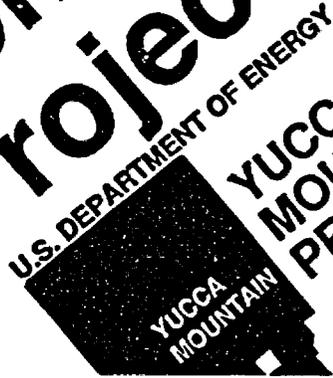


**MONTHLY HIGHLIGHTS AND STATUS REPORT**

# Yucca Mountain Site Characterization Project



**Sandia National Laboratories**

May 1993

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Sandia National Laboratories

YUCCA MOUNTAIN

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

# Monthly Status Report

May 1993

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## May Highlights

SNL staff attended the annual contract-review SCRF workshop at Stanford University on May 3 and 4.

See **1.2.3.2.2.2.2 Three-Dimensional Rock Characteristics Models** on page 4.

SNL staff prepared a structural and lithologic log for borehole NRG-2 and a section map of the North Ramp Bow Ridge Fault Area.

See **1.2.3.2.6.2.1 Surface Facilities Exploration Program** on page 6.

SNL staff completed unconfined experiments on 22 samples of core from varying depths of NRG-6.

See **1.2.3.2.6.2.2 Surface Facilities Laboratory Tests and Material Property Measurements** on page 7 and **1.2.3.2.7.1.3 Laboratory Determination of Mechanical Properties of Intact Rock** on page 11.

SNL staff submitted a data report to the Project Office, meeting Milestone OS46.

See **1.2.3.2.7.1.3 Laboratory Determination of Mechanical Properties of Intact Rock** on page 11.

## May Highlights, Continued

SNL staff met Milestone OS50 by submitting a plan to consolidate PNL global climate modeling efforts.

See **1.2.3.6.2.1.6 Future Regional Climate and Environments** on page 13.

SNL staff completed three-dimensional thermal/structural analyses to assess the impact of the potential repository thermal loading on ESF drifts.

See **1.2.4.1.1 Repository Coordination and Planning** on page 14.

SNL staff continued to analyze seismic blast monitoring and rock quality determination at the ESF north ramp starter tunnel.

See **1.2.4.2.1.1.4 In Situ Design Verification** on page 16.

SNL staff continued to compare the surface characteristics of natural fractures to frictional data gathered from surface replicas.

See **1.2.4.2.1.2 Rock Mass Analyses** on page 17.

SNL staff continued work on developing a methodology to produce epoxy casts of natural fractures and techniques to explore the effects of air entrapment on fracture permeability and tracer migration. A joint SNL-USGS program to investigate unsaturated flow behavior has been initiated.

See **1.2.5.4.6 Development and Validation of Flow and Transport Models** on page 26.

SNL staff began fielding additional monitoring activities in the north ramp starter tunnel.

See **1.2.6.1.1 Exploratory Studies Facility Coordination, Planning, and Technical Assessment** on page 31.

SNL staff is rewriting QAIPs to comply with the revised QARD. SNL QA staff also completed a "supplier qualification evaluation" for calibration services.

See **1.2.11 Quality Assurance** on page 33.

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**DISCLAIMER**

Quality assurance checks on data contained in this report have been performed only to determine that the data have been obtained and documented properly. The SNL Project Department cautions that any information is preliminary and subject to change as further analyses are performed or as an enlarged and perhaps more representative data base is accumulated. These data and interpretations should be used accordingly. Milestones have not been baselined and are included only to show status.

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## YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT EXECUTIVE SUMMARY

### WBS 1.2.3.2.2.2.2 Three-Dimensional Rock Characteristics Models

- SNL staff attended the annual contract-review Stanford Center Reservoir Forecasting (SCRF) workshop at Stanford University on May 3 and 4. Recent developments in geostatistics and their applications were presented by Stanford graduate students and by industrial affiliates. Although the scope of research at SCRF is quite broad and many of the results are somewhat preliminary, there are some very direct applications to the YMP. The reproduction of multiple-point connectivity statistics in simulated models has particular application at Yucca Mountain, because the closest anticipated drillhole spacings (conditioning data) are probably close to or slightly greater than the expected range of correlation (based upon surface transect sampling). The sparse nature of conditioning data relative to the correlation length can produce stochastic lithologies in conceptually and physically anomalous positions. Use of higher-order statistics should alleviate this problem.

### WBS 1.2.3.2.6.2.1 Surface Facilities Exploration Program

- A structural and lithologic log was prepared for borehole NRG-2. A section map of the North Ramp Bow Ridge Fault area was prepared to incorporate the most recent information from boreholes NRG-2 and NRG-2A.

### WBS 1.2.3.2.6.2.2 Surface Facilities Laboratory Tests and Material Property Measurements

- Mechanical properties experiments (WBS 1.2.3.2.7.1.3) data for core from NRG-6 at varying depths were collected and submitted to the YMP Central Records Facility.

### WBS 1.2.3.2.7.1.3 Laboratory Determination of Mechanical Properties of Intact Rock

- SAND92-1810, "Unconfined Compression Experiments on Topopah Spring Member Tuff at 22°C and a Strain Rate of 10<sup>-6</sup> s<sup>-1</sup>: Data Report," was sent to the Project Office on May 13, 1993 (Milestone 0S46).
- The first series of unconfined experiments were completed on 22 samples (collected at varying depths) of core from NRG-6. These data have been transmitted to the Exploratory Studies Facility (ESF) design team.

### WBS 1.2.3.6.2.1.6 Future Regional Climate and Environments

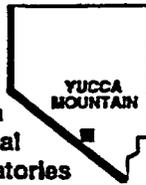
- The transition plan for consolidating Pacific Northwest Laboratory (PNL) efforts on global climate modeling into a single SNL effort was transmitted to the Project Office for review (Milestone 0S50).

### WBS 1.2.4.1.1 Repository Coordination and Planning

- Work continued on a series of analyses in support of the design of the ESF north ramp. Three-dimensional thermal/structural analyses of the repository to assess the impact of the potential repository thermal loading on the ESF drifts have been completed. Results of these analyses will support two-dimensional analyses of several cross sections of the ESF north ramp to evaluate long-term stability. Geotechnical data from the NRG holes will be incorporated into the analyses. The analyses are expected to provide input for the 90% design review.



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## YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT EXECUTIVE SUMMARY Continued

### WBS 1.2.4.2.1.1.4 In Situ Design Verification

- At the ESF north ramp starter tunnel, staff continued analyses on seismic blast monitoring, rock quality determination, and convergence monitoring.

### WBS 1.2.4.2.1.2 Rock Mass Analyses

- A study comparing the surface characteristics of natural fractures to the frictional data gathered on replicas of the surfaces is continuing. This study will place special emphasis on determining whether the fitting parameters on the Barton model for frictional behavior have physical significance.

### WBS 1.2.5.4.6 Development and Validation of Flow and Transport Models

- Development of a methodology to produce epoxy casts of natural fractures continued. Most work was concentrated on control of the boundary conditions. A test fracture prepared in April using external manifolds to control inflow and boundary conditions was subjected to preliminary tests.
- Development of experimental techniques to explore the effects of air entrapment on fracture permeability and tracer migration continued. Hardware to allow acquisition of both high- and low-resolution images of the test fracture at controlled intervals during the experiment was acquired and installed during May.
- A joint laboratory program with staff at USGS has been initiated for investigating unsaturated flow behavior in fractured volcanic tuff.

### WBS 1.2.5.4.1 Total System Performance Assessment

- SNL staff coordinated and hosted a meeting with other participants to discuss the best approach for representing infiltration and water flow at Yucca Mountain resulting from both current and future climatic conditions. The results from the discussion will be used as the basis for the percolation flux used in the second cycle of the Total System Performance Assessment (TSPA-2).

### WBS 1.2.6.1.1 ESF Coordination, Planning, and Technical Assessment

- SNL staff began fielding additional monitoring activities in the north ramp starter tunnel to address safety concerns. Convergence monitoring of the tunnel was conducted and rock bolt load cells for evaluating ground support were installed.

### WBS 1.2.11 Quality Assurance

- QA staff continued revising Quality Assurance Implementing Procedures (QAIPs) to update the criteria in keeping with the revised Quality Assurance Requirements Document.
- SNL YMP QA staff completed a "supplier qualification evaluation" of the portion of the SNL Secondary Standards Laboratories that provides calibration services for electrical/electronics, temperature, pressure, load cell, and acceleration measuring and test equipment. The facilities and personnel were found to be capable of providing such services, so are considered "qualified."



## 1.2.1 SYSTEMS ENGINEERING

The objective of the Systems Engineering element is to apply the systems engineering discipline to transform the regulatory requirements into functional needs to the MGDS design, system configuration, and site characterization activities. The Systems Engineering element is comprised of four tasks: Systems Engineering Coordination and Planning (1.2.1.1), Program-Level Requirements Document Development (1.2.1.2.1), Project-Level Requirements Documents Development and Maintenance (1.2.1.2.2), and Special Studies (1.2.1.5), which includes development of items important to safety/waste isolation.

### **1.2.1.1 SYSTEMS ENGINEERING COORDINATION AND PLANNING**

#### **1.2.1.2.1 PROGRAM-LEVEL REQUIREMENTS DOCUMENT DEVELOPMENT**

#### **1.2.1.2.2 PROJECT-LEVEL REQUIREMENTS DOCUMENTS DEVELOPMENT AND MAINTENANCE**

#### Status Report on Ongoing Activities

Several Project requirements documents, including the Exploratory Studies Facility Design Requirements Document (ESFDRD), the Surface-Based Test Facility Requirements Document (SBTFRD), and the Engineered Barrier Design Requirements Document (EBDRD), were received for another round of comment review. Because of the lack of funding in WBS element 1.2.1.2.2, this work is charged to WBS element 1.2.9.1.2.

### **1.2.1.5 SPECIAL STUDIES**

#### Major Accomplishments

SAND92-2334, "Preclosure Radiological Safety Evaluation: Exploratory Studies Facility," by F. J. Schelling and J. D. Smith, received Project approval for publication.

#### Status Report on Ongoing Activities

Staff continued to participate on several teams of the Site Characterization Plan (SCP) Thermal Goals Working Group and provided draft input for the Thermal-Mechanical Team and the Operations, Safety, and Environment Team on May 25. Because of the lack of funding in WBS element 1.2.1.5, this work is charged to WBS element 1.2.5.4.3.

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## 1.2.2 WASTE PACKAGE

The objective of the Waste Package element includes support to the Container/Waste Package Interface Analysis element (1.2.2.4.3) in the conduct of thermal and structural analysis of the near-field environment that will support evaluations of emplacement orientation, the effects of backfill properties and timing, as well as other thermal loading issues related to waste package design.

### ***1.2.2.4.3 CONTAINER/WASTE PACKAGE INTERFACE ANALYSIS***

No significant activity this reporting period.



