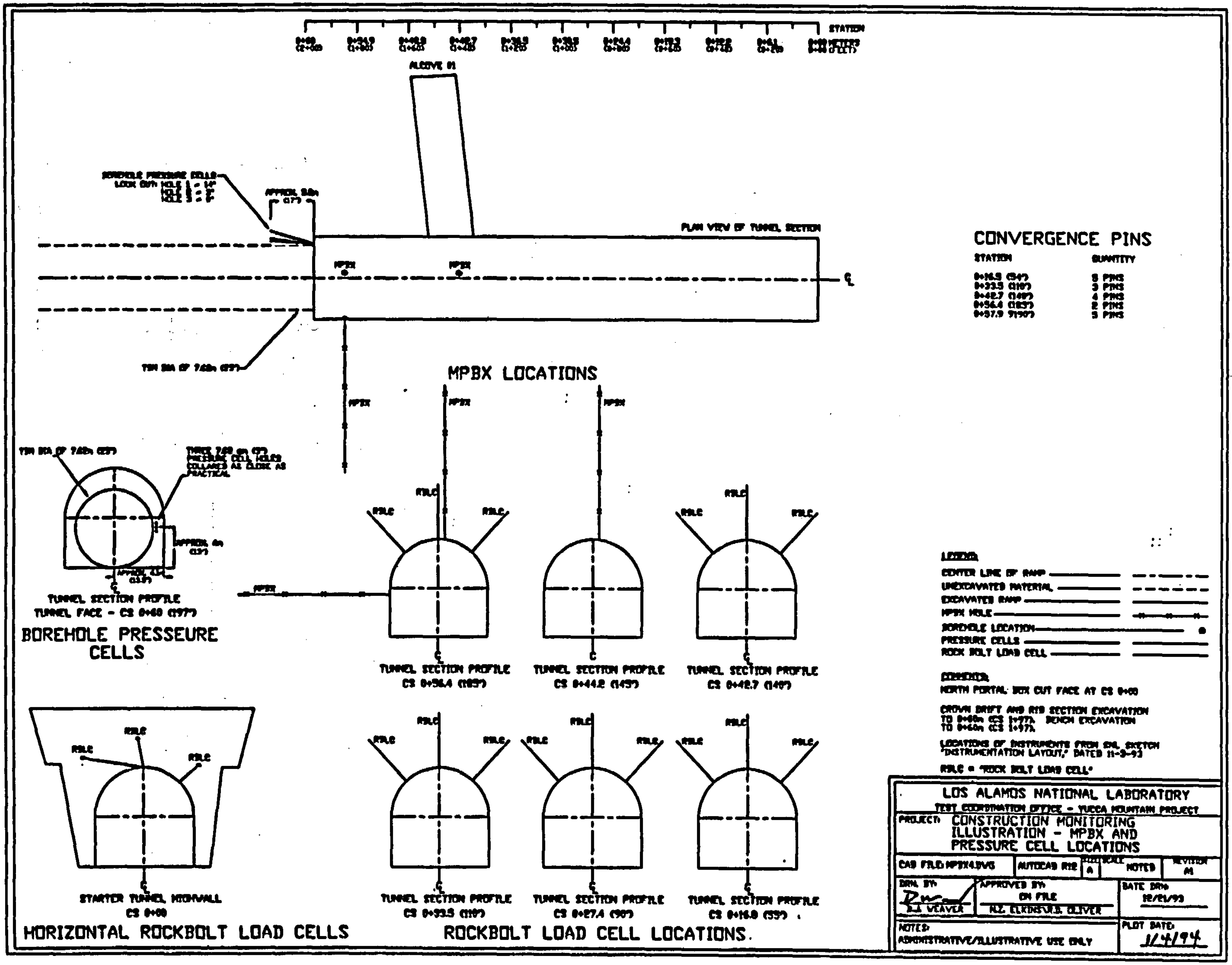
DATA FLOW INFORMATION

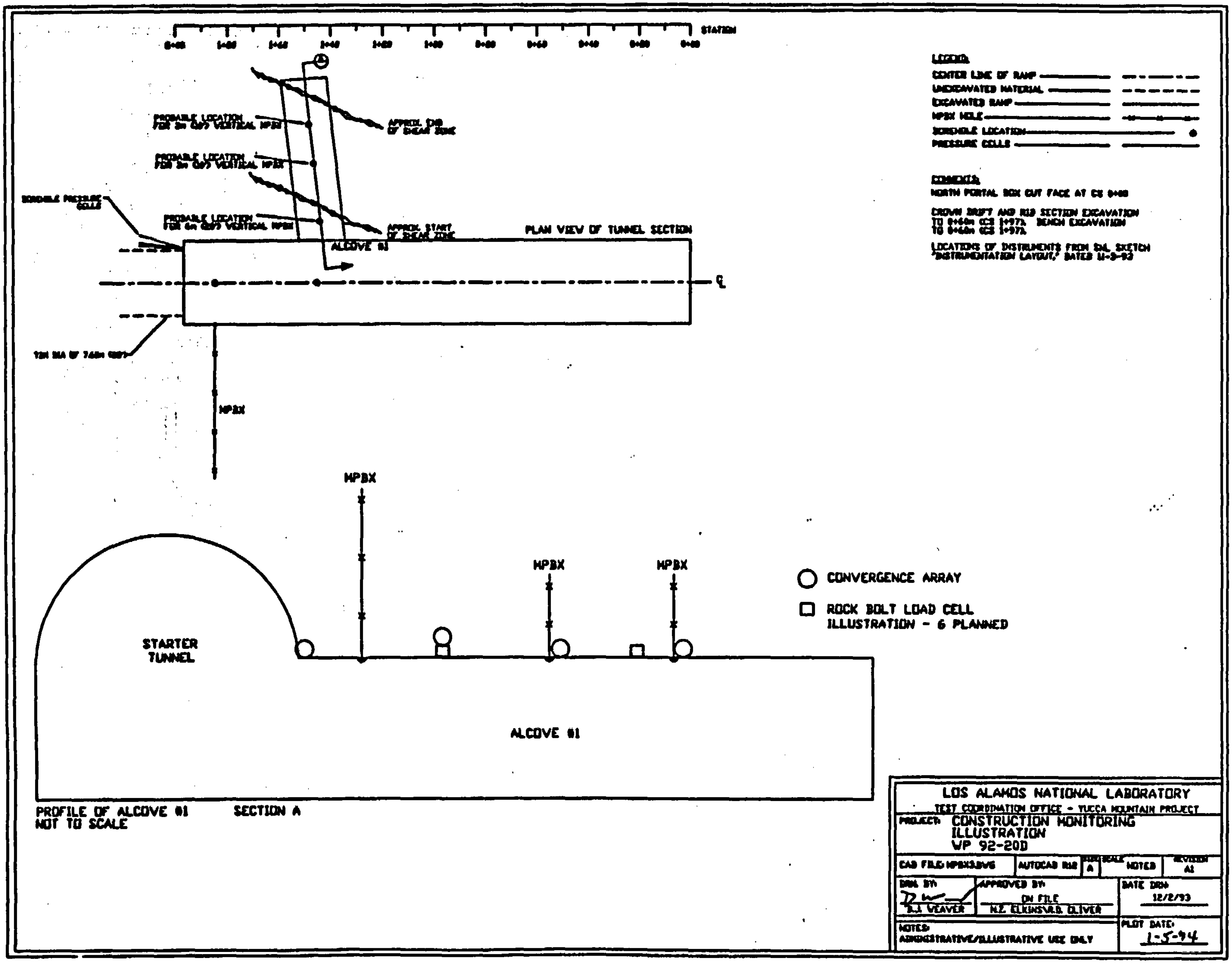
Construction monitoring data was recorded in a scientific notebook. Test-related photo and survey mission data is being submitted to the JP record file and the PIs.