## 1.2.3 SITE INVESTIGATIONS

The objective of the Site Investigations element includes work scope related to site data collection and analysis to support site suitability evaluation, design, licensing, performance assessment requirements, and the natural barrier system component of the multiple barrier system described in the physical system. The Site Investigations element is comprised of twelve tasks: Site Investigations Coordination and Planning (1.2.3.1), Systematic Acquisition of Site-Specific Subsurface Information (1.2.3.2.2.1), Three-Dimensional Rock Characteristics Models (1.2.3.2.2.2), Surface Facilities Exploration Program (1.2.3.2.6.2.1), Surface Facilities Laboratory Tests and Material Property Measurements (1.2.3.2.6.2.2), Surface Facilities Field Tests and Characterization Measurements (1.2.3.2.6.2.3), Laboratory Thermal Properties (1.2.3.2.7.1.1), Laboratory Thermal Expansion Testing (1.2.3.2.7.1.2), Laboratory Determination of Mechanical Properties of Intact Rock (1.2.3.2.7.1.3), Laboratory Determination of the Mechanical Properties of Fractures (1.2.3.2.7.1.4), Ground Motion From Regional Earthquakes and Underground Nuclear Explosions (1.2.3.2.8.3.3), and the Future Regional Climate and Environments (1.2.3.6.2.1.6).

### 1.2.3.1 SITE INVESTIGATIONS COORDINATION AND PLANNING

#### Status Report on Ongoing Activities

SNL staff were unable to attend the May 5 Sample Overview Committee (SOC) meeting because of illness and schedule conflicts for alternate representatives. The next SOC meeting is scheduled for June 2.

The FY94 Draft Site Characterization Annual Plan was reviewed in detail. Activity descriptions were updated, priorities were renewed, and FY94 deliverables were updated. Meetings were held with Project Office personnel to discuss proposed changes.

### 1.2.3.2.2.1 SYSTEMATIC ACQUISITION OF SITE-SPECIFIC SUBSURFACE INFORMATION

#### Status Report on Ongoing Activities

The paper entitled "Spatial Variability of Hydrologic Properties in Volcanic Tuff," intended for publication in the journal *Groundwater*, has entered U.S. Geological Survey (USGS) and Sandia National Laboratories (SNL) review. The paper, an expansion of work originally presented at the International High-Level Radioactive Waste Management Conference in April, includes a test of the hypotheses developed by the original work. (SCP Activities 8.3.1.4.3.1.1 and 8.3.1.2.2.3.1)

The FY94 budget process began during May. SNL staff spent a significant amount of time rewriting prior-year descriptions of expected FY94 work to reflect the accelerated drilling program resulting from the combination of hole SD-11 with SRG-5. An increased focus on identifying interactivity and interparticipant links required extra time, but will result in a more closely integrated program. (SCP Activity 8.3.1.4.3.1.1)

SNL staff normally assigned to this activity continued to provide geologic support for WBS element 1.2.3.2.6.2 (SCP Activity 8.3.1.14.2.1). Geologic logging of core is the principal focus of this support. The logging, which is being done under the scientific notebook procedure in use for the Soil and Rock Properties Study, has provided an opportunity to refine the technical procedure

that will guide work on the Systematic Drilling Program. Comparison of log results with the equivalent rock units now exposed in the portal excavations for the north ramp suggest some interesting interpretations of the "poor core recovery" observed in hole NRG-1 and elsewhere. This "poor" core recovery may actually result from the presence of large (> 1 ft) lithophysal cavities prominently displayed in the new excavations. The implications of this observation and the nonconventional interpretations will be explored as additional data are gathered. (SCP Activity 8.3.1.4.3.1.1)

The draft data reports, tentatively entitled "Physical and Hydrologic Properties of Outcrop Samples from a Nonwelded to Welded Tuff Transition, Yucca Mountain, Nevada" and "Physical and Hydrologic Properties of Surface Outcrop Samples at Yucca Mountain, Nevada," that contain the laboratory results of the outcrop sampling studies conducted at Yucca Mountain over the past several years under this activity, remain largely in deferred status pending completion of 105°C oven-drying and measurement of hard-dried material properties. Coauthor comments were incorporated into the text. (SCP Activities 8.3.1.4.3.1.1 and 8.3.1.2.2.3.1)

#### Major Activities Upcoming Next Three Months

Drafts of reports in preparation will be finalized and reviewed as appropriate. Beyond this wind-down of existing scoping activities, principal emphasis will be placed on completing all procedures and other prerequisites for initiating the Systematic Drilling Program with hole SD-11/SRG-5 in July. SNL staff are preparing input in anticipation of a mid-June workscope consolidation meeting for a second SD hole, presumably SD-12, to be located near the main test level drifts of the ESF between the north and south ramps. (SCP Activity 8.3.1.4.3.1.1)

Budget preparation for FY94 will continue. (SCP Activity 8.3.1.4.3.1.1)

Geologic support will continue to be provided to the Soil and Rock Properties Study (SCP Activity 8.3.1.14.2.1) through logging core from the north ramp boreholes. Technical procedures to support the Systematic Drilling Program will be finalized as quickly as possible. (SCP Activity 8.3.1.4.3.1.1)

#### **1.2.3.2.2.2.2 THREE-DIMENSIONAL ROCK CHARACTERISTICS MODELS**

##### Major Accomplishments

Report 6, summarizing the results of research conducted during 1992, has been received from the Stanford Center for Reservoir Forecasting (SCRF). This is the major annual deliverable for the SCRF contract. (SCP Activity 8.3.1.4.3.2.1)

##### Significant Meetings Attended

SNL staff attended the annual contract-review SCRF workshop at Stanford University on May 3 and 4. Recent developments in geostatistics and its applications were presented by Stanford graduate students and by industrial affiliates. (SNL is an industrial affiliate.) Several papers of significance addressed (1) major work on the joint simulation of multiple spatially correlated variables using a Markov-Bayes (M-B)-type model of coregionalization; (2) revisions to the sequential simulation algorithm to enhance reproduction of spatial continuity patterns; (3) a merging of fractal techniques with classic geostatistical methods; (4) an expansion of earlier work on simulating multiple-point statistics (most geostatistical methods are based on two-point continuity measures); and (5) efforts to speed simulation of very large models through probability-field techniques.

Although the scope of research at SCRF is quite broad and many of the results are somewhat preliminary, there are some very direct applications to the Yucca Mountain Site Characterization Project (YMP). The M-B approach to multiple variables is probably the most significant, because groundwater flow is inherently a multivariate problem. The material property fields used as input to flow computations must reflect properly the *joint* variability and continuity patterns. Simulating these fields separately in all likelihood distorts the cross-variable correlation patterns extant in nature, and these M-B techniques may permit more reasonable simulations without the complexity and numerical problems added by a full coregionalization model. The technique has been applied to reservoir characterization of porosity and permeability in the North Sea with apparent success. The reproduction of multiple-point connectivity statistics in simulated

models also has particular application at Yucca Mountain, because the closest anticipated drillhole spacings (conditioning data) are probably close to or slightly greater than the expected range of correlation (based upon surface transect sampling). The sparse nature of conditioning data relative to the correlation length can produce stochastic lithologies in conceptually and physically anomalous positions. Use of higher-order statistics should alleviate this problem.

The SCRF report will be evaluated for relevance to the YMP, and aspects will be incorporated into YMP modeling work as appropriate. Although most, if not all, of this work will eventually find its way into the open literature, SCRF affiliates receive the information, algorithms, and software two to three years prior to regular publication. (SCP Activity 8.3.1.4.3.2.1)

SNL staff also met with representatives of Dynamic Graphics, Inc., in Alameda, CA. The Project has been exploring converting the three-dimensional modeling work being conducted by both the USGS (geometric) and SNL (material properties) to the Dynamic Graphics system from the Lynx GMS system currently in use by both technical participants. Although the new Dynamic Graphics system is much improved over previous releases of similar software for modeling complex geometries, the package still appears less suited to the unique, data-sparse/interpretation-heavy needs of the YMP. Also, the material-properties modeling capabilities of the Dynamic Graphics package are not yet implemented. One of the major attractions of the Lynx software package was the close integration of geometric modeling (rock units, faults) with the geostatistical routines necessary for variogram analysis and driving. Lynx also features ongoing efforts to incorporate simulation algorithms in a parallel manner. Staff will continue to monitor development of both systems, and to encourage Lynx Geosystems to improve their display and post-modeling manipulation capabilities, a feature at which Dynamic Graphics excels. (SCP Activity 8.3.1.4.3.1.1)

#### Status Report on Ongoing Activities

Preparation of the study plan for the Three-Dimensional Rock Characteristics Models Study continues, using the revised U.S. Department of Energy/Nuclear Regulatory Commission

(DOE/NRC) level-of-detail agreement for study plans. Because the Three-Dimensional Rock Characteristics Models Study will create custom models upon demand to support performance assessment and design evaluation activities, the study plan will be a listing and brief description of a number of tools that can be used as needed to create the physical property distributions needed for a particular calculation. (SCP Activity 8.3.1.4.3.2.1)

Preparation of the FY94 Planning and Control System (PACS) budget began during May. Software development and modeling activities will be much more focused and more closely tied to the using groups and activities. In general, emphasis will be placed on meeting specific ESF-related assessments, while not neglecting the longer-term development of integrated modeling techniques required for license application evaluations. (SCP Activity 8.3.1.4.3.2.1)

#### Major Activities Upcoming Next Three Months

Work will commence on modifying the simulation codes to accommodate the soft information provided by the microstratigraphic units known at Yucca Mountain. SNL and USGS staff will discuss the required interfaces to the geometric model being developed by the USGS. The initial Lynx model of the Topopah Spring Member of the Paintbrush Tuff, including its internal microstratigraphic zonation, is scheduled to be completed by the USGS. A description of the theory and proposed work is being prepared to clarify the extent of the effort. (SCP Activity 8.3.1.4.3.2.1)

Additional support staff, including several personnel with significant geostatistical training, will join the study next month for portions of the summer. They will develop an underlying design for integrated software that combines the currently separate GSLIB subroutines to automate creation and evaluation of large simulations. This work is a collaborative development effort with other user groups at SNL, including YMP, the Fernald (Ohio) Integrated Demonstrations Project, and Environmental Restoration groups. (SCP Activity 8.3.1.4.3.2.1)

SNL staff will contribute text sections to the 1993 Total System Performance Assessment (TSPA) summary document describing the

construction of the repository-scale three-dimensional indicator simulations of lithology. Preliminary drafts are being revised to incorporate preliminary comments. The relative role of these text sections in the overall TSPA report will be resolved as the TSPA exercise proceeds and a final outline is prepared. (SCP Activity 8.3.1.4.3.2.1)

#### **1.2.3.2.6.2.1 SURFACE FACILITIES EXPLORATION PROGRAM**

##### Major Accomplishments

A structural and lithologic log was prepared for borehole NRG-2. A section map of the North Ramp Bow Ridge Fault area was prepared to incorporate the most recent information from boreholes NRG-2 and NRG-2A.

##### Significant Meetings Attended

The SNL Soil and Rock Properties principal investigator and staff met with the ESF Design Team, Sample Management Facility (SMF) staff geologists, and the DOE staff at the SMF on May 20 to review the core from NRG-2A and to discuss further drilling along the north ramp alignment in the vicinity of the Bow Ridge Fault. The following conclusions were developed:

1. NRG-2A will be deepened to provide a lithologic contact of high confidence.
2. NRG-2 will be deepened to ensure complete penetration of the Bow Ridge Fault and to provide a lithologic contact of high confidence to the east of the fault.
3. Another borehole, NRG-2B, will be drilled to provide additional information for a zone of no core recovery in the Rainier Mesa in NRG-2. This hole will be drilled and cored through the Rainier Mesa into the underlying Tiva Canyon caprock. The hole will not cross the Bow Ridge Fault.

An overview of the soil and rock properties study and the section map of the North Ramp Bow Ridge Fault area was presented to members of the NRC during the site visit on May 25.

##### Status Report on Ongoing Activities

Borehole NRG-5 is being deepened to approximately 1300 ft. Structural and lithologic logs have been prepared for boreholes NRG-1, RF-8, and NRG-6. Technical review of the logs is in progress, and the logs will be issued in mid-June. Structural and lithologic logs are being prepared for boreholes NRG-3, NRG-2A, and NRG-5.

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**Major Activities Upcoming Next Three Months**

Boreholes NRG-4, NRG-2B, and SRG-5 will be drilled, and structural and lithologic logs will be prepared.

**1.2.3.2.6.2.2 SURFACE FACILITIES  
LABORATORY TESTS AND  
MATERIAL PROPERTY  
MEASUREMENTS**

**Major Accomplishments**

Mechanical properties data (ultrasonic velocities, static elastic properties, and unconfined strength) for core from NRG-6 from depths of 22.2 ft to 328.7 ft were submitted to the YMP Central Records Facility (CRF).

**Status Report on Ongoing Activities**

Mechanical properties testing is underway on core samples from NRG-6 and NRG-2. Thermal properties testing is underway on core samples from NRG-6.

**Major Activities Upcoming Next Three Months**

Core samples from NRG-3, NRG-2A, NRG-4, NRG-2B, and NRG-5 will be submitted for mechanical properties testing.

### **1.2.3.2.6.2.3 SURFACE FACILITIES FIELD TESTS AND CHARACTERIZATION MEASUREMENTS**

#### **Major Accomplishments**

Procedures for Schmidt-Hammer tests of core from the north and south ramp boreholes were prepared. Equipment to perform these tests was procured.

#### **Status Report on Ongoing Activities**

Planning for soil resistivity tests on the north portal pad are underway. Equipment to perform the tests has been procured and calibrated.

#### **Major Activities Upcoming Next Three Months**

Soil resistivity tests will be performed at the north portal pad.

### **1.2.3.2.7.1.1 LABORATORY THERMAL PROPERTIES**

#### **Status Report on Ongoing Activities**

The Work Agreement (WA-0079) for the study on the effects of sample saturation on thermal conductivity was issued, and samples are ready for testing. These experiments are necessary to determine whether thermal conductivity has a predictable dependence on the saturation state of the sample and, if so, to describe the nature of the relationship. Results from these experiments will be used to determine the optimal baseline test conditions for thermal conductivity characterization. (SCP Activity 8.3.1.15.1.1.3)

A successful calibration of the C-Matic low temperature (LT) instrument was completed without the moisture containment cell. Calibration runs using moisture containment cells made from the polymer Delrin® were found to be unstable. Moisture containment cells made from Kel-F® are being fabricated and will be used for testing samples in a controlled environment. The LT is used to measure thermal conductivity using the guarded-heat-flow-meter method at temperatures below 100°C.

An additional LT instrument has been ordered to support increased thermal conductivity testing requirements. This instrument is anticipated to be operational early in June. Because testing of samples to support the ESF/repository design has priority over the study on saturation effects on thermal conductivity, the study will be delayed until sufficient equipment capacity is available to support both activities.

A successful calibration and calibration verification was compiled using the Thermal Conductivity Analyzer (TCA). The TCA measures thermal conductivity using the guarded-heat-flow-meter method at temperatures above 100°C. This instrument will be used to obtain thermal conductivity data to support the ESF/repository design.

The Work Agreement (WA-0081) for thermal conductivity testing of samples from NRG-6 was issued. Six additional thermal conductivity samples from NRG-6 (depths 392.1 ft, 354.9 ft, and 416.0 ft) were machined and are being inspected. Data from these samples will be used



to support the ESF/repository design (see WBS element 1.2.3.2.6.2.2).

The Work Agreement (WA-0080) for the study of fracture effects on thermal conductivity of unit TSw2 was issued, and samples are being machined. Calibration of the permanent and reference thermocouples for the comparative instrument used in this study was completed. If fractures are observed to have a significant effect, samples containing natural fractures will be obtained and tested. (SCP Activity 8.3.1.15.1.1.3)

Rock crushing and grinding equipment was received and is being installed at the University of New Mexico (UNM). This equipment will be used for preparing powdered rock samples for chemical analysis and mineralogic determination by x-ray diffraction. These analyses will be used to aid in the interpretation of the thermal conductivity and thermal expansion data. (SCP Activity 8.3.1.15.1.1.3)

#### Major Activities Upcoming Next Three Months

Thermal conductivity testing of samples from NRG-6 to support the ESF/repository design will be initiated after the LT instrument is calibrated using moisture containment cells made from Kel-F® (see WBS element 1.2.3.2.6.2.2).

After the new LT instrument is brought to operational status, testing activities for the scoping study on the effects of saturation on thermal conductivity will begin. Three samples of welded devitrified tuff and three samples of nonwelded zeolitic tuff will be used for this study. The thermal conductivity of each sample will be measured at nominal temperatures of 30°C, 50°C, and 70°C, at five different saturation states (fully saturated, oven-dry, air-dry, and two other intermediate states). (SCP Activity 8.3.1.15.1.1.3)

After test samples are machined and inspected, the study of the effects of fractures on thermal conductivity will be initiated. The thermal conductivity of two air-dry samples from unit TSw2 will be measured using the comparative method. A nominal temperature of 30°C and stress levels of 0 MPa, 2.5 MPa, 5 MPa, 7.5 MPa and 10 MPa will be used. After the samples are tested, they will be cut in half, and the fracture

surface will be roughened. The halves will be rejoined and the thermal conductivity measurements will be repeated. (SCP Activity 8.3.1.15.1.1.3)

The rock crushing and grinding equipment for preparation of rock samples will be installed at UNM.

#### Other Items to Report

J. Connolly, UNM, presented the analysis of the petrography, petrology, and chemistry data of tuff samples to the Institute of Meteoritics on May 17. The talk focused on how the TSw units defined in the YMP literature relate to the actual petrology of the rocks. The assumption that tridymite is largely confined to TSw1 is not borne out. Within all drillholes tridymite has been identified largely as a late-occurring, pore-filling vapor-phase or vapor-depository mineral well below the TSw1-TSw2 contact defined by Ortiz et al. (1985) and refined by Hardy and Bower (1993). These observations are in agreement with the works of Bish and Chipera (1989, LA-11497-MS). Thin-section photomicrographs of different matrix textures were presented. These photomicrographs showed gradations in matrix types and other petrographic features (like tendency in coarser crystallization in pumice fiamme) that have not been considered in the classification of thermal/mechanical units.



### 1.2.3.2.7.1.2 LABORATORY THERMAL EXPANSION TESTING

#### Status Report on Ongoing Activities

The following Work Agreements were issued.

1. Work Agreement (WA-0082) for the study on the effects of sample size on thermal expansion. Samples are ready for testing. Results from these experiments will be used to determine the optimal baseline test conditions for thermal expansion characterization. (SCP Activity 8.3.1.15.1.2.1)
2. Work Agreement (WA-0084) for the study on the effects of sample saturation on thermal expansion. These experiments are necessary to determine whether thermal expansion has a predictable dependence on the saturation state of the sample and, if so, to describe the nature of the relationship. Results from these experiments will be used to determine the optimal baseline test conditions for thermal expansion characterization. (SCP Activity 8.3.1.15.1.2.1)
3. Work Agreement (WA-0083) for thermal expansion testing of samples from NRG-6. Six additional thermal expansion samples from NRG-6 (depths 392.1 ft, 354.9 ft, and 416.0 ft) were machined and are being inspected. Data from these samples will be used to support the ESF/repository design (see WBS element 1.2.3.2.6.2.2).

An additional dilatometer with a saturation test apparatus has been ordered to support increased thermal expansion testing requirements. This instrument is anticipated to be operational early in June. Because testing of samples to support

the ESF/repository design has priority over the study on the effect of sample size on thermal expansion, this study will be delayed until sufficient equipment capacity is available to support both activities.

The thermal expansion of four air-dry samples from NRG-6 were tested from ambient temperature to 110°C. The saturation states of the samples were not controlled during testing. The samples were held at 110°C for 30 hr to obtain information on the dehydration behavior of the samples. The mean coefficient of thermal expansion (CTE) for these samples is provided on the table.

The negative CTE of NRG-6-152.9-SNL-C suggests a relatively high initial saturation level of this PTn sample.

#### Major Activities Upcoming Next Three Months

Thermal expansion testing of samples from NRG-6 to support the ESF/repository design will continue (see WBS element 1.2.3.2.6.2.2).

After the new dilatometer is brought to operational status, experiments to study the effects of sample size on thermal expansion will be initiated. Five samples of each of four different lithologies (welded devitrified, welded vitric, nonwelded vitric, and nonwelded zeolitic) will be tested for each sample size. The samples will be right cylinders of two sizes—0.25-in. (0.6-cm) diameter x 1 in. (2.54 cm) and 1-in. (2.54-cm) diameter x 4 in. (10.2 cm) nominally. The samples will be fully saturated before experiments are started. The samples will be heated, and the atmosphere surrounding the sample during testing will be controlled at high humidity in a saturation test apparatus to minimize sample dehydration at temperatures

Sample ID	Mean CTE ( $10^{-6}$ )°C <sup>-1</sup>		
	25°C-50°C	50°C-75°C	75°C-100°C
NRG-6-98.1-SNL-G	6.92	8.52	10.10
NRG-6-152.9-SNL-C	0.54	-13.40	-23.40
NRG-6-277.5-SNL-C	5.33	5.27	7.93
NRG-6-321.1-SNL-C	4.13	6.17	6.78

below the nominal boiling temperature of 100°C. When this temperature is reached, temperature will be held constant and the sample allowed to dehydrate until the length stabilizes. Heating will be restarted and continue until the temperature reaches 300°C; then the sample will be cooled to ambient temperature (25°C). (SCP Activity 8.3.1.15.1.2.1)

After the study of the effects of sample size on thermal expansion is completed, the study of the effects on sample saturation will be initiated. Five samples each of four different lithologies (welded devitrified, welded vitric, nonwelded vitric, and nonwelded zeolitic) will be tested. Three initial saturation states will be examined—fully saturated, air-dry, and oven-dry. The atmosphere surrounding the sample during testing will be controlled at high humidity in a saturation test apparatus to minimize sample dehydration at temperatures below the nominal boiling point of 100°C. When this temperature is reached, the temperature will be held constant and the sample allowed to dehydrate until the length stabilizes. Heating will be restarted and will continue until 125°C is reached; then the sample will be cooled to ambient temperature. (SCP Activity 8.3.1.15.1.2.1)

### 1.2.3.2.7.1.3 LABORATORY DETERMINATION OF MECHANICAL PROPERTIES OF INTACT ROCK

#### Major Accomplishments

SAND92-1810, "Unconfined Compression Experiments on Topopah Spring Member Tuff at 22°C and a Strain Rate of  $10^{-9}$  s<sup>-1</sup>: Data Report," has completed management review and was sent to the Project Office on May 13, satisfying Milestone OS46. (SCP Activity 8.3.1.15.1.3.2)