COST AND SCHEDULE SUMMARY

The costs and progress estimates on this activity are within the scope set by JP 92-D. No detailed cost schedule is included in this monthly report. Illustrations are provided to show progress and test status.

SCP PROGRAM NAME	SCP STUDY NAME	SCP STUDY PLAN NUMBER	TEST NAME (SCP ACTIVITY)	TPP #	JP #
Thermal and Mechanical Rock Properties Program	In Situ Design Verification	8.3.1.15.1.8	Construction Monitoring in the ESF	TPP T-93-2	JP 92-20D


STATION
ALCOVE #1
PLAN VIEW OF TUNNEL SECTION
MPBX
MPBX LOCATIONS
CONVERGENCE PINS
STATION
QUANTITY
0+16.5 (54')
0+33.5 (110')
0+42.7 (140')
0+56.4 (185')
0+57.9 (190')
5 PINS
3 PINS
4 PINS
2 PINS
5 PINS
TUNNEL SECTION PROFILE
TUNNEL FACE - CS 0+60 (197')
BOREHOLE PRESSEURE CELLS
TUNNEL SECTION PROFILE
CS 0+56.4 (185')
TUNNEL SECTION PROFILE
CS 0+44.2 (145')
TUNNEL SECTION PROFILE
CS 0+42.7 (140')
RBLC
STARTER TUNNEL HIGHWALL
CS 0+00
HORIZONTAL ROCKBOLT LOAD CELLS
TUNNEL SECTION PROFILE
CS 0+33.5 (110')
TUNNEL SECTION PROFILE
CS 0+27.4 (90')
TUNNEL SECTION PROFILE
CS 0+16.8 (55')
ROCKBOLT LOAD CELL LOCATIONS.
LEGEND
CENTER LINE OF RAMP
UNEXCAVATED MATERIAL
EXCAVATED RAMP
MPBX HOLE
BOREHOLE LOCATION
PRESSURE CELLS
ROCK BOLT LOAD CELL
COMMENTS
NORTH PORTAL BOX CUT FACE AT CS 0+00
CROWN DRIFT AND RIB SECTION EXCAVATION TO 0+60m (CS 1+97). BENCH EXCAVATION TO 0+60m (CS 1+97).
LOCATIONS OF INSTRUMENTS FROM SNL SKETCH "INSTRUMENTATION LAYOUT," DATED 11-3-93
RBLC = "ROCK BOLT LOAD CELL"
LOS ALAMOS NATIONAL LABORATORY
TEST COORDINATION OFFICE - YUCCA MOUNTAIN PROJECT
PROJECT: CONSTRUCTION MONITORING ILLUSTRATION - MPBX AND PRESSURE CELL LOCATIONS
CAD FILE: MPBX4.DWG
AUTOCAD R12
A
SCALE NOTED
REVISION A1
DRN. BY: D.J. WEAVER
APPROVED BY: ON FILE
N.Z. ELKINS/V.D. OLIVER
DATE DRN: 12/21/93
NOTES: ADMINISTRATIVE/ILLUSTRATIVE USE ONLY
PLOT DATE: 1/4/94


STATION
PROBABLE LOCATION FOR 3m (10') VERTICAL MPBX
PROBABLE LOCATION FOR 3m (10') VERTICAL MPBX
PROBABLE LOCATION FOR 6m (20') VERTICAL MPBX
APPROX. END OF SHEAR ZONE
APPROX. START OF SHEAR ZONE
BOREHOLE PRESSURE CELLS
PLAN VIEW OF TUNNEL SECTION
ALCOVE #1
MPBX
LEGEND:
CENTER LINE OF RAMP
UNEXCAVATED MATERIAL
EXCAVATED RAMP
MPBX HOLE
BOREHOLE LOCATION
PRESSURE CELLS
COMMENTS:
NORTH PORTAL BOX CUT FACE AT CS 0+00
CROWN DRIFT AND RIB SECTION EXCAVATION
LOCATIONS OF INSTRUMENTS FROM SNL SKETCH "INSTRUMENTATION LAYOUT," DATED 11-3-93
MPBX
MPBX
MPBX
STARTER TUNNEL
CONVERGENCE ARRAY
ROCK BOLT LOAD CELL
ILLUSTRATION - 6 PLANNED
ALCOVE #1
PROFILE OF ALCOVE #1
NOT TO SCALE
SECTION A
LOS ALAMOS NATIONAL LABORATORY
TEST COORDINATION OFFICE - YUCCA MOUNTAIN PROJECT
PROJECT: CONSTRUCTION MONITORING ILLUSTRATION WP 92-20D
AUTOCAD R12
A
SCALE NOTED
APPROVED BY: ON FILE
D.J. WEAVER
DATE DRN: 12/2/93
NOTES: ADMINISTRATIVE/ILLUSTRATIVE USE ONLY
PLOT DATE: 1-5-94

ENGINEERED BARRIER-FRAN RIDGE LARGE BLOCK EXPERIMENT

PROGRESS - MILESTONES AND DELIVERABLES

The Engineered Barrier - Large Block Experiment Site Preparation activity began with site cleaning and selection activities.