#### Status Report on Ongoing Activities

New England Research, Inc. (NER) is conducting a study of time-dependent deformation involving high-temperature experiments at creep and low-strain rate conditions. The most recent series of experiments consists of at least six samples of TSw2 to be tested at a pore pressure of 4.5 MPa, a confining pressure of 5 MPa, and a maximum constant differential stress of 80 MPa. The experiments are performed initially at room temperature and then at 250°C. The third experiment was completed in May, and the fourth sample is being prepared for testing beginning in June. (SCP Activity 8.3.1.15.1.3.2)

NER is conducting a study of the mechanical properties of tuff samples from a series of drillholes (denoted as NRG, north ramp geology). These holes are located along the length of the planned position of the north ramp of the ESF. The samples are machined, dried, and saturated prior to testing at uniaxial and triaxial conditions. Sample porosity is calculated from the dry and saturated bulk densities. Compressional and shear wave velocities were also measured on both the dry and saturated samples. Other samples are being tested for average grain densities and in indirect tensile (Brazil) experiments. The first series of unconfined experiments were completed in May on 22 samples of core from USW NRG-6 (depths ranging from 22 ft to 329 ft). (SCP Activities 8.3.1.15.1.3.1 and 8.3.1.15.1.3.2)

R. Price was in White River Junction, VT, on May 19 and 20 to meet with the staff at NER. Discussions centered on the results of testing time-dependent mechanical properties and the examination of rock and test results from core



recovered from the series of NRG drillholes. (SCP Activities 8.3.1.15.1.3.1 and 8.3.1.15.1.3.2)

#### Major Activities Upcoming Next Three Months

R. Price and two members of the NER staff will be in Madison, WI, in late June to attend the 34th U.S. Symposium on Rock Mechanics (June 27 through 30 at the University of Wisconsin-Madison). They will be presenting a paper entitled "The Influence of Strain Rate and Sample Inhomogeneity on the Moduli and Strength of Welded Tuff." (SCP Activity 8.3.1.15.1.3.2)

SAND92-0119, "Experimental Comparison of Laboratory Techniques in Determining Bulk Properties of Tuffaceous Rocks," has been revised in response to technical and editorial reviews. The document revision is being considered by the technical reviewers and should begin management review in June. (SCP Activities 8.3.1.15.1.3.1 and 8.3.1.15.1.3.2)

#### **1.2.3.2.7.1.4 LABORATORY DETERMINATION OF THE MECHANICAL PROPERTIES OF FRACTURES**

#### Status Report on Ongoing Activities

A series of experiments have been performed under triaxial conditions to compare the results of this experiment technique to the results observed using the rotary friction method. Rough fractures were created in three right-circular cylinders by line loading at an inclination of approximately 30° to the cylinder axes. These samples were tested at constant normal stress by initially loading the sample in hydrostatic compression and then constantly decreasing the confining pressure while loading the sample axially. The data on stiffness, dilatancy, and strength are being analyzed. (SCP Activity 8.3.1.15.1.4.2)

#### Major Activities Upcoming Next Three Months

The draft of a new standard test method, "Standard Test Method for Normal and Shear Stiffness of Rock Fractures Using a Compression/Rotary Shear Apparatus," was submitted to American Society for Testing Materials (ASTM) committee D-18 on Soil and Rock Properties and has completed the first review and vote by subcommittee D18.12 on Rock Mechanics. The results of this review will be discussed at the committee meetings in Atlanta, GA, on June 22 and 23. (SCP Activities 8.3.1.15.1.4.1 and 8.3.1.15.1.4.2)

SAND92-2333, "The Effect of Sliding Velocity on the Mechanical Response of Artificial Joints in Topopah Spring Member Tuff," is being revised in response to the comments generated during technical and editorial review. (SCP Activity 8.3.1.15.1.3.2)

A journal article, "Simple Mathematical Model of a Rough Fracture," is being drafted and will be submitted to the Project Office for review in the next two months. (SCP Activities 8.3.1.15.1.4.1 and 8.3.1.15.1.4.2)

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**1.2.3.2.8.3.3 GROUND MOTION FROM  
REGIONAL EARTHQUAKES AND  
UNDERGROUND NUCLEAR  
EXPLOSIONS**

**Status Report on Ongoing Activities**

The study plan for ground motion regional earthquake and underground nuclear explosions will be revised and updated to reflect the new ESF design and revised approaches to model development.

**1.2.3.6.2.1.6 FUTURE REGIONAL CLIMATE  
AND ENVIRONMENTS**

**Major Accomplishments**

The transition plan for consolidating Pacific Northwest Laboratory (PNL) efforts on global climate modeling into a single SNL effort was transmitted for Project Office review, satisfying Milestone OS50.

**Status Report on Ongoing Activities**

PACs planning and a review of the SCP annual plan draft were completed. Interactions with PNL to define transition product deliverables were initiated. Procurement planning was also initiated to obtain an FY94 contract with the National Center for Atmospheric Research (NCAR). Plans for preparing a new study plan for this work are being developed and discussions have been held with NCAR regarding resolution of outstanding Quality Assurance (QA) deficiencies.

**Major Activities Upcoming Next Three Months**

The study plan draft will be prepared and NCAR QA deficiencies will be resolved.

**Issues/Potential Problems Needing Resolution and Potential Impacts**

Insufficient funding remains in this WBS element to accomplish FY93 deliverables. A letter has been sent to YMP requesting additional funds.

## 1.2.4 REPOSITORY

The objective of the Repository element includes work scope related to the repository component of the physical system including the repository operations system, the underground facility component of the engineered barrier system, the access/borehole seals, and the monitoring system component of the performance evaluation system. The Repository element is comprised of nine tasks: Repository Coordination and Planning (1.2.4.1.1), Excavation Investigations (1.2.4.2.1.1.1), In Situ Thermomechanical Properties (1.2.4.2.1.1.2), In Situ Mechanical Properties (1.2.4.2.1.1.3), In Situ Design Verification (1.2.4.2.1.1.4), Rock Mass Analyses (1.2.4.2.1.2), Certification of Design Methods (1.2.4.2.3.1), Design Analysis (1.2.4.2.3.2), and Sealing and Design Requirements (1.2.4.6.1).

### 1.2.4.1.1 REPOSITORY COORDINATION AND PLANNING

#### Status Report on Ongoing Activities

Work on the initial drafts of study plans 8.3.1.15.1.6, "In Situ Thermomechanical Properties" and 8.3.1.15.1.7, "In Situ Mechanical Properties," continued.

SNL staff continues to work with the Management and Operations contractor (M&O) and staff from other participant organizations to develop a plan for resolving numerous issues related to the thermal loading of the potential repository. As part of this work, SNL is participating in an effort to review current thermal goals and develop a tentative set of revised goals for advanced conceptual design (ACD). SNL is leading the effort to examine two goals related to thermal/structural interactions. In the past month, simplified numerical computations were completed to define certain bounds on the near-field temperatures. Because of possibly large changes in thermal expansion of the host rock at elevated temperatures, the stability of the rock mass in emplacement drifts and boreholes must be examined. The recent analyses evaluated rock mass stresses around drifts and compared them to nominal failure criteria. As a result of this evaluation, initial recommendations for revised thermal goals were transmitted to the M&O for incorporation into their study.

SNL staff continued work on a series of analyses in support of the design of the ESF north ramp. Three-dimensional thermal/structural analyses of the repository to assess the impact of the potential repository thermal loading on the ESF

drifts have been completed. Results will support two-dimensional analyses of several cross sections of the ESF north ramp to evaluate long-term stability. Geotechnical data from the NRG holes will be incorporated into the analyses. The analyses are expected to provide input for the 90% design review in August 1993.

SNL staff continued construction monitoring activities at the ESF starter tunnel under study plan 8.3.1.15.1.8. In the past month, seismic records from construction blasting were recorded, rock mass quality estimates for the first 100 ft of tunnel were developed, and locations were selected for the first two stations of rock bolt load cells and bolts were installed.

#### Major Activities Upcoming Next Three Months

Significant effort will be required to implement the geotechnical monitoring effort in the starter tunnel. (SCP SP 8.3.1.15.1.8)

ESF design analyses will be completed.

#### Other Items to Report

SNL is continuing temporary monitoring of rock mass movement as the ESF starter tunnel is excavated. Several sets of tape extensometer pins have been installed to monitor close of the pilot heading. This work is not part of the design verification study plan (8.3.1.15.1.8), but it is similar in nature to the more permanent monitoring that will be installed under the study plan. This temporary monitoring is being conducted under WBS element 1.2.6.1.1.

**1.2.4.2.1.1.1 EXCAVATION INVESTIGATIONS****Status Report on Ongoing Activities**

Staff began incorporating changes to study plan 8.3.1.15.1.5, "Excavation Investigations," in response to comments received from Project Office reviewers.

**Major Activities Upcoming Next Three Months**

Staff will work with Project Office reviewers to finalize the study plan 8.3.1.15.1.15, "Excavation Investigations."

**1.2.4.2.1.1.2 IN SITU THERMOMECHANICAL PROPERTIES****Status Report on Ongoing Activities**

Staff continued work on the rough draft of study plan 8.3.1.15.1.6, "In Situ Thermomechanical Properties."

Proposed resolutions written in response to technical comments from internal SNL technical review for the SAND report entitled "Test Instrumentation for the ESF In Situ Thermomechanical Experiments" were returned to the technical reviewers.

**Major Activities Upcoming Next Three Months**

Staff will continue drafting study plan 8.3.1.15.1.6.

Staff will produce a final draft of "Test Instrumentation for the ESF In Situ Thermomechanical Experiments" that incorporates comments from reviewers.

Under LANL coordination, staff will work with LLNL staff to consolidate SNL's ESF thermomechanical testing with LLNL's hydrothermal testing, if possible.

Plans and objectives of the experiments contained in study plan 8.3.1.15.1.6, "In Situ Thermomechanical Properties," will be presented to the Nuclear Waste Technical Review Board (NWTRB) meeting that will be held on July 13 and 14.



#### **1.2.4.2.1.1.3 IN SITU MECHANICAL PROPERTIES**

##### **Status Report on Ongoing Activities**

Staff continued work on the rough draft of study plan 8.3.1.15.1.7, "In Situ Mechanical Properties."

##### **Major Activities Upcoming Next Three Months**

Staff will continue drafting study plan 8.3.1.15.1.7.

#### **1.2.4.2.1.1.4 IN SITU DESIGN VERIFICATION**

##### **Status Report on Ongoing Activities**

Staff commenced construction monitoring of the ESF north ramp starter tunnel. The monitoring plans include seismic monitoring for blasting, rock quality determination, ground support system performance evaluations, and excavation closure monitoring for stability assessments. In this reporting period, seismic blast monitoring and rock quality determination were conducted.

##### **Major Activities Upcoming Next Three Months**

Staff will continue to field construction monitoring activities and to procure and design instrumentation and a data-acquisition system needed for future monitoring activities.

A presentation of construction monitoring activities will be presented at the 34th U.S. Rock Mechanics Symposium on June 27 through 30.

### **1.2.4.2.1.2 ROCK MASS ANALYSES**

#### **Status Report on Ongoing Activities**

In work related to laboratory testing involving small polycarbonate models, this month was spent finishing a draft of a SAND report entitled "Geometrical Moiré Method of Strain Analysis with Displacement Discontinuities" (Level 3 Milestone OS18). This report describes the methods and software developed to acquire and analyze the data from tests of layered polycarbonate models.

Next month, SNL staff will analyze the data from tests conducted over the last few months and will begin writing a report on these tests.