SUMMARY OF FIELD ACTIVITIES

REECo completed drilling the 17 vertical instrumentation holes in the proposed large block. Lawrence Livermore National Laboratory (LLNL) completed a Neutron log of each of the holes. In addition, LLNL and the SNL Field Team moved the saw to the large block. REECo has removed the debris in front of the block and has commenced construction of the sump located at the foot of the large block.

The laying of telephone cable to Fran Ridge was completed.

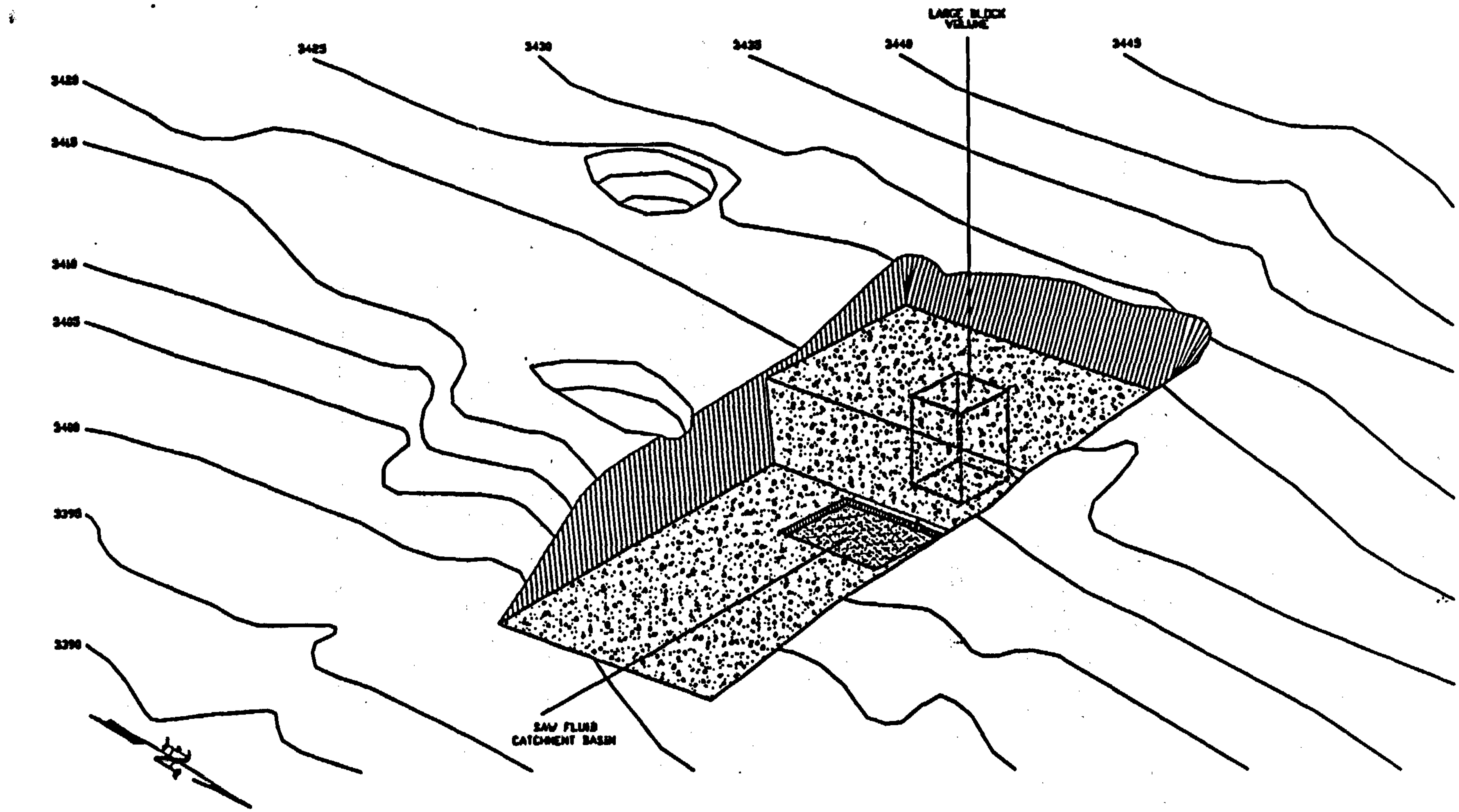
DATA FLOW INFORMATION

Construction monitoring data was recorded in a scientific notebook. Test-related photo and survey mission data is being submitted to DRC 059 and to the PIs.

COST AND SCHEDULE SUMMARY

See attached illustrations for detailed cost and schedule information. No detailed cost schedule is included in this monthly report. Illustrations are provided to show progress and Test status.

SCP PROGRAM NAME	SCP STUDY NAME	SCP STUDY PLAN NUMBER	TEST NAME (SCP ACTIVITY)	TPP #	JP #
Repository Horizon Rock-Water Interaction Large Block Experiment	Large Block Experiment	SIP-N-XX	Engineered Barrier-Fran Ridge Large Block Experiment	NA	JP 93-10



COMMENTS:

FOR REFERENCE SKETCH SEE RSN SKETCH BSK-93-D-PL17, "FRAN RIDGE SITE PHASE I, 3-D PERSPECTIVE"

TEST CONSTRUCTION ACTIVITIES WILL DISTURB THE MINIMUM AMOUNT OF SURFACE AREA REQUIRED FOR THE EFFICIENT CONSTRUCTION OF THE FACILITY.

VERTICAL CONTROL IS BASED ON BLM DATUM MEAN SEA LEVEL (MSL) 1929. HORIZONTAL CONTROL IS BASED ON NEVADA CENTRAL STATE STATE PLANE COORDINATE SYSTEM.

SURFACE CONTOURS FURNISHED BY RSN YMP SURVEY.

CONTOURS AND ARRANGEMENT IS APPROXIMATED FROM RSN SKETCH BSK-93-D-PL17.

LEGEND:

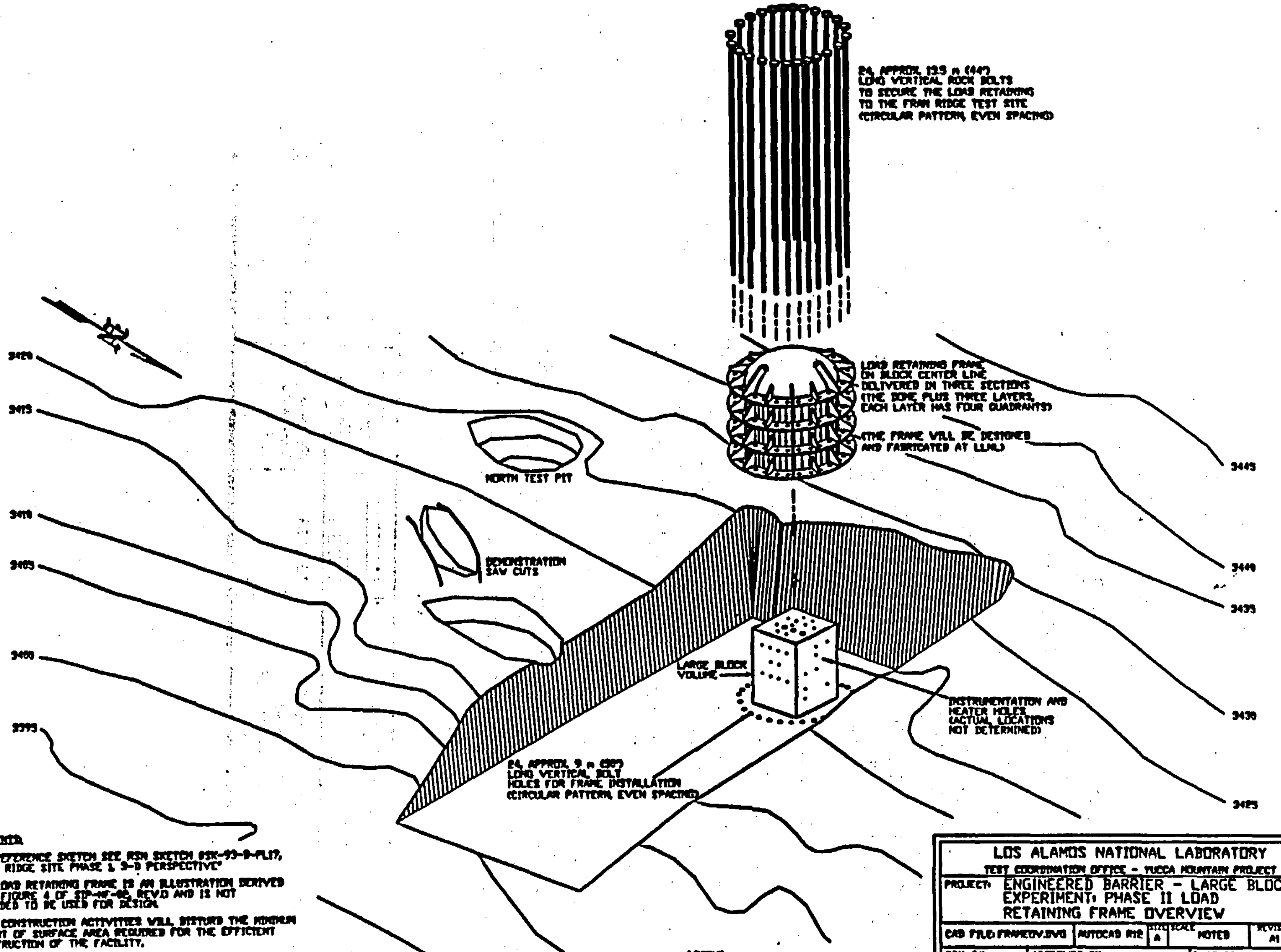
SAW CUT
HIDDEN SURFACE
FINAL BLOCK SURFACE
CONTOUR LINES

LOS ALAMOS NATIONAL LABORATORY

TEST COORDINATION OFFICE - YUCCA MOUNTAIN PROJECT

PROJECT: ENGINEERED BARRIER - LARGE BLOCK EXPERIMENT: PHASE II EXCAVATION STRATEGY ILLUSTRATION

CAD FILE: EXCAV2A.DWG	AUTOCAD R12	SIZE A	SCALE NOTED	REVISION A1
DRN. BY: D.J. WEAVER	APPROVED BY: N.Z. ELKINS/R.D. OLIVER		DATE DRN: 1/7/94	
NOTES: ADMINISTRATIVE/ILLUSTRATIVE USE ONLY			PLOT DATE: 1/14/94	



COMMENTS:

FOR REFERENCE SKETCH SEE RSN SKETCH #SK-93-D-PL17, 'FRAN RIDGE SITE PHASE I, 3-D PERSPECTIVE'

THE LOAD RETAINING FRAME IS AN ILLUSTRATION DERIVED FROM FIGURE 4 OF SIP-NF-02, REV.0 AND IS NOT INTENDED TO BE USED FOR DESIGN.

TEST CONSTRUCTION ACTIVITIES WILL DISTURB THE MINIMUM AMOUNT OF SURFACE AREA REQUIRED FOR THE EFFICIENT CONSTRUCTION OF THE FACILITY.

VERTICAL CONTROL IS BASED ON BLM DATUM MEAN SEA LEVEL (MSL) 1929. HORIZONTAL CONTROL IS BASED ON NEVADA CENTRAL STATE STATE PLANE COORDINATE SYSTEM.

SURFACE CONTOURS FURNISHED BY RSN YMP SURVEY.

CONTOURS AND ARRANGEMENT IS APPROXIMATED FROM RSN SKETCH #SK-93-D-PL17.

LEGEND:

SAW CUT
HIDDEN SURFACE
FINAL BLOCK SURFACE
CONTOUR LINES

LOS ALAMOS NATIONAL LABORATORY
TEST COORDINATION OFFICE - YUCCA MOUNTAIN PROJECT

PROJECT: ENGINEERED BARRIER - LARGE BLOCK EXPERIMENT: PHASE II LOAD RETAINING FRAME OVERVIEW

CAD FILE: FRAMEOV.DWG	AUTOCAD R12	SIZE A	SCALE NOTED	REVISION A1

DRN. BY: A.J. WEAVER
APPROVED BY: N.Z. ELKINS/R.B. OLIVER
DATE DRN: 1/13/94
NOTES: ADMINISTRATIVE/ILLUSTRATIVE USE ONLY
PLOT DATE: 1/13/94

HYDROCHEMISTRY

PROGRESS - MILESTONES AND DELIVERABLES

The Hydrochemistry Tests in Alcove #1 began in November and will run though June of 1994. The TCO will submit weekly activity reports to the FTC and monthly data collection status reports.

SUMMARY OF FIELD ACTIVITIES

Two hydrochemistry tests were performed this month, the first was on November 3, 1993, with the probe being placed in the face of the test alcove which at this time was 12 meters (40 feet) deep. The second test occurred on November 9, 1993, with the probe being located at the face; the alcove was 15 meters (48 feet) deep at that time (see *Test Alcove #1 Proposed Layout Plan and Section, 11-29-93)*.