A study comparing the surface characteristics of natural fractures to the frictional data gathered on replicas of the surfaces is continuing. This study will place special emphasis on determining whether the fitting parameters in the Barton model for frictional behavior have physical significance. This is being accomplished by investigating the effect on fracture shear strength and dilation of varying three parameters: normal stress, roughness, and the strength of the rock material. The majority of the experimental work is being carried out by a University of Colorado (CU) graduate student in the Geomechanics Development laboratory at SNL. The series of eleven rotary shear experiments were completed in March. The results are being organized, and analysis will continue for the next several weeks, leading to the data being presented in a SAND report.

A series of experiments designed to study the effects of a nonstandard loading condition on frictional properties were conducted at CU in 1992. SAND92-1853, "Effect of Boundary Conditions on the Strength and Deformability of Replicas of Natural Fractures in Welded Tuff: Data Report," details the experiment techniques and the resulting data. This SAND report has completed management review and is being revised. The first of two analysis reports, SAND92-2247 entitled "Effect of Boundary Conditions on the Strength and Deformability of Replicas of Natural Fractures in Welded Tuff: Comparison Between Predicted and Observed Behavior," has been through technical review and is in management review. The second analysis

report is being drafted and should begin SNL review soon.

SNL support of the M&O's design efforts for the north ramp continued in May. The majority of the static analyses have been conducted. In these analyses, the in situ, thermal, and equivalent seismic loads were applied to a number of north ramp cross sections. The seismic loads are clearly the dominant loads at most of the cross sections.

#### **Major Activities Upcoming Next Three Months**

Testing, data reduction, and analysis will begin for a set of layered plate experiments.

Static and dynamic analyses will be conducted to support the design of the north ramp.

### **1.2.4.2.3.1 CERTIFICATION OF DESIGN METHODS**

#### **Status Report on Ongoing Activities**

Work at CU in developing joint constitutive models is continuing. This work began by CU conducting a literature search to identify the best available joint constitutive model in the literature. This month, experimental data developed in WBS element 1.2.4.2.1.2 has been fitted to Plesha's joint constitutive model, and the model was incorporated into a finite element code.

In other work at CU, modifications to the discrete element code DDA are being performed to implement the sub-block concept. This month an augmented lagrangian method was included to handle block-to-block contact. The convergence rate is low, so CU is checking for possible coding errors. CU is also looking at the work performed by J. Jung (SNL) to see how the augmented lagrangian method can be used to perform sub-blocking (i.e., breaking large blocks into smaller blocks).

In a separate activity, the coupled finite element - boundary element research is continuing. This month J. R. Koterak (SNL) implemented a newton outer loop to the JAC2D code, which allows the explicit solvers to operate on linear systems as opposed to nonlinear systems. Incremental solutions of linear problems were obtained this month. Incremental solutions of standard plasticity problems are currently being attempted. SNL staff expects that the code will be able to solve these simple nonlinear problems early next month. Following that, coupling nonlinear finite elements to linear boundary elements will be attempted.

B. J. Thorne (SNL) has been working to improve SNL's continuum joint model. This month SNL staff finished a review of the literature and obtained a copy of another model that has some features that are different from SNL's model. SNL plans to test this model to determine if it performs better than SNL's model and, if so, to determine how these features can be incorporated into SNL's model.

#### **Major Activities Upcoming Next Three Months**

Testing of a discrete element code sub-blocking concept will continue. Implementation of the sub-blocking concept into the DDA code will continue.

Development will continue of a coupled finite element—boundary element technology to assess how to couple nonlinear finite elements to linear boundary elements.

Work on a SAND report to document JAC2D will begin in June.



#### **1.2.4.2.3.2 DESIGN ANALYSIS**

##### **Status Report on Ongoing Activities**

The development of near-field thermal/structural/seismic models for use in supporting the design of the ESF's north ramp continued. Analyses assuming equivalent-static and dynamic seismic loads are being pursued. Output from this activity is expected to be ready for transmittal to the M&O design team within the next four to six weeks.

Investigation continued on quantifying the importance to structural predictions of an observed increase in measured thermal expansion due to polymorph silica phase transformations. The results of the analyses are intended for incorporation into the ongoing reevaluation of SCP thermal goals.

#### **1.2.4.6.1 SEALING AND DESIGN REQUIREMENTS**

##### **Status Report on Ongoing Activities**

The activities during the reporting period included preparing a Work Agreement for the completion of the borehole strategy report, receiving text and artwork from Creative Computer Services, reformatting the text for the borehole strategy report, preparing and editing sections of the report. New figures for Chapter 3 were drafted and check-prints prepared. Additional information was obtained concerning the completion of new boreholes.



## 1.2.5 REGULATORY

The objective of the Regulatory element is to assure site-related compliance with Nuclear Regulatory Commission agreements, requirements, and policies; evaluate the performance of the natural barriers, engineered barriers, and total systems for meeting regulatory standards; and manage, maintain, and accumulate technical data and information produced by site characterization, design development, and performance assessment activities for the project. The Regulatory element is comprised of 11 tasks: Regulatory Coordination and Planning (1.2.5.1), Site Characterization Program (1.2.5.2.2), Technical Database Input (1.2.5.3.5), Total System Performance Assessment (1.2.5.4.1), Repository Performance Assessment (1.2.5.4.3), Site Performance Assessment (1.2.5.4.4), Interactive Graphics Information System (1.2.5.4.5), Development and Validation of Flow and Transport Models (1.2.5.4.6), Support Calculations for Postclosure Performance Analyses (1.2.5.4.7), Development and Verification of Flow and Transport Codes (1.2.5.4.9), and Special Projects (1.2.5.5).

### **1.2.5.1 REGULATORY COORDINATION AND PLANNING**

#### Significant Meetings Attended

SNL staff attended a meeting in Las Vegas, NV, to discuss elements of the Performance Assessment (PA) Annual Plan for 1994 with the M&O and LLNL.

#### Status Report on Ongoing Activities

In addition to providing routine coordination and planning support to regulatory activities, staff are developing detailed workscopes and deliverables for 1.2.5 WBS elements to be included in the PA Annual Plan. Data needs and linkages with other participants are also being identified.

### **1.2.5.2.2 SITE CHARACTERIZATION PROGRAM**

#### Status Report on Ongoing Activities

The eighth semiannual progress report was reviewed at M&O request.



### **1.2.5.3.5 TECHNICAL DATABASE INPUT**

#### **Significant Meetings Attended**

On May 6, staff attended a meeting with SNL YMP personnel affiliated with database management activities. This meeting addressed issues related to identification of developed data, disposition of the Reference Information Base (RIB), and the feasibility of appointing a database coordinator.

#### **Major Activities Upcoming Next Three Months**

On June 3, staff will attend a technical database working group meeting at the Project Office, followed by an orientation session with GENISES personnel.

The FY94 budget needs for WBS element 1.2.5.3.5 will be determined.

#### **Issues/Potential Problems Needing Resolution and Potential Impacts**

Modification of Technical Data Information Forms (TDIFs) is required to facilitate usage by technical personnel. Also, the TDIF backlog must be resolved, and the future disposition of TDIF submittals (paper vs. electronic) should be decided.

### **1.2.5.4.1 TOTAL SYSTEM PERFORMANCE ASSESSMENT**

#### **Significant Meetings Attended**

Members of the SNL staff attended the YMP Colloid Workshop, held May 3 through 5 in Santa Fe, NM. "Colloids: A Performance-Assessment Perspective" was presented by M. Wilson of SNL.

SNL staff attended the Technical Workshop on Near-Field Performance Assessment, at Cadarache, France, from May 11 to 13. Attendees included representatives from U.S., Swedish, Swiss, German, French, Finnish, UK, and Dutch waste-disposal programs. The purposes of the meeting were to review the aspects of near-field performance assessment, to develop themes that should be pursued, and to identify areas common to the programs that might be appropriate for collaboration. Topics included near-field environment, releases, transport, modeling, and performance-assessment (PA) integration. The workshop participants were split into interest groups to discuss the topics in detail and develop recommendations. Most of the emphasis was on the European programs (and their design and environmental conditions); consequently, most of the discussion was concerned with saturated repositories with bentonite backfill and reducing groundwater conditions. A member of the SNL staff was in the PA integration group, so YMP interests were included in their recommendations. Areas of mutual interest include many of the scenario classes (e.g., near-field hydraulic, radiolytic, and chemical processes; volcanic processes; repository operations), some aspects of the geochemistry (e.g., alteration of near-field hydraulic properties by the engineered barrier system), glass-waste dissolution, and salt-repository characteristics. A survey and review document and a workshop summary are being prepared by the organizers to be published within a few months.

An SNL staff member attended the Hydrology Integration Task Force meeting held in Denver, CO, on May 17 and 18. The topic of focus was the C-well testing, the current results, and future test plans.

SNL personnel coordinated and hosted a meeting on May 26 with participants from USGS,

Raytheon Servies of Nevada (RSN), and M&O/INTERA. The purpose of this meeting was to discuss the best approach for representing infiltration and water flow at Yucca Mountain resulting from both current and future climatic conditions. The results of this discussion will be used as the basis for the percolation flux used in the second cycle of the Total System Performance Assessment (TSPA-2).

SNL staff attended a meeting on May 26 at Lawrence Livermore National Laboratory (LLNL) with representatives from LLNL and the M&O. The objective of the meeting was to formulate a source term for use in the M&O version of the TSPA. The result of the meeting was that the M&O will use the same source term that had been previously determined by interactions occurring between SNL and LLNL in February. Also, a meeting was set for early June to correlate the LLNL hydrothermal calculations with SNL thermal data to determine the hydrothermal profiles to be used in the TSPA source term.

In an ongoing effort, SNL staff members hosted a meeting on May 27 and 28 with LLNL staff. The objective was to couple LLNL's Yucca Mountain Integration Model (YMIM) source model to SNL's transport models for the TSPA (both TOSPAC and WEEPTSA). There are a number of difficulties with this integration, but the collaboration is going well and this interface between SNL's programs should make future generations of YMIM easier to incorporate.

#### Status Report on Ongoing Activities

Information on the TSPA problem setups (including repository area and heat output, stratigraphy, and material properties) has been transmitted to Disposal Safety Inc. (DSI). Using this input, they have begun the gas-flow calculations for TSPA-2.

The "weeps" model was modified to incorporate LLNL's source-term model, YMIM. Modifications to the weeps model to incorporate thermal-effects data have also been started. Specifics of the modification include incorporating the number of containers outside the boiling isotherm as a function of time, the volume of rock encompassed by the boiling isotherm, and the temperature histories of representative containers.

For the composite-porosity flow model, staff began determining a new set of columns for the three potential repository footprints, based on variations in power densities. Reconfiguration of the footprint has required construction of different stratigraphic cross sections from which to draw the columns used for the one-dimensional calculations. Staff also began incorporating distributions for the hydrogeologic parameters of the stratigraphic units into the TOSPAC input files.

SNL staff is developing a source term that reflects the proper weighting of age and burn-up for spent fuel and also are attempting to include glassified high-level waste for TSPA-2. There will be two representations of the source term. The human-intrusion source term will be composed of all of the inventory, while the aqueous flow and volcanism calculations will utilize indicator nuclides, as discussed in SAND92-2431.