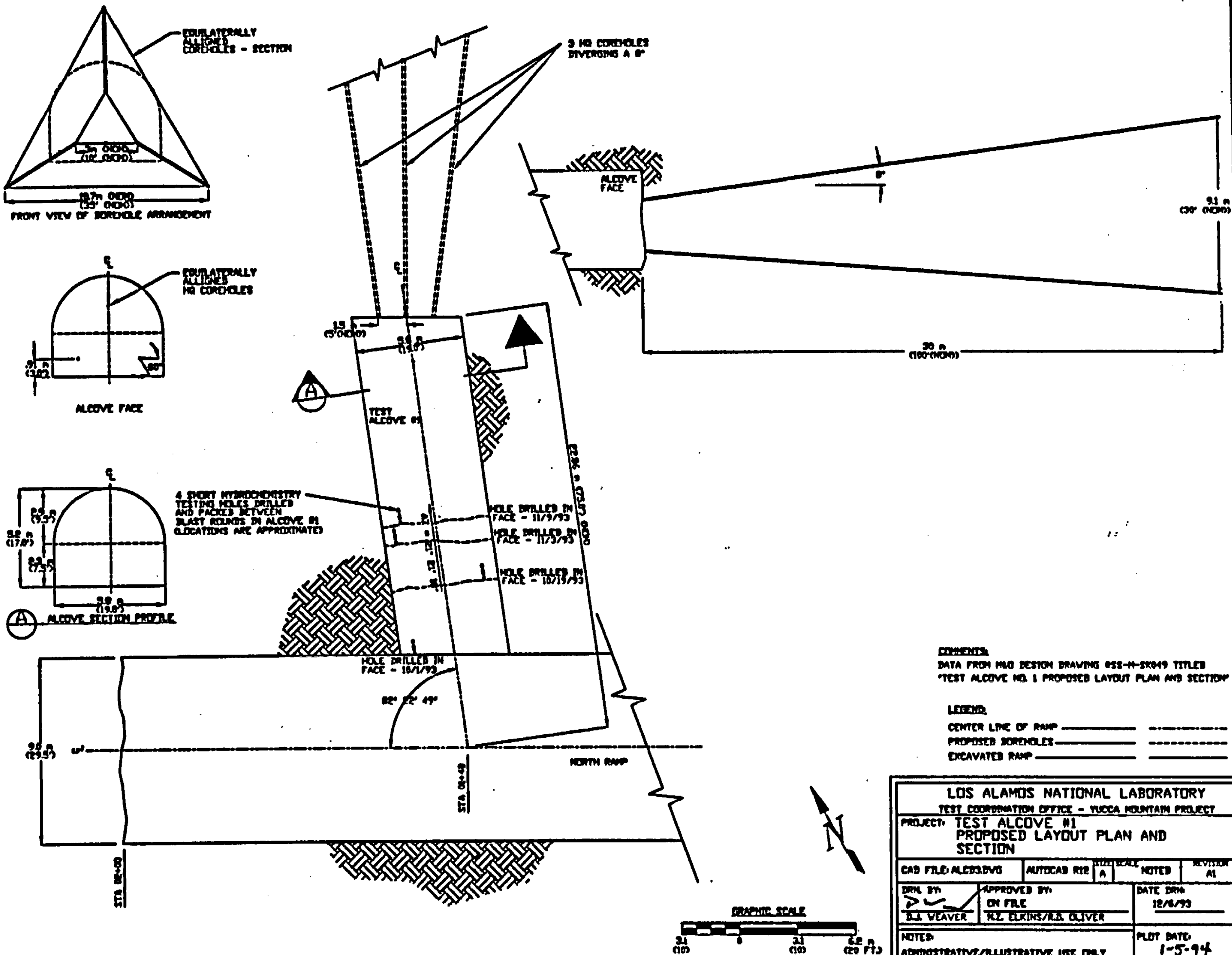
DATA FLOW INFORMATION

All field issues affecting data collection shall be brought to the attention of the Los Alamos Field Test Representative (LANL FTR). The Sample Management Facility will submit all records called for in AP-6.Q or associated procedures, such as sample collection forms and records documenting visual core recording techniques (video, etc.) to the LANL FTR. The Test Coordination Office will submit a close out report under this Job Package (JP).

COST AND SCHEDULE SUMMARY

The costs and progress estimates on this activity are within the scope set by JP 92-20E. No detailed cost schedule is included in this monthly report. Illustrations are provided to show progress and test status.

SCP PROGRAM NAME	SCP STUDY NAME	SCP STUDY PLAN NUMBER	TEST NAME (SCP ACTIVITY)	TPP #	JP #
Geohydrology Program'	Characterization of Y Percolation in the Unsaturated-Zone ESF Investigation	8.3.1.2.2.4	Hydrochemistry Tests in the ESF	TPP 92-12	JP 92-20E


EQUILATERALLY ALLIGNED COREHOLES - SECTION
3m (NOM)
(10' (NOM))
10.7m (NOM)
(35' (NOM))
FRONT VIEW OF BOREHOLE ARRANGEMENT
EQUILATERALLY ALLIGNED HQ COREHOLES
ALCOVE FACE
ALCOVE SECTION PROFILE
3 HQ COREHOLES DIVERGING A 8°
TEST ALCOVE #1
4 SHORT HYDROCHEMISTRY TESTING HOLES DRILLED AND PACKED BETWEEN BLAST ROUNDS IN ALCOVE #1 (LOCATIONS ARE APPROXIMATE)
HOLE DRILLED IN FACE - 11/9/93
HOLE DRILLED IN FACE - 11/3/93
HOLE DRILLED IN FACE - 10/15/93
HOLE DRILLED IN FACE - 10/1/93
ALCOVE FACE
30 m
(100' (NOM))
NORTH RAMP
GRAPHIC SCALE
COMMENTS:
DATA FROM M&O DESIGN DRAWING #SS-M-SK049 TITLED
"TEST ALCOVE NO. 1 PROPOSED LAYOUT PLAN AND SECTION"
LEGEND:
CENTER LINE OF RAMP
PROPOSED BOREHOLES
EXCAVATED RAMP
LOS ALAMOS NATIONAL LABORATORY
TEST COORDINATION OFFICE - YUCCA MOUNTAIN PROJECT
PROJECT: TEST ALCOVE #1
PROPOSED LAYOUT PLAN AND SECTION
CAD FILE: ALC03.DWG
AUTOCAD R12
SIZE A
SCALE NOTED
REVISION A1
DRN. BY: D.J. WEAVER
APPROVED BY: ON FILE
N.Z. ELKINS/R.D. OLIVER
DATE DRN: 12/6/93
NOTES: ADMINISTRATIVE/ILLUSTRATIVE USE ONLY
PLOT DATE: 1-5-94

TWS-EES-1-01-94-003
QA NA WBS 1.2.3.2.1.1.2

Los Alamos
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

February 9, 1994
EES-1, Geology/Geochemistry
MS D462
(505) 667-9504
FAX (505) 665-3285

THIS IS A YMP
MILESTONE
NO. 4046

Steve Saterlie
M&O/TRW Environmental Safety Systems, Inc.
101 Convention Center Drive
Mail Stop 423
Las Vegas, NV 89109

Dear Steve:

I am enclosing our informal Mineralogy-Petrology geochemical evaluation entitled "Preliminary Evaluation of Geochemical Effects of Various Repository Thermal Loads." Please let me know if you need more information.

Sincerely,

Schön Levy

SL/cw

Enc: a/s

Cy: D. Bish, EES-1, MS D469
J. Canepa, EES-13, MS J521
J. Mercer-Smith, EES-13, MS J521
CRM-4, MS A150
TWS File, MS D462
EES-1 File

FEB 11 1994

Preliminary Evaluation of Geochemical Effects of Various Repository Thermal Loads

The evaluations included in this report are very preliminary and should be considered as equivalent to the results of an elicitation session. An attempt has been made to answer questions in spite of insufficient data. Rigorous documentation of statements in the report has been omitted because the time available was insufficient to check existing references.

Geochemical Processes of Concern

This preliminary assessment concentrates on three general geochemical processes. First, mineral dehydration is the loss of internal water from zeolites, clays, and volcanic glass. This process is probably a largely reversible process for these phases although the loss of water over periods of years may be partly irreversible and may cause irreversible structural changes in zeolites and clays (Bish, 1990; Vaniman and others, in press). It is not known that such changes have any effect on the sorptive characteristics of the minerals. The contraction of the crystal structures accompanying dehydration of the affected minerals may cause irreversible changes in bulk hydraulic properties.

The second process is crystallization of volcanic glass to a secondary mineral assemblage. The term "zeolitization" is used in the thermal effects charts as a generic description of the various zeolite-clay-silica mineral assemblages that typify low- and moderate-temperature alteration of rocks containing silicic volcanic glass. In nonwelded tuffs, this process causes a reduction in hydraulic conductivity (Loeven, 1993) due perhaps to secondary-mineral cementation. In welded tuffs, the process is expected to cause a reduction in porosity, but the effects on hydraulic conductivity are more difficult to predict because fracture flow is an important component of overall conductivity.

The third process is recrystallization of clinoptilolite-silica (e.g., opal-CT) mineral assemblages to analcime-quartz assemblages. The reaction also liberates water. Thermal conditions under which this reaction might occur have been estimated from illite-smectite geothermometry of the zeolite-bearing rocks (Bish and Aronson, 1993). Analcime has less sorptive capacity for some radionuclides than clinoptilolite. The reaction involves a volume reduction of about 22% (i.e., the product minerals are denser than the reactant minerals), but it is unclear how these changes would affect the bulk hydrologic properties. A mineralogic volume reduction should result in increased porosity, and the recrystallization would change the distribution and connectivity of pores. These predicted changes cannot be translated into expected changes of hydraulic conductivity. Most analcime-bearing rocks at Yucca Mountain are poor hydraulic-property analogs for alteration of the CHnz because they have experienced compaction and alteration in the saturated zone at depths of 3000 ft. (914 m) or more (Bish and Chipera, 1989).

The following list summarizes the general geochemical concerns for each functional stratigraphic unit:

PTn: glass dehydration (partially reversible), zeolitization (irreversible)
Repository horizon: little or no mineralogic effects
TSw3: glass dehydration (partially reversible), zeolitization (irreversible)
CHnv: glass dehydration (partially reversible), zeolitization (irreversible)
CHnz: zeolite dehydration (partially reversible), zeolite recrystallization (irreversible)

Effects on Retardation

The approach being taken to mineral sorption coefficients at LANL is the highly conservative "minimum K_d" approach. Sorption values for the least sorptive minerals will be utilized in retardation calculations. Under this approach, a change in mineralogy (e.g., zeolitization of volcanic glass) or in mineralogic property (e.g., a change in the oxidation state of iron in a mineral) brought about by repository-induced processes may affect sorptive properties but is not necessarily factored into current retardation calculations. However, rock alteration resulting in mineralogic changes may also be reflected by a change in available mineral surface area, and this change may need to be taken into account in retardation calculations. There may also be changes in hydraulic conductivity as a result of alteration. For example, the zeolitization of volcanic glass can result in a volume increase of as much as 24% (Levy and Valentine, in press). Secondary-mineral sealing of fracture and matrix porosity as a result of the volume increase is tentatively identified as an enhancement of retardation. However, other changes during alteration, such as dissolution and new fracturing, could counteract the effects of mineral sealing; therefore, the overall effect on retardation is uncertain. LANL is in the process of collecting mineral-specific data; the present assessment emphasizes changes in surface area and hydraulic conductivity in evaluating possible repository thermal effects.

Effects of Mineral Dehydration on the Heat Budget

There are no zeolites or other hydrous minerals in the repository horizon (343 m) itself, beyond trace quantities (<1%). Therefore, no effects on heat or liquid saturation calculations from mineral dehydration at the repository horizon are expected. The hydrous phases closest to the repository are the clays, zeolites, and glass below the repository in the devitrified-vitric transition zone (TSw2-TSw3 boundary). This zone does not have a fixed thickness or constant hydrous mineral content, but overall, glass is the most abundant and predictable constituent. Glass contains about 4 weight percent water in non-natural state core samples. LANL has experimental data for glass (powdered Topopah Spring vitrophyre) dehydration rates at various temperatures, but all at room relative humidity. Under these conditions, at least some dehydration occurs within a few years even at temperature below 100°C (Vaniman et al., in press). Uncertainties associated with the *in situ* dehydration process include the effects of pore water (and water vapor saturation as opposed to "liquid saturation") and the lengthier diffusion pathways that the expelled water must take. The water held in glass probably is at least twice the content of pore water in the vitrophyre; therefore, whatever the contribution of the vitrophyre might be in mediating temperature increase just below the repository, factoring in glass dehydration could increase that contribution several-fold. It might be helpful to produce plots of temperature and saturation profiles for times less than 120 years (peak temperature for 110 MTU/ac case).