The human-intrusion direct release model, currently in development, will calculate releases due to drilling into a repository where the waste package configuration is based on the four variations of the thermal loads and emplacement schemes. Preliminary results of calculations for the in-drift emplacement model indicates that interception of the much larger waste package may lead to releases of very high amounts of radionuclides in any one drilling event.

SAND93-0852, "The Appropriateness of One-Dimensional Yucca Mountain Hydrologic Calculations," has been through technical review. The reviewer's comments have been incorporated. The comments from the technical editor are being addressed.

In collaboration with Dr. Nilson (S-CUBED), staff formulated a model for moisture (liquid and vapor) movement in fractured media driven by fluctuations in barometric pressure. The barometric fluctuations will be assumed periodic in time, allowing an enormous simplification in treating a coupled fracture and matrix system. In essence, the vertical transport along the fractures can be approximated in such a way to decouple the horizontal transport in the matrix blocks. A formulation for describing multiphase flow of water, air energy in a porous material has been developed. This particular formulation is appropriate for numerical treatment when coupled to the simplified description of time-periodic flow

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in the fracture system. A method-of-line code is being written to obtain numerical solutions to the fracture/matrix problem.

The nominal flow scenario-selection document should be ready for internal review by the beginning of June after final revision of figures, flow charts, and text.

#### **1.2.5.4.3 REPOSITORY PERFORMANCE ASSESSMENT**

##### **Status Report on Ongoing Activities**

Progress continued on an evaluation of the LLNL "extended dry" concept. Calculations completed during this reporting period address the importance of multiple material property designations (layering) in thermal models.

Waste stream information was obtained for use in calculations designed to support the M&O's thermal loading system study. Preliminary model development is proceeding; however, significant progress has been delayed due to a lack of guidance regarding sizes and locations of underground openings.

Near- and far-field thermal calculations are being developed for use in the next iteration of the TSPA. The goal of these analyses is to provide estimates of representative waste package temperatures, the number of packages protected by a boiling front as a function of time, and volumetric dry out.

Staff continued to participate on several teams of the Site Characterization Plan (SCP) Thermal Goals Working Group and provided draft input for the Thermal-Mechanical Team and the Operations, Safety, and Environment Team on May 25.



#### 1.2.5.4.4 SITE PERFORMANCE ASSESSMENT

##### Major Accomplishments

SAND88-7054, "Processes, Mechanisms, Parameters, and Modeling Approaches for Partially Saturated Flow in Soil and Rock Media," by J. S. Y. Wang and T. N. Narasimhan, is complete and is being printed.

##### Status Report on Ongoing Activities

**Geohydrologic Data Analysis:** SNL staff performing TSPA modeling have been provided with initial basic statistics, beta distribution parameters, and upscaled beta distribution parameters for the following matrix material properties and beta distribution classes:

- Matrix Porosity-Normal
- Saturated Matrix Hydraulic Conductivity-Log Normal
- van Genuchten Parameters:
  - Matrix Air Entry (alpha)-Log Normal
  - Matrix Saturation/Desaturation (beta)-Log Normal
  - Matrix Residual Degree of Saturation (Sr)-Exponential
- Bulk Density-Normal (parsed according to hydrogeologic unit; statistics and distributions are pending other analyst priorities)

The basic statistics report the number of data, expected value (mean), coefficient of variation, and maximum and minimum of the data. From the basic statistics, beta probability distribution parameters were derived by the RS1 statistical package. If a normal distribution could not be generated because of the lack of sufficient data, Shannon's maximum entropy routine was employed reporting the mean, the maximum and minimum, and the alpha and beta curve parameters of the distribution. Then the curve parameters were upscaled for the beta probability distribution parameters that account for the vertical correlation length and mean thickness of the hydrogeologic units. Data reported are the mean thickness of the unit, upscaled coefficient of variation, upscaled alpha and beta distribution parameters, and model specific input parameters (p and q).

To support and visually complement the numerical analyses, graphical representations of the basic statistics and beta probability distributions have been developed (histograms and beta probability distribution plots, both normal and log normal) for inclusion in the second-cycle TSPA report.

Matrix saturated hydraulic conductivity and matrix porosity data for Spearman Rank Correlations have been parsed according to hydrogeologic units and run for coefficients. Analyses of the coefficients for significance are currently being evaluated.

Bulk hydrogeologic conductivity distributions for the drillholes with pump tests resulting in bulk permeability or conductivity data have been identified. The probability distributions were generated as the matrix parameters were, but without the upscaling (due to the tests being accomplished over integral, thick sequences). Holes USW H-1, 3, and 4; UE-25b1 and p1; J-13; and USW G-4 were used for saturated bulk conductivity values. Holes USW UZ-1 and UE-25a#4 were used for air permeability data derived from barometric fluctuations. Only data representative of single, definable stratigraphic units were used. If pump tests crossed stratigraphic units, the data were not used.

Fracture data from downhole measurements have been analyzed for fracture distributions from USW G-4 as a test case to evaluate utility to the PA problem. An attempt has been initiated to derive the applicable information to correlate fracture aperture size as a function of the second moment of log saturated permeability versus log pore-size, according to an approach developed by J. Wang (LBL). If this approach is successful, a more realistic range of aperture size would be available to the modelers.

**Data Base and GIS Management:** The PA database currently is in a low-level maintenance mode with limited activity. The GIS system, ARC/INFO, has had additional coverages developed, adding proposed drillhole locations with relation to topographic features, proximity to roads, existing drillhole locations, and other affecting relationships. The GIS staff supported a walk-through visit by the President of SNL, A. Narath, with a demonstration of some of the GIS capabilities for Yucca Mountain data.



**Probability Modeling:** Modifications to the entropy fit program were made in response to problems discovered during generation of the probability distributions for TSPA II. The changes included:

- 1) A change in the computation of normalizing constant from adaptive integration to an analytical formula. The change is more complicated for bimodal and trimodal beta distributions but has also been completed.
- 2) Display of the cubic line search iteration has been added and a maximum number of iterations.
- 3) The maximum number of nonlinear iterations has been added to the input file so it can be adjusted by the user.
- 4) Error tolerances were adjusted to increase robustness. Step size used in computing derivatives was made more robust.

Staff completed modifications of probability software originally installed on the VAX. Specifications for the user interfaces are being developed for experience gained during the elicitations. A user interface in an RS/1 shell has been written and installed on the PC.

The report entitled "Progress Report on Stochastic Modeling: Generation of Correlated Random Vectors with Multivariate Normal and Beta Distributions," by J. Sun and M. Harr, has undergone internal technical review. The report describes work SNL has been supporting under a research grant to Purdue Research Foundation. Purdue will be supplying software with a graphical user interface later this summer.

**Performance Assessment Support:** Work has begun on producing stratigraphies for the revised columns for the TSPA. Computation of rank correlations for porosity and saturated matrix conductivity have been completed for each unit.

Work has continued on the east-west INTRAVAL cross section with the gradational change in porosity in the shardy base added. The adaptive grid algorithm GAG was tried on the cross section, but produced poor results. Changes are being made to GAG to improve the results.

#### **1.2.5.4.5 INTERACTIVE GRAPHICS INFORMATION SYSTEM**

##### Major Accomplishments

Staff attended the 1993 Environmental Systems Research Institute (ESRI) Conference and participated in various ARC/INFO workshops, learned about upcoming ESRI software features, and provided input into future development.

##### Status Report on Ongoing Activities

Development is continuing on a series of coverages showing the starter tunnel, alcoves, and instrument locations.

Staff continues to identify users of the VAX 3600 to help plan the retirement of the computer. The Calma/DDM thermal/mechanical model is not scheduled to be made available beyond FY93.

A workload spike on color printers caused queueing problems and excessive delays. Staff is evaluating several replacement options to accommodate the ever-increasing workload.

The following job has been completed:

- Job 404 for D. L. Eley - Create ESF starter tunnel plan

##### Major Activities Upcoming Next Three Months

Alternate platforms for users of the VAX 3600 will be found. Migration to the other platform will be accomplished, and the Calma software will be eliminated.

Staff will plan and begin implementing a user environment that provides access to data obtained from instruments placed in the tunnels at Yucca Mountain. The tool will enable users to utilize several tools to manipulate, visualize, and output the data as needed.

The following jobs are in progress:

- Job 397 for D. L. Eley - Convert GTMs to ARC/INFO
- Job 398 for D. Guerin - Hydrogeologic drillholes



- Job 401 for L. H. Skinner - Contours of Yucca Mountain
- Job 405 for C. A. Rautman - Rebuild TSw1 model per new input
- Job 407 for M. L. Jones - Add new data coverages
- Job 408 for L. E. Shephard - Profile through USW G-4

#### **1.2.5.4.6 DEVELOPMENT AND VALIDATION OF FLOW AND TRANSPORT MODELS**

All activities addressed in this monthly status report support SCP Section 8.3.5.12.2.1.1.

#### **Significant Meetings Attended**

R. J. Glass and M. J. Nicholl attended the 1993 Spring Meeting of the American Geophysical Union held in Baltimore, MD, during the week of May 24 through 28. They presented "Influence of Fracture Saturation and Wetted Structure on Fracture Permeability," by M. J. Nicholl and R. J. Glass; "Infiltration Flow Instability in Unsaturated Fractures," by M. J. Nicholl and R. J. Glass; and "Gravity-Driven Fingering in Rough-Walled Fractures: Analysis Using Modified Percolation Theory," by R. J. Glass.

#### **Status Report on Ongoing Activities**

**Flow and Transport Through Single Fractures:** Development of a methodology to produce epoxy casts of natural fractures continued. Most work was concentrated on control of the boundary conditions. A test fracture prepared in April using external manifolds to control inflow and boundary conditions was subjected to preliminary tests. It was observed that the boundary must have a smooth, flat surface to effect an adequate seal. In addition, as the fracture trace will not be a straight line, great care must be taken to assure that the manifold gasket fully encloses the fracture aperture. Using external manifolds to satisfy these criteria requires a significant amount of care and forethought during preparation of the sample. Work is progressing toward development of a new methodology yielding better control of boundary conditions with less time expenditure. The test fracture was disassembled and internal manifolds machined into the fracture surfaces. Preliminary tests using the internal manifolds showed excellent promise; efforts to refine this technique will continue in June. Evaluation of the wetting, optical, and mechanical properties characteristic of various epoxy formulations and preparation techniques will also continue in June.

Development of experimental techniques to explore the effects of air entrapment on fracture permeability and tracer migration continued.

Hardware to allow acquisition of both high- and low-resolution images of the test fracture at controlled intervals during the experiment was acquired and installed during May. Low-level software control of the hardware was also implemented; integration of control into existing image-acquisition software will proceed in June. The cooling system for the high-resolution camera was reworked to include filtration of the water supply. To prevent equipment damage should the supply of cooling fluid be interrupted during a long-term test, a relay was designed to shut off the camera. Fabrication and installation of the relay should be accomplished in June.

**Fracture/Matrix Interaction:** Construction continued on an enlarged test chamber to facilitate larger-scale investigations of fracture-matrix interaction. The new test chamber will be capable of securing multiple fractured rock slabs measuring 2 ft by 2 ft with thicknesses ~1 in. Efforts have also been made to improve the means by which various boundary conditions are applied to the experimental systems (upper flux boundary and lower prescribed tension boundary).