Glass and zeolite-bearing moderately welded and nonwelded tuffs further down (CHnv and CHnz) may have more of an effect on temperatures below the repository after 120 years. During the first 120 years or more (up to 454 perhaps, based on the 110 MTU/ac model output), the liquid saturation in this interval increases, making it less likely that dehydration of hydrous minerals would occur (the issue of phase changes will be treated separately). But, some time between 120 and 454 years, the liquid saturation falls to or below the original ambient saturation and stays below for >1000 years. Under these conditions, mineral dehydration is likely, but the effect on the repository heat budget requires further calculations to estimate. It is likely that the enthalpy of dehydration of zeolites in this interval will make a significant contribution to the heat budget.

Mineral dehydration may be a negligible concern for temperature moderation in the 24 MTU/ac case because the model results (not included) show little or no change in liquid saturation (relatively high in most of the geologic section) from ambient conditions and peak temperatures well below boiling. Under these conditions, simple dehydration of existing hydrous minerals may be minimal.

Major Uncertainties

The following are only a few examples of either uncertainties or information needs:

1. data on energetics and kinetics of zeolite dehydration and transformation (recrystallization).
2. effects of existing lateral stratigraphic variation, in particular the differences between sections where CHnv is thick (west) and thin (east).
3. mineralogic alteration will probably increase the heterogeneity of all rock properties.

References

Bish, D., "Long-term thermal stability of clinoptilolite: The development of a "B" phase," Eur. J. Mineral., v. 2, 771-777 (1990).

Bish, D., and J. Aronson, "Paleogeothermal and Paleohydrologic Conditions in Silicic Tuff from Yucca Mountain, Nevada," Clays and Clay Minerals, v. 41, 148-161 (1993).

Bish D., and S. Chipera, "Revised Mineralogic Summary of Yucca Mountain, Nevada," Los Alamos National Laboratory Report LA-11497-MS (March 1989).

Levy, S., and G. Valentine, "Natural Alteration in the Cooling Topopah Spring Tuff, Yucca Mountain, Nevada, as an Analog to a Waste-Repository Hydrothermal Regime," Focus '93 (in press).

Loeven, C., "A Summary and Discussion of Hydrologic Data from the Calico Hills Nonwelded Hydrologic Unit at Yucca Mountain, Nevada," Los Alamos National Laboratory Report LA-12376-MS, 102 pp. (1993).

Vaniman, D., D. Bish, and S. Chipera, "Dehydration and Rehydration of a Tuff Vitrophyre," J. Geophys. Res. (in press).

110 MTU/ac

FUNCTIONAL UNIT	PRIMARY CONCERNS	PRIMARY REPOSITORY EFFECTS	MINERALOGIC PROCESSES: EFFECT ON RETARDATION		
			DEHYDRATION	ZEOLITIZATION	OTHER
PTn	HYDROLOGIC BARRIER	T_{max} ~95°C INCREASED SATURATION	POSSIBLE IN UPPER PART: NO EFFECT	PROBABLE: EFFECT UNCERTAIN	INCREASED CHANNELING OF RECHARGE WATER
Repository Horizon	–	T_{max} ~190°C ROCK DEHYDRATION	–	–	–
TSw3	RETARDATION	T_{max} ~160 (central) ~100 (boundary) DEHYDRATION PREDOMINATES	PROBABLE: EFFECT UNKNOWN	POSSIBLE IN FIRST 100 YR, CONCENTRATED NEAR BOUND. & FLOW PATHS: POSSIBLE ENHANCEMENT OF RETARDATION	–
CHn v	"	T_{max} ~145 (central) ~100 (boundary) EARLY FULL SAT. DEHYD. BELOW CENTER, INCREASED SAT. BELOW BOUND.	PROBABLE: IRREVERSIBLE CHANGES IN HYDROLOGIC PROPERTIES	"	–
Z	"	MOST OF SECTION >100° FOR >500 YR. EARLY FULL SAT. DEHYD. BELOW CENTER, INCR. SAT. BELOW BOUNDARIES	"	–	POSSIBLE CLINOPTILOLITE + OPAL-CT → ANALCIME + QUARTZ: EFFECTS UNCERTAIN.

83 MTU/ac

FUNCTIONAL UNIT	PRIMARY CONCERNS	PRIMARY REPOSITORY EFFECTS	MINERALOGIC PROCESSES: EFFECT ON RETARDATION		
			DEHYDRATION	ZEOLITIZATION	OTHER
PTn	HYDROLOGIC BARRIER	T_{max} ~30-60°C LITTLE OR NO CHANGE IN AMBIENT SATURATION	POSSIBLE: NO EFFECT ON RETARDATION	NOT EXPECTED	-
Repository Horizon	-	T_{max} ~147 DEHYDRATION PREDOMINATES	-	-	-
TSw3	RETARDATION	T_{max} ~110-125 (central) ~60-90 (boundary) EARLY NEAR-SATURATION	PROBABLE, AFTER EARLY TIME; EFFECTS UNKNOWN	PROBABLE: CHANGES IN FRACTURE POROSITY & SURFACE AREA. EFFECTS ON RETARDATION UNKNOWN	-
CHn v	"	T_{max} ~110 (central) ~80 (bound.) EARLY NEAR-SATURATION	PROBABLE REVERSIBLE DEHYD.: NO LONG-TERM EFFECTS	PROBABLE: POSSIBLE ENHANCED RETARDATION	-
Z	"	T_{max} ~80-110 (cent.) ~60-75 (bound.) PARTIAL DEHYD. BELOW CENTRAL REP.; LITTLE CHANGE AT BOUNDARIES	LITTLE OR NO DEHYDRATION?: EFFECTS PROBABLY MINIMAL	-	-

65 MTU/ac

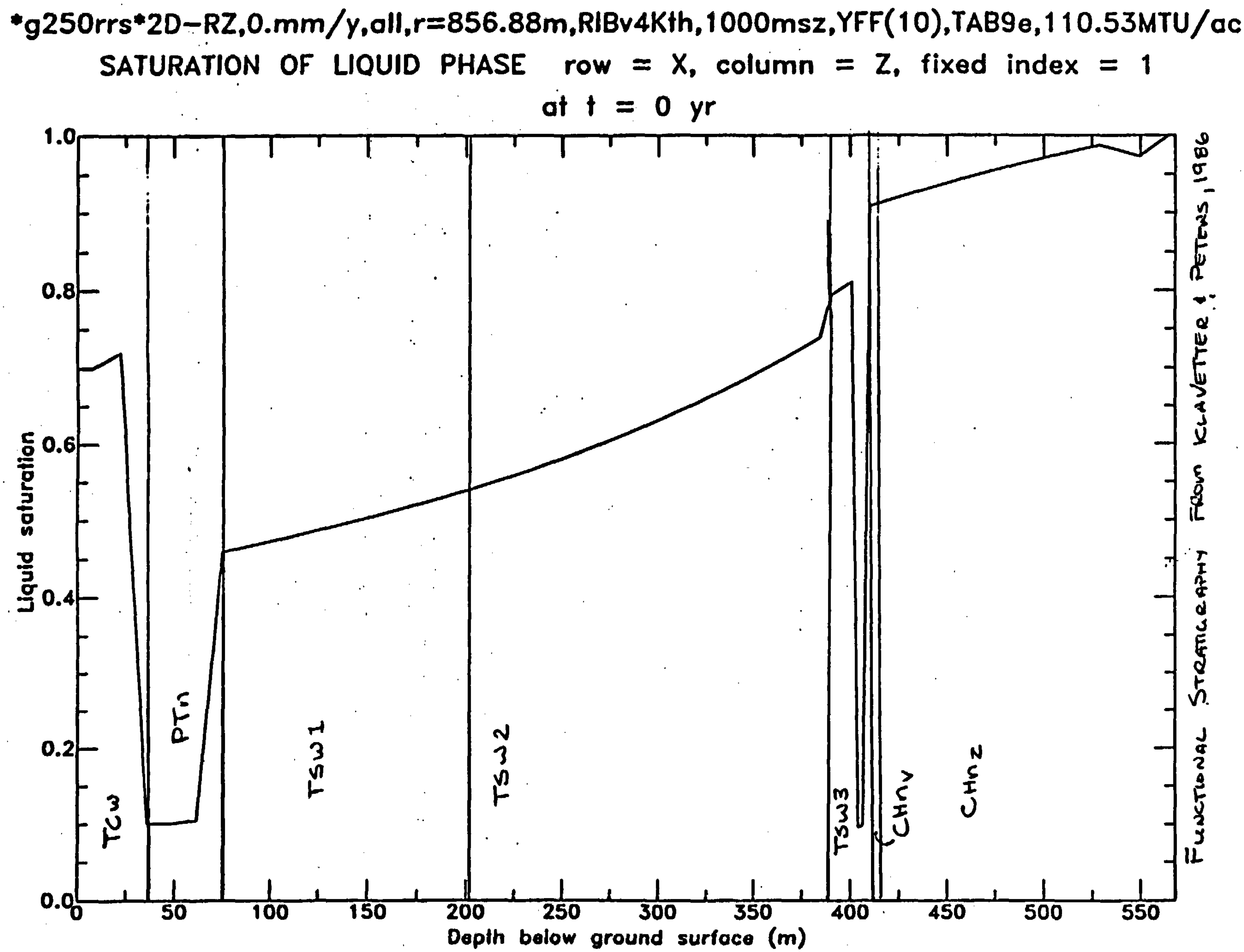
FUNCTIONAL UNIT	PRIMARY CONCERNS	PRIMARY REPOSITORY EFFECTS	MINERALOGIC PROCESSES: EFFECT ON RETARDATION		
			DEHYDRATION	ZEOLITIZATION	OTHER
PTn	HYDROLOGIC BARRIER	T_{max} ~18-45°C (central) NO SATURATION CHANGE	NOT EXPECTED	MINOR, LOCAL: NO EFFECT	–
Repository Horizon	–	T_{max} ~ 108 DEHYDRATION PREDOMINATES	–	–	–
TSw 3	RETARDATION	T_{max} ~68-100 (cent.) ~65-90 (bound.) EARLY FULL SAT. IN CENTRAL PART, RETURN TO AMBIENT	NOT EXPECTED	POSSIBLE: MINOR	–
CHn v	"	T_{max} ~65-68 EARLY SLIGHT INCREASE FROM AMBIENT SAT. (HIGH)	NOT EXPECTED	POSSIBLE: POSSIBLE ENHANCED RETARDATION	–
Z	"	T_{max} ~ 55-68 (cent.) ~55-65 (bound.) EARLY SL. INCREASE FROM AMBIENT (HIGH)	NOT EXPECTED	–	–

36 MTU/ac

FUNCTIONAL UNIT	PRIMARY CONCERNS	PRIMARY REPOSITORY EFFECTS	MINERALOGIC PROCESSES: EFFECT ON RETARDATION		
			DEHYDRATION	ZEOLITIZATION	OTHER
PTn	HYDROLOGIC BARRIER	T_{max} ~17-35°C (central) ~15-25 (boundary) NO SATURATION CHANGE	NOT EXPECTED	NOT EXPECTED	–
Repository Horizon	–	T_{max} ~70-85 NEGLIGIBLE CHANGE IN AMBIENT SAT.	–	–	–
TSw3	RETARDATION	T_{max} ~63-65 (cent.) ~47 (bound.) NEGLIGIBLE CHANGE IN AMBIENT SAT.	POSSIBLE: MINOR	POSSIBLE: MINOR	–
CHn v	"	T_{max} ~63 (cent.) ~47 (bound.) NEGLIGIBLE CHANGE IN AMBIENT SAT.	NOT EXPECTED	POSSIBLE: POSSIBLE ENHANCED RETARDATION	–
Z	"	T_{max} ~52-63 (cent.) ~47 (bound.) NEGLIGIBLE CHANGE IN AMBIENT SAT.	NOT EXPECTED	–	–

24 MTU/ac

FUNCTIONAL UNIT	PRIMARY CONCERNS	PRIMARY REPOSITORY EFFECTS	MINERALOGIC PROCESSES: EFFECT ON RETARDATION		
			DEHYDRATION	ZEOLITIZATION	OTHER
PTn	HYDROLOGIC BARRIER	$T_{max} \sim 30°C$ NO SATURATION CHANGE	NOT EXPECTED	NOT EXPECTED	–
Repository Horizon	–	$T_{max} \sim 66$ NO SATURATION CHANGE	–	–	–
TSw 3	RETARDATION	$T_{max} \sim 60$ NO SATURATION CHANGE	NOT EXPECTED	POSSIBLE: SLIGHT RETARDATION INCREASE?	
CHn v	"	NO SATURATION CHANGE	NOT EXPECTED	–	–
Z	"	NO SATURATION CHANGE	NOT EXPECTED	–	–



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M. B. Blanchard, DOE/YMP, Las Vegas, NV

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NATIONAL LABORATORY
Los Alamos, New Mexico 87545