A joint laboratory program with A. Flint (USGS, YMP test site) and E. Kwicklis (USGS, Denver) has been initiated for investigating unsaturated flow behavior in fractured volcanic tuff. These experiments will make use of slabs of welded tuff cut from a tuff block previously used in infiltration studies conducted by E. Kwicklis. Fracture-matrix interaction studies will be conducted by introducing water at the top of the natural fractures that cut the tuff slab. X-ray absorption techniques will then be used to monitor the developing flow field over time.

Experiments have continued in efforts to develop real-time x-ray analysis capabilities. Currently, investigations are conducted in two systems: the simple x-ray detector/image intensifier system and the more sophisticated Seimen's Polytron. The goal is to achieve a high degree of image contrast in porous systems that have short time constants.

**Field, Laboratory, and Numerical Experimentation to Determine Scaling Laws for Effective-Media Properties in Heterogeneous Media:** Efforts are continuing on the development of software to drive the automated gas-permeameter test system as well as the development of a test procedure that addresses such issues as sampling strategy, calculation of gas permeability from permeameter

data, and data-reduction protocols. A survey of accessible rock/heterogeneity types has been conducted to help guide the selection of block samples to use in the initial stages of this program.

**Caisson Test:** A second systematic study of sorption of bromine (Br) by the Wedron 510 sand under carbon dioxide (CO<sub>2</sub>)-free conditions was completed and reduced the uncertainty of the  $K_d$  value for the conservative tracer for the caisson experiment. A new technician was trained in the techniques for lithium (Li) analysis by flame atomic adsorption in preparation for the caisson test. A draft technical procedure for the Li analysis technique was prepared. Additional nickel (Ni) sorption data was collected under CO<sub>2</sub>-free conditions to calculate surface complexation constants. Ni sorption experiments using the batch sorption techniques described in Los Alamos National Laboratory (LANL) Detailed Technical Procedures TWS-INC-DP-05-R2 and LANL-INC-DP-86-RO were initiated. The data from these experiments will be used to calculate retardation factors for use in transport codes such as TRACR3D and TRANS and will be compared with those collected in previous studies at SNL. M. Siegel (SNL) and K. Stetzenbach (UNLV) met to determine the schedule and number of samples that will be analyzed at UNLV during the caisson experiment. The final design of the caisson, including locations of TDR probes and ceramic and hollow fiber solution samplers, was completed and submitted to LANL prior to filling of the caisson.

**Reactive Transport Model Development:** Linkage of the new version of EQMOD with the flow module was completed; the new version of the chemical speciation module contains multiple sorption and ion-exchange sites. Four alternative PCG solvers were incorporated into LEHGC1.1. Testing of both the incorporated new EQMOD and the PCG solvers is in progress.

**Reactive Transport Experimentation:** Development of methods to carry out in-situ batch sorption studies in unsaturated media continued. Responses were prepared for the Corrective Action Requests (CARs) that resulted from the QA audit that was held at the Massachusetts Institute of Technology in March.

Planning and instrumentation of the reactive transport laboratory continued. The design of the

unsaturated hanging column experiments was tested with a column of Wedron 510 sand and a LiBr tracer. Saturation was determined by a mass balance on the water. Column effluent was collected automatically by a fraction collector once steady flow was established. Analysis for both Li and Br will be conducted in the first week of June. A second run using continuous feed of LiBr solution was initiated to determine breakthrough curves for Li and Br. Analysis of the pulse and breakthrough data with the computer code CTXFIT will give retardation factors and dispersivities for Li and Br. Data acquisition interfaces for collection of real-time pH and water flux data using the LabTech software are being developed.

Evaluation of the stability of the autotitrator showed that the drift rate under CO<sub>2</sub>-free conditions at pH 7 is sensitive to argon (Ar) flow rate, with high flows producing drift to basic pH and low flows to acidic pH. The optimal Ar flow was determined, producing drift rates of better than  $\pm 0.001$  pH/min at pH 7. This stability is probably adequate for general potentiometric titration work. An initial titration curve was measured for raw Wedron 510 sand and showed that the stirrer can effectively suspend a 1:1 solid:solution mixture of electrolyte and sand. The sand settles quite rapidly; therefore, a high stirrer setting is required, possibly leading to grain-to-grain collisions and consequent production of clay-size particles. Rapid setting also induced a "settling potential" at the pH electrode, causing it to be sensitive to the flow orientation, leading to reading variations of as much as  $\pm 0.05$  pH units. Shielding the electrode from the direct flow eliminated this problem. Present efforts are directed toward obtaining a batch of sand that has been stripped of its carbonate content by maintaining it at pH 3 until no further additions of acid are required.

The precipitate formed in the Ni solubility experiment was identified as predominantly Ni(OH)<sub>2</sub> by x-ray diffraction, but there are two unidentified peaks of minor intensity on the x-ray pattern.

#### Major Activities Upcoming Next Three Months

Staff will obtain surface complexation constants of Br, Li, and Ni by sand to be used in caisson or in supporting laboratory studies. Li-Ni ion exchange studies with sand will be carried out. Isotherm experiments to determine the linear range of sorption of tracers will continue, as will surface potentiometric titration of sand. The LEHGC code will be implemented on massively parallel architecture. Development of a method of unsaturated K<sub>d</sub> measurements with a Turbula mixer will continue, and the method for laser fluorescence measurements of uranium (U) in sand and fractured media will be optimized.



#### **1.2.5.4.7 SUPPORTING CALCULATIONS FOR POSTCLOSURE PERFORMANCE ANALYSES**

##### **Major Accomplishments**

ESF PA Analysis No. 13, which addresses concerns regarding underground water usage for dust control during excavation and fire fighting in the ESF north ramp, south ramp, and main test level tunnels, completed technical review. Also, recommendations for inclusion in Appendix I of the ESFDR completed technical and management reviews and were transmitted to the Project Office.

##### **Status Report on Ongoing Activities**

Preliminary efforts have begun for model validation exercises in nonisothermal flow in collaboration with WBS element 1.2.5.4.3 and the Department 6115 Flow Laboratory. A series of experiments using two different constant temperature boundaries have begun. Staff members are currently learning the code TOUGH-2 to use for these early efforts.

Preliminary PACS exercises have begun. Potential activities, Level III Milestones, and deliverables for FY94 have been identified for WBS element 1.2.5.4.7. These activities include analyses of effects of diesel smoke, grout, and epoxy resin used in the ESF on waste isolation (ESF PA Analysis No. 11); sealing requirements for the ESF and boreholes; potential effects of ventilation on waste isolation; and sensitivity of previous analyses on the material properties used for the Paintbrush Tuff nonwelded unit (PTn) (ESF PA Analysis No. 14).

##### **Major Activities Upcoming Next Three Months**

ESF Analysis No. 13 will be continuing, with a SAND report (SAND93-1182) to complete technical and management review by the end of FY93 (Level III Milestone OS14).

The report SAND92-2248, "Estimations of the Extent of Migration of Surficially Applied Water for Various Surface Conditions Near the Potential Repository Perimeter," will be published.

Testing and numerical simulations for the nonisothermal experiments planned with WBS element 1.2.5.4.3 will continue.

##### **Other Items to Report**

A new ESF PA Analysis (No. 14) investigating the sensitivity of previous analyses to uncertainty in the hydrologic properties of the nonwelded Paintbrush Tuff has been postponed until August to allow staff to participate in the nonisothermal flow experiments. This PA analysis has been identified as a potential activity with a Level III Milestone for FY94.



#### **1.2.5.4.9 DEVELOPMENT AND VERIFICATION OF FLOW AND TRANSPORT CODES**

##### **Status Report on Ongoing Activities**

**Code Development:** The integrated finite difference code TOUGH2 (Pruess, 1991) has been used to make one-dimensional predictions of the multiphase flow in the vicinity of the proposed underground nuclear waste repository at Yucca Mountain, NV, for times to 10,000 yr. (SCP Subactivity 1.6.2.1.2)

A memo has been written discussing the results of these computations. The results can be summarized as follows.

- The two-dimensional global repository problem can be reasonably approximated by one-dimensional flow for waste burial times up to 600 yr.
- The use of a composite model is necessary to obtain computational results that predict dry out in the vicinity of the repository.
- The use of an approximate composite model in TOUGH2 resulted in unrealistic execution times.
- The sensitivity of repository dry out to material properties will be investigated upon the incorporation of a workable composite material characteristic model in the SNL version of TOUGH2. Staff has been in contact with J. Nitao of LLNL regarding the composite model used in VTOUGH. He is sending a listing of their composite model.

**Software QA:** Staff have completed the Software Configuration Management Course (CS777). (No SCP activity)

SNL staff are continuing to participate in the software QA Team. The objective of this group is to assist in rewriting QAIP 3-2.

An audit of software QA records in the Local Records Center (LRC) was performed.

Qualification of software codes UDEC and ALGEBRA for use in the Yucca Mountain Site Characterization Project is continuing. In addition, staff continues to process software QA records.

#### **1.2.5.5 SPECIAL PROJECTS**

No significant activity this reporting period.

## 1.2.6 EXPLORATORY STUDIES FACILITY

The objective of the Exploratory Studies Facility element includes work scope related to the design, construction, and operation of the Exploratory Studies Facility. The Exploratory Studies Facility element includes the Exploratory Studies Coordination, Planning, and Technical Assessment (1.2.6.1.1) task.

### ***1.2.6.1.1 ESF COORDINATION, PLANNING, AND TECHNICAL ASSESSMENT***

#### **Status Report on Ongoing Activities**

As an activity separate from construction monitoring (see WBS element 1.2.4.2.1.1.4), staff began fielding additional monitoring activities in the north ramp starter tunnel to address safety concerns. Convergence monitoring of the tunnel was conducted, and rock bolt load cells for evaluating ground support were installed.

#### **Major Activities Upcoming Next Three Months**

Under LANL coordination, staff will work with LLNL staff to consolidate SNL's ESF thermomechanical testing with LLNL's hydrothermal testing, if possible.

Plans and objectives of the experiments contained in study plan 8.3.1.15.1.6, "In Situ Thermo-mechanical Properties," will be presented to the NWTRB meeting that will be held on July 13 and 14.

Staff will supply a preliminary estimate of support needed from the Integrated Data-Aquisition System (IDS) by the SNL in situ field experiments to aid the designers of the IDS system to develop the IDS system.

Staff will field additional monitoring activities in the north ramp starter tunnel to address safety concerns as an activity separate from construction monitoring.

#### **Other Items to Report**

SNL is continuing temporary monitoring of rock mass movement as the ESF starter tunnel is excavated. Several sets of tape extensometer pins have been installed to monitor close of the pilot heading. This work is not part of the design verification study plan (8.3.1.15.1.8), but it is similar in nature to the more permanent monitoring that will be installed under the study plan. This temporary monitoring is being conducted under WBS element 1.2.6.1.1.

## 1.2.9 PROJECT MANAGEMENT

The objective of the Project Management element includes work scope related to project-level planning and control, and management of contract activities. The Project Management element includes two tasks: Technical Project Office Management (1.2.9.1.2) and Project Control (1.2.9.2.2).

### 1.2.9.1.2 TECHNICAL PROJECT OFFICE MANAGEMENT

#### Status Report on Ongoing Activities

Staff participated in a number of Project meetings in Las Vegas, NV, including Technical Data, Sample Overview Committee, NRC Site Visit Preparation, Assessment Team, Field Engineering, and Characteristics Database meetings. Staff also worked on several internal issues, including office space needs in Las Vegas, NV, and at the Nevada Test Site (NTS), draft QA procedures, strategic planning, and configuration management. Staff regularly facilitates responding to requests for information from DOE and other participants.

Several Project requirements documents, including the Exploratory Studies Facility Design Requirements Document (ESFDRD), the Surface-Based Test Facility Requirements Document (SBTFRD), and the Engineered Barrier Design Requirements Document (EBDRD), were received for another round of comment review.

### 1.2.9.2.2 PROJECT CONTROL

#### Major Accomplishments

To date, a total of 19 of 52 fiscal year 1993 milestones have been completed.

#### Status Report on Ongoing Activities

Analysis began on the SNL/YMP internal budget, cost, and schedule processes, initiating the development of the SNL Baseline Configuration Management Plan.

The FY94 budget planning exercise commenced. The emphasis for the initial steps in the planning process was on the detailing of technical workscopes, deliverables, milestones, the prioritization of work, and assignment of projected funding allocations.

Work began on a further revision of the Milestone Tracking database. The new version will reside on the Administrative Information Management System (AIMS) database network and be integrated with the PACS cost/budget database.

Installation of several versions of workstation software was completed.

Work has been completed to produce graphic plots from the PACS cumulative monthly budget, cost, and schedule data at the project level down to the summary account level. These graphics will be distributed to managers and task leaders as an attachment to the monthly cost report.

#### Major Activities Upcoming Next Three Months

The Draft SNL Baseline Configuration Management Plan will be completed.

## 1.2.11 QUALITY ASSURANCE

The objective of the Quality Assurance element includes the development, maintenance, and implementation of project participants' quality assurance programs.

### 1.2.11 QUALITY ASSURANCE

#### Major Accomplishments

SNL YMP QA staff completed a "supplier qualification evaluation" of the portion of the SNL Secondary Standards Laboratories that provides calibration services for electrical/electronics, temperature, pressure, load cell, and acceleration measuring and test equipment. The facilities and personnel were found to be capable of providing such services, so are considered "qualified."

#### Significant Meetings Attended

J. V. Voigt and D. R. Hawkinson attended a seminar on Management Self-Assessments.

#### Status Report on Ongoing Activities

Staff continues to revise and improve procedures and implement transition to the new Quality Assurance Requirements and Description (QARD). The following list summarizes the status of particular procedures.

- QAIP 2-4, Conducting and Documenting Analyses - In review.
- QAIP 2-5, Training (Revised) - Ready for review.
- QAIP 3-5, Design Analysis Verification - Issued.
- QAIP 3-10, Routine Calculations - Issued.
- QAIP 3-12, Peer Review - Issued.
- QAIP 5-1, Quality Assurance Implementing Procedure - In review.
- QAIP 17-2, Participant Data Archive - Approved, ready for issue.
- QAIP 20-3, Sample Control - In review.
- QAIP 20-4, Operation of the SNL Samples Library (replaces DOP 8-2) - Issued.

Surveillance of the use of Work Agreements in controlling work activities is ongoing.

A new QA Policy Statement from L. E. Shephard for inclusion in the Orientation Manual, as required by the QARD, was issued to replace the similar statement in the obsolete QA Program Description.

#### Major Activities Upcoming Next Three Months

QARD matrix data will be input into the YMP Quality Assurance Division (QAD) database.

Training on Underground Worker Safety is scheduled in June.

The SNL audit of International Technology Corporation (ITC), Albuquerque office has been set for June 16 and 17. The focus of the audit will be on ITC activities conducted to WA-0086 for WBS element 1.2.4.6.1.

The annual internal QA audit of the SNL YMP is scheduled to occur the week of July 12.

## 1.2.12 INFORMATION MANAGEMENT

The objective of the Information Management element includes work scope related to the project-level establishment of systems to facilitate organization, storage, and retrieval of information/documents. The Information Management element is comprised of four tasks: Information Management Coordination and Planning (1.2.12.1), Local Records Center Operation (1.2.12.2.2), Participant Records Management (1.2.12.2.3), and Document Control (1.2.12.2.5).

### **1.2.12.1 INFORMATION MANAGEMENT COORDINATION AND PLANNING**

#### Status Report on Ongoing Activities

Routine oversight of information management coordination and planning was conducted.

### **1.2.12.2.2 LOCAL RECORDS CENTER OPERATION**

#### Major Accomplishments

Twenty-six cited references for publications (1,001 pages) were copied and submitted to the CRF.

Eleven TDIFs were prepared and submitted to the Records Management System (RMS).

Three TDIFs were entered into the YMP Automated Technical Data Tracking System (ATDT).

#### Significant Meetings Attended

In addition to the 6352 Department meeting and a technical data meeting to discuss activity coordination needs, two staff members attended technical data meetings with SNL technical staff at the Yucca Mountain Site Office (YMSO). They also visited the Central Records Facility (CRF) and Project Microfilming Centers in Las Vegas, NV.

#### Status Report on Ongoing Activities

Verification of Project and SNL microfilmed records/documents continued with 1,760 pages of materials being verified against the microfilm and boxed for approved destruction.

Efforts have begun to process 897 reports to identify "developed data" and prepare TDIFs.



### Major Activities Upcoming Next Three Months

The QA Quality Action Team (QAT) members have been identified and the first meeting has been held. Members will assess and redesign the current filing system.

Staff will verify all microfilm against records from 1989 to the beginning of the Project and either destroy verified hardcopy, if approvals are issued, or box and send the hardcopy to the SNL Archives. To date, 57,561 pages have been verified. No direction has been issued by the Office of Civilian Radioactive Waste Management (OCRWM) regarding ownership and disposition of dual storage YMP records.

All SAND reports and supporting data for 1986 will be reviewed against CRF microfilm.

Staff will research and propose a phased approach to development of a Disaster Preparedness and Recovery Plan for the YMP Records Management Program. A Phase I presentation was given to S. Sharpton, Project Support Manager.

SNL has published a total of 897 SAND reports in the support of YMP. Twenty-five of these reports have had TDIFs prepared and submitted to the ATDT. The rest (a majority of them considered to be "backlog") are currently being reviewed to determine if TDIFs should be prepared for entry into the ATDT. Staff will establish a plan for completion of this activity. Funding has been reestablished by the Project Office to assist with this project for the remainder of FY93.

The effort to establish a technical data team to evaluate SNL YMP processes and integrate requirements, technical efforts, and support efforts for improved efficiency of personnel has been delayed due to "backlog" processing efforts.

Staff will review and revise the Desk Guidance for Participant Data Archive (PDA) activities. A final draft is being prepared for review and approval.

### **1.2.12.2.3 PARTICIPANT RECORDS MANAGEMENT**

#### Major Accomplishments

A new supervisor was identified for the YMP Records Management Support efforts. Final contract processing is being conducted.

Staff reviewed and commented on the Proposed YMP-AP1.18Q Record Source Procedure.

#### Significant Meetings Attended

On May 7, staff attended the QA Team meeting for the NWM Information Center relocation.

#### Major Activities Upcoming Next Three Months

Staff will obtain SNL and OCRWM approval/ authorization for the identification of YMP duplicate storage records as Federal nonrecords. When so designated, staff will obtain approval/ authorization for the verification and destruction of said records. The staff will meet with SNL Recorded Information Management to ensure appropriate disposition for SNL.

Staff will research and prepare FY94 budget information. Figures will be revised due to SNL 32% on-site space charge for contractors and the addition of the new supervisor.

### **1.2.12.2.5 DOCUMENT CONTROL**

#### **Major Accomplishments**

SNL YMP has started evaluating alternative methods (i.e., UNIX-based operating systems and Apple MACs) for viewing Controlled Documents on a totally electronic medium. SNL YMP is currently setting up accounts on the SUN Server (SASS377) to accomplish this.

#### **Status Report on Ongoing Activities**

The second notice listing of all active recipient's Controlled Documents was sent to all holders of SNL Controlled Documents in response to CAR 93-021, YMP 93-03.

The SNL TPO sent out a notice to all SNL YMP staff members to evaluate their individual need to have Controlled Documents in their possession. This may result in a reduction of the number of Controlled Documents maintained and audited.

#### **Major Activities Upcoming Next Three Months**

SNL staff will continue to prepare and submit records packages to the LRC for superseded and recalled Controlled Documents.

Merging of the SNL Controlled Documents System and the SNL Training System with the People Database is ongoing. A beta version should be up and running within the next few months.

## 1.2.15 SUPPORT SERVICES

The objective of the Support Services element includes work related to project-level general administrative and project support activities. The Support Services element is comprised of three tasks: Support Services Coordination and Planning (1.2.15.1), Administrative Support (1.2.15.2), and YMP Support for the Training Mission (1.2.15.3).

### **1.2.15.1 SUPPORT SERVICES COORDINATION AND PLANNING**

#### Significant Meetings Attended

A monthly status meeting with one of the primary support contractors for this element was conducted on May 27.

#### Status Report on Ongoing Activities

Routine oversight of support service activities was conducted.

### **1.2.15.2 ADMINISTRATIVE SUPPORT**

#### Major Accomplishments

During the month of May, one SAND report was sent to the Project Office for review.

#### Status Report on Ongoing Activities

Work on the procurements database design continued. Efforts concentrated on developing queries that will provide downloaded financial information from SNL's financial system. The database will be designed to provide detailed procurement information as required by the YMP socioeconomic monitoring plan and will perform three major functions: procurement tracking, financial data downloads, and reporting.

Extensive efforts were made to complete the reclassification of manpower contracts to ensure that year-to-date costs are spread to accurate cases.

Efforts continue to consolidate a list of Nuclear Waste Fund (NWF)/YMP equipment to be returned to SNL YMP from other locations within and outside of the laboratory.

### **1.2.15.3 YMP SUPPORT FOR THE TRAINING MISSION**

#### **Major Accomplishments**

Seven YMP managers completed an eight-hour workshop entitled "Project Control System (PCS) Overview."

Nineteen YMP staff members completed a three-day course on site at SNL entitled "Project Control System Guidelines."

SNL QAIP 2-5 has been revised and is in the final approval stage.

SNL YMP Training Assignment form (TR-3) has been redesigned.

A new "Person" table has been designed to network information shared by the SNL/YMP Training Database and the SNL Controlled Documents Database.

The SNL YMP Employee Orientation manual has been updated.

The SNL YMP Training Manager toured the Project site while attending a Property Control meeting in Las Vegas, NV.

The SNL YMP sponsored a two-day Technical Integration Retreat.

#### **Status Report on Ongoing Activities**

Staff is continuing to convert the training database from Foxpro to Informix and continuing development of a relational database interlocking the training and the Control Document System; a plan to revise the "new employee orientation" to include one-on-one sessions on specific procedures; and training to be based on Work Assignment "point of use."

Ten videotapes of the "Geology for Non-Geologists" course are being edited. Training record packages were prepared and submitted to the LRC.

A Training Systems Team is formulating recommendations for improving the effectiveness and adequacy of the training program.

The major steps of the new Training Program flow are in the process of final approval before implementation.

#### **Major Activities Upcoming Next Three Months**

A three day course on "Technical Presentation Skills" will be offered to YMP staff.

A four day course on "Leadership for the Future" will also be offered to YMP staff.

Editing of the "Geology for Non-Geologists" course tapes will continue. Training for improving computing skills will be initiated.

The training database will be improved and converted to AIMS.

Replacement training support staff may be hired for the summer.